ISSN: 3032-3134 (ONLINE)
InaJBCS | Indonesian Journal of Biomedicine and Clinical Sciences

Association of sleep quality and body mass index (BMI) with metabolic syndrome risk factors among medical students

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https://doi.org/10.22146/inajbcs.v57i3.19259

Submitted: 2025-01-10
Accepted : 2025-06-12

ABSTRACT

Sleep quality reflects an individual's satisfaction with the sleep process, which is essential for cognitive, psychological, metabolic, and cardiovascular health. Poor sleep quality is prevalent among medical students and may elevate their risk of metabolic syndrome. This study investigated the association between sleep quality and body mass index (BMI) with metabolic syndrome risk factors in medical students. This was a cross-sectional study involving 98 first- to third-year preclinical medical students. Sleep quality was assessed by using the Pittsburgh sleep quality index (PSQI) questionnaire, BMI was measured from body weight and height, and metabolic syndrome risk factors were evaluated through waist circumference, blood pressure, fasting blood glucose, and high-density lipoprotein (HDL) cholesterol levels. Data was analyzed using Chi square and Fisher's exact test. Results showed that 54.08% of students had good sleep quality and 42.86% had a normal BMI. However, 59.18% of students exhibited at least one metabolic syndrome risk factor, including central obesity (51.02%), hypertension (20.41%), dyslipidemia (13.27%), and high fasting blood glucose (1.02%). There was no association between sleep quality and metabolic syndrome risk factors. The BMI showed no association with fasting blood glucose and HDL cholesterol level. However, BMI showed a significant association with waist circumference ($p<0.001$) and blood pressure ($p = 0.005$). These findings emphasize the importance of addressing the MBI in mitigating metabolic syndrome risks among medical students.

ABSTRAK

Kualitas tidur mencerminkan tingkat kepuasan individu terhadap proses tidur, yang penting untuk kesehatan kognitif, psikologis, metabolik, dan kardiovaskular. Kualitas tidur yang buruk umum terjadi pada mahasiswa kedokteran dan dapat meningkatkan risiko sindrom metabolik. Penelitian ini bertujuan untuk menganalisis hubungan antara kualitas tidur dan indeks massa tubuh (IMT) dengan faktor risiko sindrom metabolik pada mahasiswa kedokteran. Penelitian ini menggunakan desain potong lintang yang melibatkan 98 mahasiswa kedokteran preklinik tahun pertama hingga ketiga. Kualitas tidur diukur menggunakan kuesioner *Pittsburgh Sleep Quality Index* (PSQI), IMT dihitung dari berat badan dan tinggi badan, sedangkan faktor risiko sindrom metabolik dinilai melalui lingkar pinggang, tekanan darah, kadar gula darah puasa, dan kadar kolesterol *high-density lipoprotein* (HDL). Data dianalisis menggunakan uji *Chi-square* dan Fisher's *exact*. Hasil penelitian menunjukkan bahwa 54,08% mahasiswa memiliki kualitas tidur yang baik dan 42,86% memiliki IMT normal. Namun, 59,18% mahassiwa menunjukkan minimal satu faktor risiko sindrom metabolik, termasuk obesitas sentral (51,02%), hipertensi (20,41%), dislipidemia (13,27%), dan kadar gula darah puasa tinggi (1,02%). Kualitas tidur tidak menunjukkan hubungan signifikan dengan faktor risiko sindrom metabolik. Indeks massa tubuh juga tidak memiliki hubungan signifikan dengan kadar gula darah puasa dan kolesterol HDL, namun menunjukkan hubungan yang signifikan dengan lingkar pinggang ($p<0,001$) dan tekanan darah ($p=0,005$). Temuan ini menekankan pentingnya perhatian terhadap IMT dalam mengurangi risiko sindrom metabolik pada mahasiswa kedokteran.

