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Association of blood glucose levels and body mass index with menstrual cycle patterns among female medical students at Universitas Syiah Kuala

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Abstract

Background: Menstrual cycle disorders are prevalent among women of reproductive age and may be influenced by nutritional and metabolic factors. Body mass index (BMI) and blood glucose levels play important roles in hormonal regulation and reproductive function.

Objective: This study examined the association between blood glucose levels and body mass index with menstrual cycle patterns among female medical students at Universitas Syiah Kuala.

Methods: An analytical cross-sectional study was conducted among 249 female medical students from the 2022–2024 cohorts using quota sampling. Data were collected from 8 - 16 September 2025. Menstrual cycle patterns were assessed using an online menstrual diary based on International Federation of Gynecology and Obstetrics criteria. Blood glucose levels were measured using random blood glucose testing, and BMI was calculated from measured weight and height. Associations were analyzed using Spearman rank correlation and ordinal logistic regression.

Results: Most participants had normal blood glucose levels (61.8%) and normal BMI (44.6%). Normal menstrual cycles were reported by 57% of participants. Blood glucose levels were significantly associated with menstrual cycle patterns ($p = 0.022$; $r_s = 0.145$). BMI was also significantly associated with menstrual cycle patterns ($p = 0.038$; $r_s = 0.132$). The correlation coefficients indicated weak positive relationships between blood glucose levels and BMI with menstrual cycle. Multivariate analysis showed that BMI (OR = 5.06) had a stronger association with menstrual cycle disturbances than blood glucose levels (OR = 4.66).

Conclusion: Blood glucose levels and body mass index are significantly associated with menstrual cycle patterns, with BMI identified as the dominant factor. Maintaining optimal nutritional and metabolic status may support menstrual health in young women.

Keywords: body mass index, blood glucose, menstrual cycle

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Introduction

Puberty is a complex developmental phase involving physiological, morphological, and psychological changes that occur naturally. In adolescent girls, puberty is marked by menarche, which represents the onset of the menstrual cycle and reflects maturation of the reproductive system.[1] However, menstrual cycle disorders remain a common reproductive health problem among women of reproductive age worldwide. The World Health Organization reported that the global prevalence of menstrual cycle irregularities reaches approximately 38.45%, indicating a substantial public health concern.[2] In Indonesia, data from the 2018 National Basic Health Research (Riskesdas) showed that 11.7% of adolescent girls experienced irregular menstruation.[3]

Menstrual cycle irregularities are multifactorial in nature. Hormonal imbalance, psychological stress, unhealthy dietary patterns, and certain medical conditions affecting reproductive function have been identified as contributing factors.[4] In addition, metabolic status and nutritional status commonly assessed through blood glucose levels and body mass index (BMI) play crucial roles in regulating reproductive hormones.[5] Disruption in metabolic homeostasis may interfere with the hypothalamic–pituitary–ovarian (HPO) axis, leading to alterations in ovulation and menstrual regularity.[6]

Abnormal blood glucose levels can be broadly categorized into hyperglycemia and hypoglycemia. Hyperglycemia, defined as elevated blood glucose beyond normal limits, is a hallmark of diabetes mellitus.[7] According to the World Health Organization, the number of individuals with diabetes mellitus in Indonesia is projected to increase from 8.4 million in 2000 to 21.3 million by 2030, with a potential two- to threefold increase by 2035. Data from Riskesdas 2013 reported a diabetes mellitus prevalence of 2.1% among individuals aged 15 years and older, highlighting the growing burden of metabolic disorders in young and productive populations.[8]

Nutritional status, as reflected by BMI, is another important determinant of reproductive health.[9] Riskesdas 2018 reported that among adults aged over 18 years in Indonesia, 9.3% were underweight, 13.6% were overweight, and 21.8% were obese.[3] Furthermore, inadequate dietary intake remains prevalent; approximately 95.7% of individuals aged 20–24 years did not meet recommended fiber intake, while nearly half of the population consumed high-fat foods one to six times per week. These dietary patterns contribute to nutritional imbalance and increase the risk of metabolic disturbances, including abnormal BMI and impaired glucose regulation.[3]

