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A Cross-Sectional Study of the Relationship Between BMI and Menstrual Cycle Regularity in Women of Reproductive Age in Pamekasan

Ratna Hermawati[1], Dewangga Wahyu Praja[2], and Khoirul Umam*[3]

[1]Larasati Hospital, Madura: Email: ratna.larasatipmk@gmail.com
[2]Larasati Hospital, Madura: Email: dewangga.larasatipmk@gmail.com
[3]Larasati Hospital, Madura: irul.rsot@gmail.com
*Corresponding author: irul.rsot@gmail.com

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Obesity is increasingly recognized as a significant determinant of women's reproductive health, particularly in relation to menstrual cycle irregularities. This cross-sectional study aimed to examine the relationship between Body Mass Index (BMI) and menstrual cycle regularity among women of reproductive age in Pamekasan, Indonesia. A total of 113 respondents aged 18–45 years were selected through simple random sampling. BMI data were obtained through anthropometric measurements, while menstrual cycle patterns were assessed using structured questionnaires. The study identified a notable trend: the likelihood of menstrual disturbances increased with higher BMI classifications. Women classified as overweight and obese experienced a higher prevalence of irregular menstrual cycles compared to those with normal BMI. These findings highlight the potential influence of excess body weight on hormonal regulation and ovulatory function. In rural settings like Pamekasan, where the prevalence of obesity is rising, this study emphasizes the need to integrate weight management into reproductive health programs. Targeted interventions through community education, nutritional counseling, and primary care integration could play a vital role in improving reproductive outcomes and reducing the burden of menstrual disorders.

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Public Interest Statement

Menstrual cycle irregularities are common yet often overlooked issues affecting women's reproductive health. This study addresses a crucial gap by examining the relationship between Body Mass Index (BMI) and menstrual cycle regularity among women of reproductive age in Pamekasan, Indonesia, a context underrepresented in the current literature. These findings highlight the growing impact of obesity on hormonal balance and fertility, emphasizing the need for integrated health interventions. This research is valuable for public health practitioners, educators, and policymakers aiming to improve women's health outcomes through early prevention and community-based weight-management strategies.

Introduction

Reproductive health among women of childbearing age is a crucial component of global health initiatives, particularly in relation to fertility, hormonal balance, and overall well-being of women. The regularity of the menstrual cycle is a core indicator of reproductive health. Irregular menstrual cycles can be a clinical manifestation of various physiological disturbances, including hormonal imbalances, ovulatory disorders, and metabolic conditions (Bull et al., 2019). From a public health perspective, menstrual regularity serves as a fundamental marker for assessing women's reproductive health outcomes and guiding policy interventions (Schoenaker et al., 2014; Wang et al., 2020).

Numerous studies have explored the relationship between Body Mass Index (BMI) and menstrual irregularities. BMI, as a measure of nutritional status, has consistently been linked to endocrine function. Research conducted by Chen et al. (2020) found that underweight and overweight women exhibited higher rates of menstrual irregularity, suggesting a non-linear relationship between BMI and menstrual health. Similarly, Hashim in the United Arab Emirates reported that obese university students were significantly more likely to experience oligomenorrhea and amenorrhea than their normal-weight peers (Hashim et al. 2019). Although these findings have strengthened the understanding of BMI as a reproductive risk factor, most studies were conducted in urbanized, high-income populations. Studies from rural or semi-urban areas in developing countries, such as Indonesia, remain scarce and largely uncontextualized in the literature.

Indonesia is currently facing a dual nutritional burden, with rising obesity rates and micronutrient deficiencies. According to Indonesia's Ministry of Health, the national prevalence of obesity among women aged 18 years and older increased from 32.9% in 2018 to 35.2% in 2023 (Rokom, 2024). In Pamekasan Regency, East Java, a predominantly rural and agrarian region, local health surveillance recorded 66,668 cases of obesity in 2023, which only slightly decreased to 62,689 cases in 2024 (Rokom, 2024). This high burden is driven by dietary patterns rich in refined carbohydrates, limited access to balanced nutrition, and low physical activity among women primarily engaged in domestic labor. Despite this, data on the reproductive consequences of excess weight in this region remain scarce.

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Pamekasan presents a unique sociocultural and epidemiological context that warrants further scientific inquiry. As an area with limited reproductive health infrastructure and deeply rooted food-related cultural norms, it reflects a broader trend observed across many rural Indonesian districts. Nonetheless, only a limited number of epidemiological studies have explored the impact of BMI on menstrual health in such specific rural settings.