Keywords:
BMI;
metabolic syndrome;
PSQI;
sleep quality;
medical student

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INTRODUCTION

Sleep quality reflects an individual's satisfaction with all aspects of the sleep process, which is essential for cognitive, psychological, metabolic, and cardiovascular health.[1] It was reported, 28.98% of the global population experiences sleep disturbances, which negatively impact sleep quality.[2] Poor sleep quality is strongly associated with an increased risk of metabolic syndrome due to sympathetic activation leading to elevated catecholamine levels, alterations in the HPA axis resulting in increased cortisol levels, oxidative stress causing higher levels of reactive oxygen species (ROS), and activation of inflammatory pathways leading to elevated levels of IL-6 and TNF-α. These conditions induce insulin resistance and pancreatic β-cell dysfunction, ultimately resulting in type 2 diabetes mellitus (T2DM), hypertension, cardiovascular disease risk, and obesity.[3]

Poor sleep quality among medical students has been reported in various university across countries. In Karachi Pakistan, 96.3% of medical students in Public Sector Medical Colleges had poor sleep quality,[4] whereas in Ghanaian university, 54.1% had poor sleep quality and its associated with metabolic syndrome.[5] Poor sleep quality affected 66.6% among the university students in Bangladesh,[6] and 62.7% in Saudi Arabia university students.[7] In addition, the prevalence of metabolic syndrome has increased significantly among medical students. Lavalle *et al.*,[8] reported that the prevalence of metabolic syndrome among medical students increased by 4.7% with 76.4% of them having at least one associated risk factor.

Metabolic syndrome is a cluster of conditions that occur together leading to the risk of heart disease, stroke, and T2DM. These includes abdominal obesity, high blood pressure, high blood sugar, high triglyceride, and low high-density lipoprotein (HDL). Someone who has three or more of these risk factors indicates metabolic syndrome. For the assessment of dyslipidemia, HDL levels were often used as the primary variable. It was chosen instead of triglycerides or a combination of both due to cost considerations. Moreover, it is proven that HDL is involved in reverse cholesterol transport and plays a cardioprotective role, including the regulation of immune function.[9-10]

Body mass index (BMI), as a primary indicator of general obesity, is often identified as a key determinant of metabolic syndrome risk.[10] Marcus *et al.*,[11] reported that an increase in BMI is directly associated with risk factors of metabolic syndrome, including hypertension, hyperglycemic, and low HDL cholesterol levels.

This study aimed to investigate the association between sleep quality and BMI with risk factors of metabolic syndrome among medical students. Medical students represent a relevant population for this research due to specific stressors, such as academic pressure and demanding coursework. These factors often lead to reduced sleep as a coping mechanism, which may predispose them to both poor sleep quality and an increased risk of metabolic syndrome.[12]

MATERIAL AND METHODS

Research subjects

This cross-sectional study used probability proportional to size (PPS) sampling from the name list based on the inclusion and exclusion criteria. A total of 609 preclinical medical students at the School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta were recruited. Among 522 students (85.71% response rate) were willing to participate in this study, after completing the questionnaire and signing the informed consent, 121 students were excluded due to not meet

the inclusion. Furthermore, among 401 students who meet the inclusion criteria, 98 students, minimal sample based on Lemeshow's rule, were involved in this study. The inclusion criteria were active preclinical medical students at the first to third year, willing to participate in the study by signing the informed consent. The exclusion criteria were students with a history of autoimmune diseases, depression, drug abuse patients, diabetes mellitus, cardiopulmonary diseases, dyslipidemia, smoking history, and pregnancy. The protocol for this study was approved by the Medical and Health Research Ethics Committee of the School of Medicine and Health Science, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia with reference number 02/02/KEP-FKIKUAJ/2024.

Selected respondents were given detailed explanations and preparation guidelines prior to the study. Respondents were instructed to fast for 10–12 hr before the day of data collection to facilitate blood sample analysis. The data collection schedule was coordinated with the participants' academic calendar to ensure convenience and minimize disruption.

Anthropometric data collection

Anthropometric data were measured including body height (m), weight (kg), and waist circumference (cm). The BMI criteria were based on the Asia-Pacific Body Mass Index classification. The subjects were grouped into four categories: underweight (BMI < 18.5 kg/m^2), normal (BMI 18.5-22.9 kg/m^2), overweight (BMI 23-24.9 kg/m^2), and obese (BMI ≥ 25 kg/m^2). A wall-mounted stadiometer as a measurement tool to assess respondents' height was used. The stadiometer is a gold standard from the World Health Organization and the Centers for Disease Control and Prevention to assess height.[13] A standing scale was used to measure respondents' weight. The standing scale is a gold standard for body weight measurement.[14] Waist circumference was measured using a measuring tape placed at the level of the iliac crest, in a horizontal plane around the abdomen. Before measurement, it was made sure the tape is snug and doesn't compress the skin.[15]