Several studies have demonstrated a potential association between blood glucose levels and menstrual cycle disturbances. Elevated blood glucose may affect ovulatory function and hormonal balance, thereby increasing the risk of menstrual irregularities. Previous research reported that women with abnormal blood glucose levels had a significantly higher risk of experiencing menstrual cycle disorders.[10] Similarly, abnormal BMI both underweight and overweight/obesity has been linked to menstrual irregularities through mechanisms involving altered estrogen production, insulin resistance, and ovarian dysfunction. Nevertheless, findings across studies remain inconsistent, with some reporting no significant association between BMI and menstrual cycle patterns.[11]

Given the increasing prevalence of metabolic disorders and nutritional imbalance among young women, particularly university students, further investigation is warranted. Medical students are particularly vulnerable to metabolic and reproductive health disturbances due to high academic demands, irregular sleep patterns, psychological stress, and inconsistent dietary habits. These factors may contribute to metabolic dysregulation,

including impaired glucose metabolism and abnormal body mass index, which in turn can disrupt hormonal balance and menstrual function. Given that menstrual irregularities may reflect underlying endocrine or metabolic disturbances, early identification of these risk factors in medical students is essential to prevent long-term reproductive and metabolic complications.[12] Therefore, this study aimed to examine the association between blood glucose levels and body mass index with menstrual cycle patterns among female medical students at Universitas Syiah Kuala, with the expectation that the findings may contribute to early preventive strategies in reproductive and nutritional health.

Methods

This study employed an analytical observational design with a cross-sectional approach. The research was conducted at the Medical Education Program, Faculty of Medicine, Universitas Syiah Kuala, from 8 to 16 September 2025. The study population consisted of all active female medical students from the 2022, 2023, and 2024 cohorts, totaling 510 students. The sample size was determined using the Slovin formula with a 5% margin of error, resulting in a minimum required sample of 249 participants. Quota sampling was applied to ensure proportional representation from each cohort. The sampling technique employed in this study was quota sampling, selected due to limited access to a comprehensive population sampling frame. In addition, this method enabled the researchers to ensure proportional representation across each academic cohort. Although quota sampling is categorized as a non-probability sampling technique, the determination of quotas was based on the actual population distribution, thereby minimizing the potential for selection bias.

Inclusion criteria were active female medical students from the 2022–2024 cohorts who agreed to participate in the study. Exclusion criteria included participants who were currently using hormonal medications (such as clomiphene, progestin, oral contraceptive pills, metformin, bromocriptine, or gonadotropins), had a physician-diagnosed reproductive system disorder (including cervical cancer, ovarian tumors, polycystic ovary syndrome, or endometriosis), were married, or had moderate to high stress levels based on the Depression Anxiety Stress Scale–42 (DASS-42).

This study was approved by the Ethics Committee of Universitas Syiah Kuala (Ethical Approval No. 175/EA/FK/2025). All participants provided informed consent prior to data collection, and confidentiality of personal data was strictly maintained. Primary data were collected through both questionnaire-based and direct measurements. Menstrual cycle patterns were assessed using an online menstrual diary form based on the International Federation of Gynecology and Obstetrics (FIGO) menstrual cycle parameters. The menstrual cycle was classified as normal, frequent (<24 days), infrequent (>38 days), or amenorrhea (absence of menstruation).[13]

Blood glucose levels were measured directly using random blood glucose testing and classified according to national and international guidelines as normal (<140 mg/dL), prediabetes (140–199 mg/dL), or diabetes (≥200 mg/dL).[14] Body weight and height were measured directly using standardized instruments, and body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). BMI was categorized according to the Asia-Pacific classification into underweight (<18.5 kg/m^2), normal (18.5–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2), obesity class I (25.0–29.9 kg/m^2), and obesity class II (≥30.0 kg/m^2).[15]

The instrument used to measure and interpret blood glucose levels was the Sinocare Gluco Check device, which has demonstrated validity and reliability in assessing blood glucose concentrations.[16] To ensure measurement validity, the Sinocare Gluco Check device was calibrated according to the manufacturer's standard operating procedures before data collection commenced.