The growing prevalence of obesity in Indonesia, particularly among women, necessitates urgent investigation of its potential reproductive consequences. In Pamekasan Regency, East Java, recent local health data revealed that the number of obesity cases reached 66,668 in 2023 and slightly decreased to 62,689 in 2024 (Pamekasan District Health Office). International findings have shown that obesity alters hormonal pathways, impairs ovulation, and increases the risk of menstrual disorders (Vigil et al., 2017). However, there is a notable absence of epidemiological data regarding menstrual cycle disorders in the region. This lack of localized evidence presents a critical challenge for reproductive health planning and underscores the need for studies that consider sociocultural, demographic, and lifestyle-specific factors within the Indonesian context (WHO, 2024; Octaria et al., 2020)

This study is the first empirical investigation to explicitly explore the relationship between BMI and menstrual cycle regularity among women of reproductive age in Pamekasan. This study contributes new evidence to the limited literature on reproductive health disparities in rural Indonesia and aims to fill the knowledge gap by providing region-specific data that can inform both local and national health policies. By highlighting the intersection between metabolic health and menstrual function, this study seeks to strengthen the foundation for context-sensitive interventions grounded in the lived realities of rural women.

This study used a quantitative, cross-sectional research design. Data were collected from women aged 15–49 years through a combination of anthropometric measurements and menstrual health questionnaires. Statistical analysis, including chi-square and logistic regression tests, was used to assess the strength and direction of the relationship between BMI categories and menstrual cycle regularity while controlling for other factors such as physical activity and age.

Literature Review

The study conducted by Zhou and Yang (2020) examined the relationship between body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and menstrual cycle disorders in women of reproductive age in China. In this cross-sectional study, 1,423 Han women aged 19–39 years participated and completed a menstrual questionnaire and anthropometric measurements. Logistic regression analysis revealed that women with a BMI ≥30 kg/m² had a 2.5 times higher risk of experiencing irregular menstruation (OR = 2.509; 95% CI: 1.591–3.958; $p < 0.001$) than those with normal weight. Additionally, a WC ≥90 cm significantly increased the risk of oligomenorrhea

and menstrual irregularities, even more strongly than BMI. These findings underscore that obesity, particularly abdominal obesity, significantly contributes to irregularities in the menstrual cycle.

The main strength of this study is its large number of participants and the use of direct body measurements instead of self-reported data, which reduces the bias. However, this study had some limitations. As it is cross-sectional, it cannot show cause and effect. It also lacks hormonal and ultrasonographic tests to support the clinical data. Despite these issues, the findings of Zhou and Yang (2020) are important to this study. They provide strong evidence that being overweight or obese, especially with fat around the belly, is a major factor in irregular periods in women of childbearing age.

Al Sabbah (2020) investigated the prevalence of overweight, obesity, and anemia, and their associations with lifestyle factors, body fat, and abdominal obesity among female university students in Dubai, United Arab Emirates. This cross-sectional study included 251 female students from various faculties at a national university. The results showed that 29.3% of the respondents were overweight or obese, 18.1% had anemia, and 8.5% had abdominal obesity. Students with anemia had a higher average body fat percentage (38.9%) and reported lower physical activity than those without anemia. Irregular eating patterns and fast-food preference were more common among those with poorer nutritional statuses, including obesity and anemia. The strength of this study lies in the use of direct measurements for anthropometry, hemoglobin levels, and body fat, enhancing data accuracy and minimizing self-reporting bias. However, due to its cross-sectional design, the study could not establish causal relationships between obesity, anemia, and the lifestyle factors. The lack of detailed food intake tracking limits the interpretation of the links between fast food consumption, anemia, and obesity. Nonetheless, Al Sabbah's contribution addresses the literature gap in the Middle Eastern region, particularly regarding the interaction between excess body fat and menstrual disorders that may be induced by iron deficiency in young female populations. This makes it relevant for supporting studies exploring BMI's influence of BMI on menstrual cycle regularity. (Al Sabbah, 2020) .

Jiang (2024) conducted a two-sample Mendelian randomization meta-analysis to investigate the causal relationship between body mass index (BMI) and female reproductive system tumors. Using genetic data from 339,000 individuals, the study found that increased BMI significantly raised the risk of endometrial cancer risk (OR 1.53; 95% CI: 1.16–2.01) and serous and endometrioid ovarian cancer subtypes. BMI was negatively correlated with breast cancer, including estrogen receptor-positive and -negative subtypes, but no causal association was found with cervical cancer or uterine fibroids. The strength of this study lies in its Mendelian randomization methodology, which minimizes confounding bias, and its use of data from major consortia, such as the UK Biobank and FinnGen. However, limitations include the predominantly European sample population and BMI's inability of BMI to account for specific fat distribution patterns (Soca Daru Indraswari, 2025). These findings emphasize that increased adiposity affects both menstrual irregularities and genetically elevates reproductive cancer risks, highlighting the importance of weight management in preventing female reproductive system disorders (Jiang et al., 2024).