The metabolic syndrome criteria were determined based on the Joint Interim Statement (JIS) of the International Diabetes Federation Task Force on Epidemiology and Prevention, the National Heart, Lung, and Blood Institute, the American Heart Association; World Heart Federation, the International Atherosclerosis Society, and the International Association for the Study of Obesity in 2009. Three abnormal findings out of five confirmed the diagnosis of metabolic syndrome.[16] The detail criteria to diagnose the metabolic syndrome according to JIS are elevated waist circumference (specific by population, in Asian, men ≥ 90 cm, women ≥ 80 cm), elevated triglycerides ≥ 150 mg/dL, reduced HDL-C < 40 mg/dL (in males), < 50 mg/dL (in females), elevated blood pressure (systolic ≥ 130 mmHg and/or diastolic ≥ 85 mmHg), elevated fasting glucose ≥ 100 mg/dL. In 2024, the criteria have been renewed (recommendation from the National Heart, Lung and Blood Institute/American Heart Association), where there are at least 3 organizations have suggested the criteria to diagnose metabolic syndrome. All criteria were similar in many aspects, with only a little difference in cutoff values. The differences in criteria can be seen in the ATP III (Adult Treatment Panel III) recommendation, which includes a waist circumference of >102 cm for men and >88 cm for women, and a fasting blood glucose cutoff value of 110 mg/dL. In contrast, the WHO recommendation includes blood pressure criteria of systolic ≥140 mmHg or diastolic ≥90 mmHg, HDL cholesterol <35 mg/dL in men and <39

mg/dL in women, as well as additional variables such as insulin resistance, BMI, and urinary albumin excretion rate.[16] Blood pressure was measured using an aneroid sphygmomanometer, with two measurement taken 1-min interval.

Assessment of sleep quality

Sleep quality was assessed by using the Pittsburgh sleep quality index (PSQI) questionnaire. The PSQI contains 19 self-rated questions. The 19 self-rated questions are combined to form seven component scores. Each component's scores have a score from 0 (indicates no difficulty) to 3 (indicates severe difficulty), with total scores ranging from 0 (minimum score) to 21 (maximum score). The 7 components of PSQI consists of duration of sleep, sleep disturbances, sleep latency, day dysfunction due to sleepiness, sleep efficiency, overall sleep quality, and need meds to sleep. Cut off scoring for PSQI is 0 to 5, indicating good quality of sleep, and > 5, poor quality of sleep. The questions used to track respondents' sleep patterns over the last month.[17] After obtaining informed consent, the participants were instructed to track their sleep patterns and other specified parameters outlined in the questionnaire.[17]

Laboratory analysis

Laboratory examinations included fasting blood glucose and lipid profile (HDL levels) by using participants' venous blood samples. Fasting blood glucose levels were measured by the Hexokinase method, while HDL levels were measured by using the direct method. The blood sample collection and examination were conducted with the assistance of the certified personnel from a trusted, up-to-date clinic laboratory with a minimum qualification of a diploma in health analysis or nursing and possessing certification as a phlebotomist. Laboratory analyses were performed using an automated clinical chemistry analyzer (Indiko, model no. 864000000788, calibrated).

Statistical analysis

A descriptive analysis was conducted to illustrate the sample distribution based on various characteristics. Data were analyzed with bivariate statistical tests using the Chi-square test or Fisher's exact test. The Chi-square test was used when the sample size was large and the expected frequency in each table cell was ≥ 5. In contrast, Fisher's exact test was used when sample size was small or when any expected cell count fell < 5, as it calculates an exact p-value and does not rely on the same assumptions as the Chi-square test. p-value < 0.05 was statistically significant. Statistical analysis was conducted using the Statistical Software for Data Science (STATA) version 15.0 application.

RESULTS

Subjects characteristics

TABLE 1 presented the basic demographics of the respondents. A total of 98 preclinical medical students consisting of 68 female (69.39%) and 30 male (30.61%) were involved in this study. The respondents were evenly distributed across all academic years.