Body weight and height were measured to determine Body Mass Index (BMI) categories using the following instruments:

a. A calibrated GEA digital weighing scale, measured in kilograms (kg).
b. A GEA stature meter for height measurement, with a precision of 0.1 cm.

Menstrual cycle assessment was conducted using the menstrual parameter criteria established by the International Federation of Gynecology and Obstetrics (FIGO). Data were collected through a self-administered Google Form questionnaire. The menstrual cycle was evaluated over the previous three months to determine whether it was normal or abnormal. Assessment was based on several key parameters, including frequency, regularity, duration of bleeding, and volume of bleeding. In this context, cycle frequency was defined as the interval from the first day of the last menstrual period to the first day of the subsequent menstrual period. According to FIGO criteria, a normal menstrual cycle ranges from 24 to 38 days. In the ordinal logistic regression model, menstrual cycle categories were coded numerically in ascending order based on clinical severity (1 = normal, 2 = frequent, 3 = infrequent, and 4 = amenorrhea). Higher category values represented increasing severity of menstrual disturbance.

The Depression Anxiety Stress Scales (DASS-42) questionnaire was administered in the form of a Google Form to measure respondents' stress levels. The instrument was included alongside the informed consent form to ensure appropriate participant selection based on the predefined inclusion and exclusion criteria.

This study was conducted with the assistance of six enumerators, who were 2022 cohort medical students from the Undergraduate Medical Education Program and were not included as research participants. Both the principal investigator and the enumerators had a clear and comprehensive understanding of the procedures for blood glucose testing and anthropometric measurements (body weight and height). This competency was obtained through a structured Training of Trainers (ToT) program conducted as part of a community service initiative organized by the Faculty of Medicine, Universitas Syiah Kuala.

This study has a limitation in that blood glucose levels were measured only once using a random assessment, which may not fully represent the participants' long-term metabolic status.

Data were analyzed using statistical software. Univariate analysis was conducted to describe the distribution of respondent characteristics (age and academic cohort), blood glucose levels, BMI, and menstrual cycle patterns. Bivariate analysis was performed using Spearman rank correlation to assess the association between blood glucose levels and BMI with menstrual cycle patterns. Variables with significant associations were further analyzed using multivariate ordinal logistic regression to determine the dominant factor associated with menstrual cycle disturbances.[16] Statistical significance was set at $p < 0.05$.

Results

The results of this study are presented according to the characteristics and frequency distribution of blood glucose levels, body mass index, and menstrual cycle patterns.

Table 1. Frequency distribution of respondents

Variable	Frequency (n=249)	Percentage (%)
Age (years)		
17	2	1
18	28	11
19	63	25
20	91	37
21	52	21
22	13	5
Cohort Year		
2022	97	39
2023	64	26
2024	88	35
Blood Glucose Level		
Normal (< 140 mg/dL)	154	61.8
Prediabetes (140-199 mg/dL)	63	25.3
Diabetes (≥ 200 mg/dL)	32	12.9
Body Mass Index (BMI)		
Underweight (<18,5)	27	10.8
Normal (18,5-22,9)	111	44.6
Overweight (23-24,9)	34	13.7
Obesity class I (25-29,9)	48	19.3
Obesity class II (≥30)	29	11.6
Menstrual Cycle		
Normal	142	57
Frequent (<24 days)	33	13.3
Infrequent (>38 days)	52	20.9
Amenorrhea (absence of menstruation)	22	8.8

Based on **Table 1**, most respondents were 20 years old, accounting for 91 participants (37%), and the majority were from the 2022 cohort (39%). The number of respondents in each cohort was determined according to sample size calculations and adjusted to the population proportion of each cohort. Based on random blood glucose measurements, most respondents had normal blood glucose levels, totaling 154 participants (61.8%), while 38.2% had abnormal blood glucose levels, classified as prediabetes or diabetes. The largest proportion of participants had a normal body mass index, comprising 111 participants (44.6%). However, 55.4% of respondents had abnormal BMI, including underweight, overweight, and obesity class I–II, indicating that more than half of the study population was at risk of body weight imbalance. Normal menstrual cycle patterns were the most common, reported by 142 participants (57%).