A meta-analytic study conducted by Jenabi et al. (2019) investigated the relationship between body mass index (BMI) and the risk of endometriosis in women of reproductive age. This study analyzed data from nine observational studies involving 50,926 participants. The results showed that underweight women (BMI <18.5 kg/m²) had a 41% higher likelihood of developing endometriosis than normal-weight women (OR = 1.41; 95% CI: 1.16–1.66). No significant associations were found between being overweight (OR 0.95; 95% CI: 0.72–1.18) or obese (OR 0.88; 95% CI: 0.54–1.21) and endometriosis. The strength of this study was its use of a random-effects model, with low heterogeneity across studies (I^2 = 4.5%) and rigorous quality assessment using the Ottawa Scale. Limitations included the inability to conduct demographic subgroup analyses and potential bias from the observational studies. These findings contribute to understanding BMI as a risk indicator for reproductive disorders, particularly linking underweight status to disruptions in the female reproductive system and conditions affecting menstrual regularity.

Materials and Methods

This study employed a quantitative, cross-sectional research design to explore the relationship between Body Mass Index (BMI) and menstrual cycle regularity among women of reproductive age in Pamekasan Regency, Indonesia. The cross-sectional approach enabled a snapshot assessment of the reproductive health status of the population and its potential associations with anthropometric and lifestyle indicators.

The target population consisted of women aged 15–49 years who resided in Pamekasan. A total of 113 respondents were selected through simple random sampling from community health center (Puskesmas) registries. The inclusion criteria were women who had experienced menstruation within the past three months and were not currently pregnant, lactating, or undergoing hormonal therapy. Exclusion criteria were designed to reduce confounding and

included women with diagnosed polycystic ovary syndrome (PCOS), endometriosis, thyroid disorders, or diabetes mellitus—all of which can influence menstrual patterns independently of BMI (McGee et al., 2014; Wei et al., 2009)

The anthropometric data in this study were obtained through direct measurements using calibrated and standardized instruments to ensure accuracy. Body weight was measured using a digital scale (Camry EB9380, China) with a precision of 0.1 kg. Height was recorded using a Seca 213 portable stadiometer (Germany), which is accurate to 0.1 cm. These instruments were selected for their reliability and suitability for field-based data collection. The measurements were conducted by trained enumerators following standardized procedures, with participants asked to remove footwear and heavy clothing to minimize measurement errors. Body Mass Index (BMI) was calculated using the conventional formula: weight in kilograms divided by the square of height in meters (kg/m^2). The resulting BMI values were categorized based on the World Health Organization (WHO) Asia-Pacific criteria, allowing for accurate classification of the nutritional status of women of reproductive age in the study area. (World Health Organization (WHO), 2000)

Table 1. Body Mass Index (BMI) Classification According to WHO Asia-Pacific Guidelines

BMI Category	BMI Range (kg/m^2)	Interpretation
Underweight	< 18.5	Insufficient body weight
Normal weight	18.5 – 22.9	Healthy range
Overweight	23.0 – 24.9	Increased health risk
Obese	≥ 25.0	High health risk

Source: World Health Organization (2000). *The Asia-Pacific Perspective: Redefining Obesity and Its Treatment*.

Table 1 shows that menstrual cycle regularity was evaluated using a structured, self-administered questionnaire adapted from the 2018 classification system established by the International Federation of Gynecology and Obstetrics (FIGO) (Munro et al., 2018). To strengthen the validity of the self-reported data, participants were instructed to recall the details of their menstrual patterns over the past 12 months, with responses corroborated, when possible, by personal health records or digital menstrual tracking applications. Women who had used hormonal contraceptives within the last year were excluded from participation to minimize hormonal bias that could interfere with the accuracy of the cycle reporting. The questionnaire was carefully translated into the local language, combining Bahasa Indonesia with culturally relevant Madurese terminology to ensure clear comprehension and minimize potential misreporting. Within this framework, menstrual irregularity was defined using operational criteria: oligomenorrhea was identified in participants whose average cycle length exceeded 38 days, while irregular menstruation was characterized by a difference of more than seven days between the shortest and longest cycles reported during the previous year.

To reduce confounding bias, the questionnaire included sections on physical activity (categorized by WHO standards of ≥150 min/week), dietary patterns (high-carb, processed food intake frequency), sleep quality, and psychosocial stress using a simplified Perceived Stress Scale (PSS-10). These variables were adjusted using multivariate logistic regression models to isolate the relationship between BMI and menstrual irregularities.

Statistical analyses were performed using SPSS version 26. Descriptive statistics were used to summarize demographic, lifestyle, and reproductive data. The chi-square test was used to assess the association between BMI categories and menstrual irregularities. Logistic regression models were used to control for age, physical activity, and dietary patterns. Statistical significance was set at $p < 0.05$.