Majority of respondents (54.08%) had good sleep quality with a PSQI of 5.37±1.74 (TABLE 2). Mostly of poor sleep quality was reported among female respondents (34 (75.56%). The majority of male medical students (56.67%) had waist circumferences above the normal threshold, while most female medical students (51.47%) had waist circumferences within the normal range. The majority of medical students, both male and female, had blood pressure, HDL cholesterol levels, fasting blood glucose levels, and BMI within normal limits (TABLE 2).

TABLE 1. Basic demographics of respondents (n=98)

Variables	Frequency	%
Gender		
• Male	30	30.61
• Female	68	69.39
Study phase		
• First year	29	29.59
• Second year	37	37.76
• Third year	32	32.65

TABLE 2. Sleep quality, metabolic syndrome risk factors, and BMI of respondents (n=98)

Variables	Mean ± SD	Frequency [n (%)]		
		Male	Female	Total
Sleep quality	5.37 ± 1.74	-	-	-
• Good	-	19 (35.85)	34 (64.15)	53 (54.08)
• Poor	-	11 (24.44)	34 (75.56)	45 (45.92)
Waist circumference	84.18 ± 11.99	-	-	-
• <90 / <80 cm (male/female)	-	13 (43.33)	35 (51.47)	48 (48.98)
• ≥90 / ≥80 cm (male/female)	-	17 (56.67)	33 (48.53)	50 (51.02)
Blood pressure	116.69±13.5 & 74.62±8.94	-	-	-
• SBP/DBP (<130 and/or <85 mmHg)	-	18 (60.0)	60 (88.24)	78 (79.6)
• SBP/DBP (≥130 and/or ≥85 mmHg)	-	12 (40.0)	8 (11.76)	20 (20.4)
Fasting blood glucose	84.70±22.08	-	-	-
• < 100 mg/dL	-	30 (100)	67 (98.53)	97 (98.98)
• ≥ 100 mg/dL	-	0 (0)	1 (1.47)	1 (1.02)
HDL level	60.41±14.26	-	-	-
• ≥ 40 / ≥ 50 mg/dL (male/female)	-	29 (96.67)	56 (82.35)	85 (86.73)
• < 40 / < 50 mg/dL (male/female)	-	1 (33.33)	12 (17.65)	13 (13.27)
BMI	23.91±5.08	-	-	-
• Underweight	-	2 (6.67)	8 (11.76)	10 (10.20)
• Normal	-	8 (26.67)	34 (50.0)	42 (42.86)
• Overweight	-	4 (13.33)	7 (10.29)	11 (11.22)
• Obesity	-	16 (53.33)	19 (27.94)	35 (35.71)
Having at least one risk factor				
• No	-	-	-	40 (40.82)
• Yes	-	-	-	58 (59.18)
Having metabolic syndrome				
• No	-	-	-	95 (96.94)
• Yes	-	-	-	3 (3.06)

Note: BMI: body mass index

Association between sleep quality and metabolic syndrome risk factors among medical students is presented in TABLE 3. The sleep quality of medical students was not associated with waist circumference, blood pressure, fasting blood glucose levels, and HDL levels ($p>0.05$).

Association between BMI and metabolic syndrome risk factors among medical students is presented in TABLE 4. The BMI of medical students was not associated with waist circumference, blood pressure, fasting blood glucose levels, and HDL levels ($p>0.05$). A significant relationship was observed between BMI and waist circumference ($p < 0.001$). Among students classified as overweight and obese, the majority have a waist circumference above the threshold, with proportions of 54.55% and 92.29%, respectively. In contrast, most students with a normal BMI (76.19%) and all underweight students (90.0%) have a waist circumference below the threshold. Body mass index was also significantly associated with blood pressure ($p = 0.005$). Students with normal BMI predominantly had SBP of < 130 mmHg and/or DBP < 85 mmHg (88.10%), whereas the proportion decreased among overweight (60%) and obese (40%) students. However, no significant associations between BMI with fasting blood glucose or HDL levels was observed ($p > 0.05$).