Table 2. Association of blood glucose levels and body mass index with menstrual cycle

Variable	Menstrual Cycle								Total		Spearman rank	
	Normal		Frequent		Infrequent		Amenorrhea				rs	p value
	n	%	n	%	n	%	n	%	n	%		
Blood Glucose												
Normal	110	71.4	13	8.4	23	14.9	8	5.2	154	100	0.145	0.022
Prediabetes	25	39.7	13	20.6	19	30.2	6	9.5	63	100		
Diabetes	7	21.9	7	21.9	10	31.3	8	25.0	32	100		
BMI												
Underweight	15	55.6	3	11.1	6	22.2	3	11.1	27	100		
Normal weight	84	75.7	10	9.0	14	12.6	3	2.7	111	100		
Overweight	17	50.0	4	11.8	10	29.4	3	8.8	34	100	0.132	0.038
Obesity class I	18	37.5	11	22.9	13	27.1	6	12.5	48	100		
Obesity class II	8	27.6	5	17.2	9	31.0	7	24.2	29	100		

Table 2 shows that 110 participants (71.4%) with normal blood glucose levels had normal menstrual cycles. Spearman correlation analysis revealed a statistically significant association between blood glucose levels and menstrual cycle patterns ($p = 0.022$; $r_s = 0.145$), indicating a positive correlation. The correlation coefficient ($r = 0.145$) indicates a weak positive relationship between blood glucose levels and menstrual cycle, although the association was statistically significant ($p < 0.05$). This finding suggests that higher blood glucose levels are associated with an increased likelihood of menstrual cycle irregularities among female students. Menstrual cycle categories were coded numerically in ascending order based on clinical severity (1=normal, 2=frequent, 3=infrequent, and 4=amenorrhea). Higher category values represented increasing severity of menstrual disturbance.

Regarding body mass index, 84 participants (75.7%) with normal BMI had normal menstrual cycles, while 31% of participants with obesity class II experienced infrequent menstrual cycles. Spearman rank correlation analysis demonstrated a statistically significant association between BMI and menstrual cycle patterns ($p = 0.038$; $r_s = 0.132$). The correlation coefficient ($r = 0.132$) indicates a weak positive relationship between BMI and menstrual cycle, although the association was statistically significant ($p < 0.05$). The positive direction of the association indicates that abnormal BMI is associated with a greater tendency toward menstrual cycle disturbances.

Table 3. Multivariable ordinal regression analysis

Variable	Coefficient (B)	OR	95% CI for OR	p value
Blood Glucose Level	1.538	4.66	2.13 – 10.17	<0.001
Body Mass Index	1.621	5.06	2.17 – 11.57	<0.001

Table 3 shows that both blood glucose levels and body mass index were significantly associated with menstrual cycle patterns ($p < 0.05$). The odds ratio (OR) for blood glucose levels was 4.66, indicating that participants with abnormal blood glucose levels had a 4.66-fold greater likelihood of experiencing menstrual cycle disturbances compared with those with normal blood glucose levels. Meanwhile, the OR for BMI was 5.06, suggesting that higher BMI increased the odds of menstrual cycle disturbances by 5.06 times. The confidence interval did not cross 1.0, confirming the statistical significance and suggesting a meaningful strength of association. Both blood glucose level and BMI demonstrated strong positive associations with menstrual cycle disturbances, as reflected

by odds ratios greater than 4.0. Among the two variables, BMI showed a slightly higher odds ratio, indicating a relatively stronger association with menstrual cycle irregularities in this study population.