Results

This section presents the empirical findings of the study, focusing on the relationship between Body Mass Index (BMI) and menstrual cycle regularity among women of reproductive age in Pamekasan Regency. The results are structured thematically to provide a clear and systematic analysis. It begins by describing the sociodemographic and anthropometric characteristics of the participants, followed by the prevalence of menstrual disturbances across the BMI categories. Statistical analysis was then performed to determine the significance and strength of the observed association, and a graphical visualization was included to support the interpretation of the data. The findings are concluded with a concise summary that synthesizes the key patterns.

1. Participant Characteristics

This study included 113 women of reproductive age (15–49 years) who resided in Pamekasan Regency. Based on the Body Mass Index (BMI) classification, the distribution was as follows: 43 participants (38.05%) had a normal BMI (18.5–24.9 kg/m^2), 50 participants (44.25%) were overweight (BMI 25.0–29.9 kg/m^2), and 20 participants (17.70%) were classified as obese (BMI ≥30.0 kg/m^2). No respondents were categorized as underweight (BMI <18.5 kg/m^2). These findings suggest that a majority of the sample population (61.95%) fell into the overweight and obese categories, reflecting a concerning prevalence of excess weight among women of reproductive age in the region.

Table 2. Distribution of Respondents by Body Mass Index (BMI) Category

BMI Category	Frequency (n)	Percentage (%)
Normal (18,5-24.9)	43	38.05%
Overweight (25.0–29.9)	50	44.25%
Obese (≥30.0)	20	17.70%
Total	113	100.00%

Source: Data Processed by Author, 2025

Table 2 presents the distribution of 113 women of reproductive age based on their Body Mass Index (BMI), categorized into normal, overweight, and obese groups using the standard WHO classification.

Of the total sample, 43 participants (38.05%) had a normal BMI ranging from 18.5 to 24.9 kg/m². This indicates that slightly more than one-third of respondents maintained a healthy weight. Meanwhile, the largest proportion of the population, 50 individuals (44.25%), were categorized as overweight (BMI between 25.0 and 29.9 kg/m²). This suggests that nearly half of the study participants had elevated body weight that exceeded the normal range but did not yet qualify as obesity.

Additionally, 20 participants (17.70%) were classified as obese, with a BMI of ≥ 30.0 kg/m². When combined, the overweight and obese categories accounted for 62% of the population, reflecting a significant burden of excess weight among women of reproductive age in this sample.

This distribution underscores a public health concern regarding nutritional and lifestyle patterns within the study population, particularly as both overweight and obesity are known risk factors for menstrual irregularities, infertility, and other reproductive disorders. The high prevalence of overweight and obesity serves as a critical baseline for contextualizing subsequent findings regarding menstrual cycle disturbances, as discussed in the following sections.

2. Prevalence of Menstrual Irregularity Across BMI Categories

Menstrual irregularity was reported by 58 of the 113 respondents (51.33%), whereas 55 respondents (48.67%) reported having regular menstrual cycles. Among women with a normal BMI, 18 out of 43 (41.86%) experienced menstrual irregularities. In the overweight group, this figure increased to 25 out of 50 respondents (50.00%). The highest prevalence was observed in the obese group, where 15 of the 20 women (75.00%) reported menstrual disturbances. These data demonstrate a clear upward trend in the prevalence of menstrual irregularities corresponding to the increased BMI classification.

Table 3. Distribution of Menstrual Cycle Irregularities by BMI Category

BMI Category	Frequency (n)	No Irregularity (n)	Total (n)	Percentage (%)
Normal (18,5-24.9)	18	25	43	41.86%
Overweight (25.0–29.9)	25	25	50	50.00 %
Obese (≥30.0)	15	5	20	75.00 %
Total	58	55	113	51.33%

Source: Data Processed by Author, 2025

Table 3 shows an increasing proportion of menstrual cycle disorders corresponding to higher Body Mass Index (BMI) categories. Among the 43 respondents with normal BMI, 41.86% experienced menstrual irregularity. This percentage increased to 50% in the overweight group and 75% in the obese group. Overall, 51.33% of the respondents reported menstrual cycle disorders. These findings indicate a clear trend suggesting that the higher a person's BMI, the greater the likelihood of experiencing menstrual irregularities.

3. Statistical Association Between BMI and Menstrual Irregularity

A chi-square test of independence was conducted to examine the association between the BMI category and menstrual cycle regularity. The results revealed a statistically significant association ($\chi^2 = 10.741$, $p = 0.00465$, degrees of freedom = 2). This confirms that BMI classification is significantly related to the presence of menstrual irregularities in adolescents. The strength of the association was assessed using Cramér's V, which was approximately 0.308. According to Cohen's interpretation, this represents a moderate effect size, suggesting that BMI is a meaningful contributor to menstrual cycle disturbance in the population studied.

A Cramér's V value of 0.308 indicates a moderate association between BMI categories and irregularities in the menstrual cycle. In statistical interpretation, a value between 0.1 and 0.3 typically suggests a weak association, whereas a value between 0.3 and 0.5 is considered moderate. Therefore, this finding suggests that BMI is not merely a supporting variable but plays a meaningful role in explaining the variation in menstrual disturbance. This reinforces the importance of incorporating weight management strategies as a critical component of women's reproductive health programs.