TABLE 3. The association between sleep quality and metabolic syndrome risk factors among medical students (n=98)

Variable/category	Good sleep quality [n (%)]	Poor sleep quality [n (%)]	p
Waist circumference			
• <90 / <80 cm (male/female)	30 (56.6)	18 (40.0)	0.101
• ≥90 / ≥80 cm (male/female)	23 (43.4)	27 (60.0)	
Blood pressure			
• SBP/DBP (<130 and/or <85 mmHg)	43 (81.13)	35 (77.78)	0.681
• SBP/DBP (≥130 and/or ≥85 mmHg)	10 (18.87)	10 (22.22)	
Fasting blood glucose			
• < 100 mg/dL	53 (100.0)	44 (97.78)	0.459
• ≥ 100 mg/dL	0 (0.0)	1 (2.22)	
HDL level			
• ≥ 40 / ≥ 50 mg/dL (male/female)	45 (84.91)	40 (88.89)	0.652
• < 40 / < 50 mg/dL (male/female)	8 (15.09)	5 (11.11)	

TABLE 4. The association between BMI and metabolic syndrome risk factors among medical students

Variable/category	BMI [n (%)]				p
	Underweight	Normal	Overweight	Obese	
Waist circumference					
• <90 / <80 cm (male/female)	9 (90.0)	32 (76.19)	5 (45.45)	2 (5.71)	0.001*
• ≥90 / ≥80 cm (male/female)	1 (10.0)	10 (23.81)	6 (54.55)	33 (92.29)	
Blood pressure					
• SBP/DBP (<130 and/or <85 mmHg)	10 (100.0)	37 (88.1)	10 (90.91)	21 (60.0)	0.005*
• SBP/DBP (≥130 and/or ≥85 mmHg)	0 (0)	5 (11.9)	1 (9.09)	14 (40.0)	
Fasting blood glucose					
• < 100 mg/dL	10 (100.0)	42 (100.0)	11 (100.0)	34 (97.14)	0.571
• ≥ 100 mg/dL	0 (0)	0 (0)	0 (0)	1 (2.86)	
HDL level					
• ≥ 40 / ≥ 50 mg/dL (male/female)	10 (100.0)	39 (92.86)	10 (90.91)	26 (74.29)	0.066
• < 40 / < 50 mg/dL (male/female)	0 (0)	3 (7.14)	1 (9.09)	9 (25.71)	

Note: *Fisher's exact test

DISCUSSION

Subjects characteristics

The study included 98 respondents who met the inclusion and exclusion criteria. The majority were female (69.39%; n=68). Most respondents were second-year preclinical medical students (37.76%; n=37), followed by first-year (32.65%; n=32), and third-year medical students (29.59%; n=29). This aligns with findings by Yeboah *et al.*,[5] where female respondents comprised 64.7% of the study population.[5] The prevalence of poor sleep quality in this study was 45%, indicating that most respondents had good sleep quality. Mostly poor sleep quality cases occurred among female students, consistent with Amin *et al.*,[12] who reported 63.1% of poor sleep quality cases among female medical students.

Most respondents had normal HDL levels, blood pressure, and fasting blood glucose. However, central obesity and the obese category were more prevalent among male students, while female students had normal waist circumferences and normal BMI. These findings align with Phaneendra *et al.*,[18] who reported normal HDL and glucose levels among medical students, though central obesity was more common among females in their study.

The majority of respondents (59.18%) had at least one metabolic syndrome risk factor, with central obesity being the most prevalent (51.02%). The prevalence of metabolic syndrome was 3.06%. This is consistent with Phaneendra *et al.*,[18] who reported that central obesity was the most common risk factor (44.1%), and 7.6% of respondents had metabolic syndrome. The difference may be due to variations in body weight criteria used, as this study employed the JIS criteria, while Phaneendra *et al.*,[18] used IDF criteria.

Among respondents, 51.02% had a waist circumference above the normal threshold (≥ 90 cm for males and ≥ 80 cm for females). It is higher than Phaneendra *et al.*,[18] findings (44.1%). Raouf *et al.*,[19] reported that 41.8% of medical students

had central obesity, linked to unhealthy eating patterns and inadequate physical activity. Most respondents had normal systolic (87.76%) and diastolic (85.71%) blood pressure. The prevalence of fasting blood glucose >100 mg/dL was 1.02%, indicating that most respondents had normal glucose levels. This follows previous studies by Yeboah *et al.*,[5] that reported only 19.7% of students had impaired glucose levels, attributed to unhealthy lifestyles. Most respondents had normal HDL levels (86.73%), with 13.27% having low HDL levels. This aligns with Haider *et al.*,[20] who found 32.5% of medical students had low HDL levels, possibly influenced by differences in respondent age and sex distribution. Lastly, 10.20% of respondents were underweight, 42.86% had normal BMI, 11.22% were overweight, and 35.71% were obese. Jha *et al.*,[21] similarly reported a majority with normal BMI but with a higher prevalence due to different BMI classifications. The high proportion of overweight and obese respondents in this study might result from poor dietary habits, inadequate physical activity, and stress associated with the intensive medical curriculum.