Discussion

This study investigated the association between blood glucose levels and body mass index with menstrual cycle patterns among female medical students at Universitas Syiah Kuala. The findings demonstrated that both metabolic status, reflected by blood glucose levels, and nutritional status, assessed through BMI, were significantly associated with menstrual cycle disturbances. Notably, body mass index showed a stronger association than blood glucose levels in multivariate analysis.[11]

The majority of participants were aged 17–22 years, with most in late adolescence.[17] At this stage of development, the female reproductive system has generally achieved hormonal maturity, which is expected to support regular menstrual cycles. The relative homogeneity of age in this study reduces potential confounding related to reproductive aging and strengthens the internal validity of the findings. Similar age distributions have been reported in previous studies among female medical students, indicating that menstrual and metabolic health concerns remain relevant even in young, educated populations.[18]

Most participants had normal blood glucose levels; however, more than one-third were classified as having prediabetes or diabetes.[14] This finding highlights an important public health concern, as metabolic disturbances are increasingly observed among young adults.[19] Lifestyle factors commonly encountered in university settings, such as irregular eating patterns, high consumption of energy-dense foods, limited physical activity, and academic stress, may contribute to impaired glucose regulation.[20] The relatively high proportion of abnormal blood glucose levels observed in this study underscores the need for early metabolic screening in young women.[21]

This study found a significant positive association between blood glucose levels and menstrual cycle disturbances. The Spearman correlation test demonstrated a statistically significant association between blood glucose levels and menstrual cycle patterns among female students ($p = 0.022$; $p < 0.05$), with a correlation coefficient of $rs = 0.145$. This finding indicates a significant yet weak positive relationship between the two variables. Participants with higher blood glucose levels were more likely to experience abnormal menstrual cycles, including infrequent cycles and amenorrhea.[22] This finding is consistent with previous studies reporting that abnormal glucose metabolism increases the risk of menstrual irregularities.[23] From a physiological perspective, hyperglycemia is closely linked to insulin resistance, which plays a key role in reproductive endocrinology. Insulin resistance leads to compensatory hyperinsulinemia, which can stimulate ovarian androgen production and disrupt follicular development, thereby impairing ovulation and menstrual regularity.[24]

Additionally, chronic hyperglycemia may interfere with the hypothalamic–pituitary–ovarian axis by altering gonadotropin secretion and reducing estrogen receptor expression.[25] Oxidative stress induced by elevated glucose levels has been suggested to impair hormonal signaling pathways essential for normal menstrual regulation.[26] These mechanisms provide a plausible biological explanation for the observed association between blood glucose levels and menstrual cycle disturbances in this study.[27]

Body mass index was also significantly associated with menstrual cycle patterns, with abnormal BMI increasing the likelihood of menstrual irregularities.[28] The statistical analysis yielded a p-value of 0.038 and a Spearman correlation coefficient (rs) of 0.132. These results indicate a statistically significant association between the two variables, with the strength of correlation classified as weak. Participants with normal BMI showed the highest proportion of regular menstrual cycles, supporting the role of balanced nutritional status in maintaining reproductive hormonal stability. In contrast, both underweight and overweight/obese participants exhibited higher rates of menstrual disturbances.[29]

In individuals with overweight and obesity, excess adipose tissue increases peripheral aromatization of androgens to estrogens, leading to hormonal imbalance and disrupted feedback mechanisms within the hypothalamic–pituitary–ovarian axis.[15] Obesity is also strongly associated with insulin resistance, further exacerbating hormonal dysregulation and increasing the risk of ovulatory dysfunction. These mechanisms may explain the higher prevalence of infrequent menstrual cycles and amenorrhea observed among participants with obesity in this study.[30]

Conversely, underweight participants also demonstrated a tendency toward menstrual irregularities.[6] Insufficient body fat reduces estrogen production, which may suppress gonadotropin-releasing hormone secretion and subsequently decrease luteinizing hormone and follicle-stimulating hormone levels.[31] This hormonal suppression can impair follicular maturation and ovulation, leading to irregular or absent menstruation. These findings highlight that both extremes of nutritional status can negatively affect menstrual health.[32]

A more critical comparison with previous studies reveals both consistencies and inconsistencies in findings regarding the association between BMI and menstrual cycle patterns. Several studies have reported that elevated BMI is significantly associated with menstrual irregularities, potentially due to altered estrogen production, insulin resistance, and disruption of the hypothalamic–pituitary–ovarian axis. However, other studies have found no significant relationship, suggesting that the association may be influenced by differences in study design, population characteristics, sample size, lifestyle factors, and methods used to classify menstrual abnormalities. These discrepancies highlight the multifactorial nature of menstrual cycle regulation and indicate that BMI alone may not fully explain variations in menstrual patterns across different populations.