Table 4. Chi-Square Test Results for the Association between BMI and Menstrual Cycle Regularity

Parameter	Value
Chi-square (χ^2)	10.741
Degrees of freedom (df)	2
p-value	0.00465
Cramér's V	0.308
Interpretation	Moderate association

Source: Data Processed by Author, 2025

Table 4 presents the results of a chi-square test, confirming a significant relationship between Body Mass Index (BMI) categories and menstrual cycle disorders, with a χ^2 value of 10.741 and a p-value of 0.00465 ($p < 0.05$). The Cramér's V value of 0.308 indicates a moderate strength of association. These findings suggest that an increase in BMI is significantly associated with a higher likelihood of menstrual disorders in women of reproductive age.

4. Visual Analysis: Distribution of Overweight and Obese Respondents

To further illustrate the distribution of BMI-related weight categories, a simple bar plot was generated to show the proportion of overweight and obese individuals in the study population. As depicted in Figure 1, 21 participants were classified as overweight and 10 as obese. Together, this constituted 31 individuals out of a subset of 60 surveyed, yielding a combined overweight/obesity prevalence of 51.67%. This reinforces the finding that excessive weight is common among women in this demographic and may serve as a risk factor for reproductive health issues.

Table 5. Distribution of Menstrual Irregularities among Overweight and Obese Respondents

Category	n	%
Overweight	21	35.00%
Obese	10	16.67%
Total	31	51.67 %

Source: Data Processed by Author, 2025

Table 5 shows that out of the 60 respondents, 21 individuals (35.00%) were classified as overweight and 10 individuals (16.67%) as obese. When these two categories were combined, 31 respondents (51.67%) were found to have excess body weight. This finding indicates that more than half of the sample population had a BMI above the normal range, which may be a significant risk factor for reproductive health issues, including irregular menstrual cycles. This relatively high proportion underscores the importance of considering nutritional status and body weight as part of preventive efforts to address menstrual disorders in women of reproductive age.

The results of this study demonstrated a consistent positive association between increasing BMI and the likelihood of experiencing menstrual irregularities. The prevalence of menstrual cycle disorders rose markedly from the normal BMI group (41.86%) to the overweight (50.00%) and obese (75.00%) categories. The statistically significant chi-square result and moderate Cramér's V underscore the reliability of this finding. These findings align with existing international literature linking elevated adiposity with disruptions in the hypothalamic–pituitary–gonadal (HPG) axis, insulin resistance, and hormonal imbalance, all of which are known contributors to irregular menstrual function. The implications of these results are further explored in the subsequent discussion.

Discussion

This study examined the relationship between Body Mass Index (BMI) and menstrual cycle regularity among 113 women of reproductive age in Pamekasan Regency. The findings indicate that as BMI categories increase from normal to overweight and obese, there is a corresponding rise in the prevalence of menstrual disorders, defined in this study as having fewer than 11 menstrual cycles per year. Specifically, 41.86% of women with normal BMI experienced menstrual irregularities, which increased to 50% in the overweight group and 75% among those classified as obese. These results revealed a positive correlation between a higher BMI and menstrual irregularities.

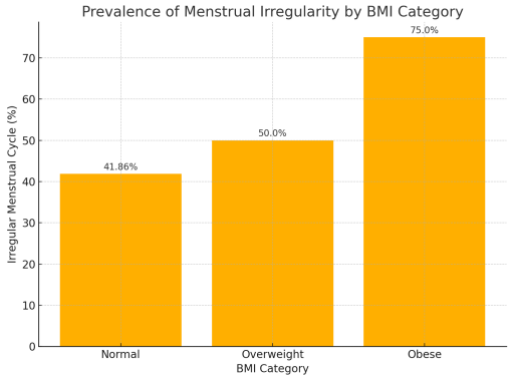

Figure 1. Prevalence of Menstrual Irregularity by BMI Category

Figure 1 reveals an increasing trend in the prevalence of menstrual cycle irregularities corresponding to higher Body Mass Index (BMI) categories. Among women with a normal BMI, 41.86% reported experiencing menstrual irregularities. This figure increased to 50.00% in the overweight group, where half of the respondents reported cycle disturbance. The most significant increase was observed in the obese group, where 75.00% of women experienced irregular menstrual cycles. These findings indicate that the likelihood of menstrual irregularities increases with an increase in BMI. This pattern reinforces the hypothesis that excess body weight and obesity can disrupt hormonal regulation and ovulatory function, which, in turn, directly affect menstrual cycle regularity.

These findings are consistent with those of previous studies that have confirmed the negative impact of being overweight and obese on the female reproductive system, particularly in relation to the hormonal regulation of ovulation and menstrual cycles. For instance, Sridhar found that obesity can trigger insulin resistance and increase levels of androgens and leptin, which collectively disrupt ovulation and lead to prolonged or irregular menstrual cycles. (Sridhar et al. 2023). Similarly, studies by Zhou and Yang (2020) in China and Jiang using a Mendelian randomization approach have shown that increased BMI is significantly associated with various forms of reproductive system dysfunction, including menstrual disorders and an elevated risk of endometrial and ovarian tumors.

1. Socio-Cultural Context of Pamekasan

One of the distinctive contributions of this study lies in mapping the relationship between Body Mass Index (BMI) and menstrual cycle disorders within the sociocultural and geographical context of Pamekasan, a region characterized by its agrarian society, carbohydrate-dense dietary pattern, and limited reproductive health service infrastructure. This study highlights a dimension that has often been overlooked in the global literature: how local contexts mediate the structural and behavioral determinants of reproductive health disorders.

The traditional dietary habits of the Madurese community heavily rely on white rice, sugar, and cooking oil, which collectively contribute to a high glycemic index and an increased risk of abdominal obesity. This is in line with the Global Nutrition Report (Global Nutrition, 2020), which identifies Indonesia as a country facing a double burden of malnutrition: a sharp rise in obesity prevalence occurring alongside widespread micronutrient deficiencies among women of reproductive age. Furthermore, Popkin et al. (2020) emphasized that the nutrition transition in developing countries is marked by a growing intake of ultra-processed foods that are high in calories but low in nutrients, contributing to obesity and metabolic complications, including menstrual dysfunction.

Beyond nutritional aspects, the context of Pamekasan also reveals low levels of physical activity, particularly among women, most of whom engage in domestic work with limited mobilities. This contributes to low energy expenditure, exacerbating the energy imbalance described in the Energy Availability Hypothesis (Loucks & Thuma, 2003). In this regard, our study confirms that visceral obesity (abdominal obesity) is a significant predictor of menstrual disorders, primarily mediated through insulin resistance and impaired secretion of Gonadotropin-Releasing Hormone (GnRH), as outlined by Pasquali (Pasquali et al., 2006) and further reinforced by Sridhar (Sridhar et al., 2023)

In addition to biological and behavioral factors, this study highlights the limited access to reproductive health services in rural areas such as Pamekasan. Say et al. (2014) emphasized that spatial disparities in the availability and quality of maternal and reproductive health services directly contribute to the burden of untreated reproductive health issues among women of reproductive age in developing countries. This underscores the importance of the present study, as it reveals that menstrual disorders among respondents are not solely the result of individual factors (such as diet or activity levels) but are also shaped by structural and systemic determinants.

Thus, adopting a biopsychosocial framework is crucial for comprehensive analysis. It requires consideration of not only biological elements such as hormones and BMI, but also psychosocial determinants, including dietary upbringing, cultural norms regarding the female body, and limitations within public service systems. Moving forward, it is essential for studies in Indonesia to move beyond merely replicating Western research designs and adapt methodologies that account for the complexity of local contexts more meaningfully.

2. How Obesity, Hormonal Imbalance, and Psychosocial Factors Disrupt the Menstrual Cycle

The menstrual cycle is a complex biological process regulated by hormonal interactions, primarily between *estrogens* and *progesterones*. *Estrogen*, produced by the ovaries during the follicular phase, stimulates endometrial proliferation and maturation. Following ovulation, *progesterone* secreted by the corpus luteum prepares the endometrium for implantation in the uterus. Hormonal imbalances, whether due to deficiency or excess, can lead to anovulation and menstrual irregularities. Suboptimal BMI, particularly in cases of obesity, has the potential to disrupt hormonal equilibrium through metabolic and endocrine pathways, such as insulin resistance and hyperandrogenism (Sridhar et al., 2023)

Insulin resistance, commonly observed in individuals with obesity, impairs ovarian function and elevates androgen levels, which are typical characteristics of Polycystic Ovary Syndrome (PCOS). In addition, adipose tissue secretes adipokines, such as leptin and adiponectin. Leptin plays a role in regulating the secretion of Gonadotropin-Releasing Hormone (GnRH), which in turn governs Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH), while adiponectin enhances insulin sensitivity and exerts anti-inflammatory effects. The imbalance of leptin and adiponectin levels, commonly found in individuals with obesity, contributes to the dysregulation of the menstrual cycle (Angelidis et al., 2013).

Chronic psychological stress activates the hypothalamic-pituitary-adrenal (HPA) axis, leading to elevated cortisol levels. High cortisol levels are known to inhibit the activity of the hypothalamic pituitary-gonadal (HPG) axis, ultimately suppressing the production of GnRH, LH, and FSH, thereby disrupting ovulation and causing amenorrhea (Ferin, 1999; Nakamura et al., 2008)

Cwikel's (2004) findings indicate that infertile women exhibit higher levels of cortisol and prolactin than fertile women, which are associated with reduced endometrial thickness and decreased chances of conception. Both internal and environmental stress must be considered in the evaluation of menstrual disorders, as they significantly affect the hormonal balance of the reproductive system (Cwikel et al., 2004).