Multivariate analysis revealed that BMI had a stronger association with menstrual cycle disturbances than blood glucose levels. This suggests that nutritional status may play a more dominant role in influencing menstrual regularity among young women.[33] While blood glucose levels reflect metabolic function at a given time, BMI represents longer-term nutritional and energy balance, which may exert a more sustained effect on reproductive hormonal regulation.[34]

The findings of this study have important implications for reproductive and nutritional health promotion among female university students.[35] Early identification of abnormal BMI and impaired glucose regulation may allow for timely lifestyle interventions aimed at improving dietary habits, physical activity, and metabolic health.[36] Such interventions may contribute not only to the prevention of metabolic diseases but also to the preservation of normal menstrual function and overall reproductive health.[37]

Several limitations should be considered when interpreting these findings. The cross-sectional design precludes causal inference, and blood glucose levels were assessed using a single random measurement, which may not fully capture long-term glycemic status.[38]

Additionally, other potential confounding factors such as detailed dietary intake, physical activity levels, and sleep patterns were not assessed.[39] Future studies are encouraged to incorporate longitudinal designs, repeated metabolic measurements, and more comprehensive lifestyle assessments to better elucidate causal relationships.[40]

Conclusion

This study demonstrates that both blood glucose levels and body mass index are significantly associated with menstrual cycle patterns among female medical students at Universitas Syiah Kuala with the strength of correlation classified as weak. Participants with elevated blood glucose levels were more likely to experience menstrual cycle disturbances, indicating the role of metabolic dysregulation in reproductive health. Similarly, abnormal body mass index, including both underweight and overweight/obesity, was associated with an increased likelihood of menstrual irregularities.

Multivariate analysis revealed that body mass index had a stronger association with menstrual cycle disturbances compared to blood glucose levels, suggesting that long-term nutritional status plays a dominant role in influencing menstrual regularity. These findings highlight the importance of maintaining balanced nutritional status and metabolic health to support normal reproductive function in young women.

Recommendation

1. For Female Students : Female university students are encouraged to adopt healthy dietary patterns, engage in regular physical activity, and maintain a balanced lifestyle to support normal body mass index and stable blood glucose levels, thereby promoting regular menstrual cycles.
2. For Educational Institutions and Campus Health Services: Universities and campus health providers should implement routine health education programs focusing on reproductive health, nutrition, and metabolic screening, including body mass index assessment and basic glucose monitoring, to enable early detection and prevention of menstrual cycle disturbances.
3. For Healthcare Providers: Healthcare professionals should consider metabolic factors and nutritional status during the initial assessment of menstrual cycle disorders, as early identification may allow for more targeted and effective interventions.
4. For Future Research: Future studies are recommended to include repeated or longitudinal blood glucose measurements, additional metabolic parameters, and more diverse study populations to improve generalizability. Given the relatively high prevalence of prediabetes and diabetes observed in this study, further research is needed to explore metabolic risk factors for diabetes mellitus among young women.

Conflict of interest

There was no conflict of interest related to this research. The authors have no personal or financial relationship that could influence the judgment or action.

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Author's contribution

ASBM contributed to conceptualization, study design, data acquisition, formal analysis, interpretation of the results, and drafting of the manuscript; H contributed to supervision, methodological guidance, and critical revision of the manuscript for important intellectual content; NS contributed to data interpretation, validation of the analysis, and critical manuscript review; DM contributed to supervision, academic guidance, and substantial revision of the manuscript; CRM contributed to overall research supervision, critical intellectual input, and final approval of the version to be published.

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