Poor nutrition can disrupt hormonal balance through various mechanisms, including the deficiency of micronutrients. Vitamin D, which influences the expression of reproductive genes and modulates sex hormone levels, has been linked to ovarian dysfunction, particularly in the context of Polycystic Ovary Syndrome (PCOS) (Motsinger et al., 2012). Subramanian and Gernand highlighted that vitamin D levels fluctuate throughout the menstrual cycle, although the study results remain mixed. Supplementation with vitamin D, especially when combined with omega-3 fatty acids and calcium, has shown potential for improving hormonal balance and insulin sensitivity (Subramanian & Gernand 2019).

Menstrual disorders, particularly those associated with PCOS, have a genetic component. Khan et al. (2019) found that genes regulating hormone production, inflammation, and insulin metabolism contribute to PCOS predisposition. A more recent study by Mykhalchenko (2017) identified CYP1A1 and CYP19A1 as being associated with estrogen metabolism disorders and ovarian dysfunction. The interaction between genetic predisposition and environmental factors, such as obesity, increases the risk of menstrual irregularities.

Balanced physical activity is essential for maintaining hormonal balance. Peña et al. (2020) demonstrated that excessive physical exercise without adequate energy intake suppresses ovulation and leads to amenorrhea. Kraemer (2005) also reported that the hormonal response to physical activity depends on the intensity and duration of exercise and the individual's metabolic condition. Conversely, a lack of physical activity contributes to increased insulin resistance and obesity, which further exacerbates menstrual irregularities.

The role of gut microbiota in *estrogen* metabolism and hormonal homeostasis has gained increasing attention in the field of reproductive medicine. Baker et al. (2017) found that an imbalance in the gut microbiota can lower estrogen levels, affecting endometrial and brain health. Guo and Zhang (2024) noted that gut microbiota disturbances can increase systemic inflammation in patients with endometriosis, emphasizing the importance of microbiome balance in supporting fertility and successful pregnancy outcomes.

Lifestyle interventions, such as nutritional regulation, stress management, and physical activity, have shown promising effects in managing menstrual cycle disorders. Dhawan and Dada (2020)found that yoga practice can reduce cortisol levels and improve reproductive hormone balance. Moran et al.(2020) recommended a low-glycemic diet rich in

omega-3 and vitamin D, along with weight management, as core therapeutic strategies for managing PCOS and irregular menstrual cycles.

This theoretical understanding supports the view that the menstrual cycle reflects the body's systemic balance, involving the endocrine, metabolic, neurological, and microbial networks. Therefore, interventions targeting a single aspect should be integrated into a multidisciplinary approach to achieve optimal results.

3. Policy and Community-Based Interventions for Menstrual Health and Nutritional Balance

The findings of this study underscore the importance of comprehensive interventions in addressing menstrual cycle disorders associated with the Body Mass Index (BMI). Menstrual irregularities not only affect women's quality of life and psychosocial well-being but may also serve as early indicators of long-term complications such as infertility, chronic anemia, Polycystic Ovary Syndrome (PCOS), and endometrial cancer (Pasquali & Gambineri, 2006).

In the context of this study, the traditional dietary patterns observed among the Madurese population in Pamekasan may have contributed to the high prevalence of overweight and obesity among women of reproductive ages. The typical local diet is characterized by a high intake of refined carbohydrates, such as white rice and sugary beverages, combined with the frequent use of cooking oil and fried foods. These eating habits, coupled with limited physical activity among women due to predominant domestic roles and a lack of structured exercise culture, likely promote a positive energy balance and fat accumulation, particularly visceral fat, which is strongly associated with hormonal dysregulation. Such metabolic disturbances can interfere with the hypothalamic–pituitary–gonadal (HPG) axis, thereby increasing the risk of irregularities in the menstrual cycle. These findings emphasize that addressing menstrual health issues in rural areas, such as Pamekasan, requires culturally sensitive strategies that incorporate dietary behavior changes within the broader framework of reproductive health interventions.

The dietary and lifestyle patterns identified in Pamekasan offer important contextual explanations for the elevated Body Mass Index (BMI) levels observed among women of reproductive age in this study. The predominance of high-calorie, nutrient-poor food in the local diet—such as white rice, fried snacks, sweetened beverages, and processed side dishes—suggests a pattern consistent with the global trend of the "nutrition transition." This theory, popularized by Barry Popkin, describes a shift in dietary consumption and energy expenditure that accompanies economic development, urbanization, and globalization. In rural Indonesian settings, such as Pamekasan, the transition is not characterized by the adoption of Western diets per se, but by a convergence of traditional starchy staples and industrially processed, energy-dense foods, which are both affordable and culturally ingrained. Although these foods are readily accessible, they lack micronutrients necessary for metabolic and hormonal regulation, particularly iron, vitamin D, and essential fatty acids, all of which play important roles in maintaining reproductive health.

In addition to poor dietary diversity, the study population reflected characteristics consistent with the Energy Availability Hypothesis, which postulates that reproductive function is highly sensitive to the balance between caloric intake and energy expenditure (Shirley et al., 2022). Among the participants, low levels of physical activity, especially among married or caregiving women, may contribute to a chronic positive energy balance, resulting in excess fat accumulation. This surplus energy, particularly when stored as visceral fat, disrupts the secretion of key hormones, such as leptin and insulin, which in turn modulates the hypothalamic-pituitary-gonadal (HPG) axis. Consequently, ovulatory dysfunction and menstrual irregularities are more likely to occur, even in the absence of overt gynecological disease. These mechanisms are corroborated by the findings of this study, which revealed a significantly higher prevalence of menstrual disturbances among overweight and obese respondents.

Thus, the sociocultural environment of Pamekasan, shaped by traditional dietary norms and limited physical mobility, provides a critical lens through which the study results can be interpreted. This underscores the need to move beyond biomedical explanations and consider how metabolic and reproductive outcomes are socially constructed and environmentally mediated. Addressing menstrual cycle disorders in this context, therefore, requires integrative strategies that not only target individual behavior but also reshape food systems, health education, and gendered divisions of labor to improve women's long-term reproductive well-being.

Therefore, the development of community-based health promotion strategies must be participatory, context-specific, and prevention-oriented in nature. Promoting healthy lifestyles, including balanced nutrition, regular physical activity, and menstrual literacy education, should be an integral part of public health programs, particularly targeting adolescent and reproductive-age women. These educational programs should be tailored to local cultural values and practices, as emphasized by the World Health Organization (WHO) through its life-course approach to women's reproductive health (World Health Organization (WHO), 2000).

Additionally, reproductive health services must be integrative and multisectoral. Services should go beyond curative care to include preventive measures such as hormonal and metabolic screenings, nutritional status assessments, and early detection of reproductive-metabolic syndromes such as PCOS and endometriosis, especially in rural and semi-urban areas. Doubova (2013) found that an integrative approach involving general practitioners, endocrinologists, psychologists, and nutritionists significantly reduced the incidence of ovulatory disorders and improved patient satisfaction.

Furthermore, strengthening the primary healthcare system must be prioritized. Starfield et al. (2005) emphasized that a robust primary care system focusing on the early detection and intervention of metabolic risk factors can reduce the burden of chronic reproductive health conditions among women. School- and family based interventions to monitor menstrual changes, along with the integration of digital platforms for cycle tracking and online nutritional consultations, represent innovative community-level solutions (Meherali et al., 2024).

Finally, supportive public policies are essential, particularly those regulating ultra-processed foods, improving access to healthy food, and implementing gender-sensitive nutrition education programs. Without structural support and multisectoral policies, promotive and preventive efforts will struggle to effectively reach vulnerable populations. As noted by Chong et al. (2023), reducing the nutritional burden on women depends not only on individual behavior but also on an enabling environment shaped by economic, social, and food policies.

Conclusion

This study provides strong empirical evidence of a significant association between Body Mass Index (BMI) and menstrual cycle disorders among women of reproductive age in Pamekasan Regency. An increase in BMI, particularly in the overweight and obese categories, was correlated with a higher prevalence of menstrual irregularities. These findings affirm that obesity is not merely a metabolic issue but a critical determinant of reproductive health, particularly in relation to ovulatory function and menstrual regularity.

These results highlight the urgent need to strengthen reproductive health programs in Pamekasan, with the prevention and management of obesity as a top priority. Continuous health promotion and education efforts must be emphasized to raise awareness among women of reproductive age regarding the importance of maintaining an ideal body weight. These strategies can be implemented through community-based outreach, utilizing local cultural approaches, mass media, and the active involvement of community groups to effectively reach the target populations.

Additionally, reproductive health services should be designed to be more comprehensive and accessible. Community health centers (Puskesmas), as the frontline of primary healthcare, can serve as hubs for integrated services, such as routine BMI assessments, nutritional counseling, and psychosocial support to assist with lifestyle changes. Effective implementation requires capacity building for healthcare workers to provide accurate education and facilitate referrals when necessary. Cross-sector collaboration, including partnerships with civil society organizations, women's groups, and religious leaders, is essential for fostering a supportive social environment for behavioral change and improved reproductive health.

Thus, this study not only contributes to the scientific understanding of the relationship between BMI and menstrual cycle but also serves as a strong foundation for developing contextually relevant, effective local policies that empower women to manage their reproductive health independently and sustainably.

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