Association between sleep quality and metabolic syndrome risk factors

No association was found between sleep quality and waist circumference was observed in this study (p=0.101). Sleep quality among the respondents was normally distributed. It is thought to be a factor that plays a role in that no association condition. In contrast, a study by Peltzer *et al.*,[22] found a significant association between sleep quality and waist circumference in young adults across 24 countries. Poor sleep quality may influence appetite regulation, food choices, and caloric intake, ultimately affecting waist circumference. However, demographic differences, whereas in this study, a predominantly female respondents and a small sample size, may explain the discrepancy in the findings, as females may exhibit greater resilience to the adverse effects of poor sleep quality.

This study found no association between sleep quality and blood pressure (p=0.681). These findings are consistent with Putri *et al.*,[23] research in Mataram, Indonesia, which reported no significant correlation between sleep quality and blood pressure among medical students (r=-0.63; p=0.540). Young adults typically exhibit optimal cardiac function, lower venous return resistance, and peripheral resistance. Most respondents had good sleep quality, possibly due to data collection not during high-stress periods, such as exams. Good sleep quality supports blood pressure regulation via circadian rhythms, contributing to normal blood pressure levels. However, Aulia *et al.*,[24] identified a significant association between sleep quality and blood pressure (p=0.00), possibly due to differences in blood pressure categorization and academic burden across different education levels, affecting sleep quality and blood pressure outcomes.

This study also observed no association between sleep quality and fasting blood glucose levels (p=0.459). These findings aligned to prior studies that reported no association between sleep quality and fasting blood glucose levels in healthy young adult populations. Wikanendra *et al.*,[25] found no association between sleep duration and fasting blood glucose levels (r=-0.029; p=0.835). Similarly, Mahadarmika *et al.*,[26] found no association between sleep quality and glucose intolerance (p=0.704). Young adults without diabetes typically maintain effective insulin regulation, sustaining normal fasting blood glucose levels.

No association was found between sleep quality and HDL levels in this study (p=0.562). This result is consistent with

previous studies, such as Musharaf *et al.*,[27] who found no association between sleep quality and HDL levels (p=0.06) in young women using PSQI questionnaire. However, Hariri *et al.*,[28] identified a significant association between sleep quality and lipid profiles (p=0.0039) in older populations. Some explanation for these findings that aging increases the risk of dyslipidemia and poor sleep quality are common among the elderly, which can disrupt lipid metabolism. Other factors, such as dietary habits and physical activity, may also play significant roles in HDL regulation.

Association between BMI and metabolic syndrome risk factors

This study revealed a significant association between BMI and waist circumference (p<0.001). This finding aligns with the study by Castaneda *et al.*[29] which identified that waist circumference was significantly related to overweight/obesity (p<0.05). However, in that study, a waist circumference increase is not necessarily associated with an increase in BMI and can be abnormal even when the BMI is within the normal range.

This study also showed a significant association between BMI and blood pressure (p=0.005). This is consistent with Song *et al.*,[30] who reported a strong positive correlation between BMI and systolic blood pressure (r=0.372; p<0.001) and a moderate positive correlation with diastolic blood pressure (r=0.257; p<0.001) among young adults. Similarly, Siddiqui *et al.*,[31] found that higher BMI was associated with increased systolic and diastolic blood pressure (p<0.05). Increased BMI can activate the sympathetic nervous system, causing arterial vasoconstriction and higher blood pressure, which may lead to hypertension over time. Among young adults, every 1 kg/m^2 increase in BMI is associated with a 1.6 mmHg increase in systolic and a 0.834 mmHg increase in diastolic blood pressure.[32]

However, this study found no association between BMI and fasting blood glucose levels (p=0.571). This aligns with Setyawati *et al.*,[33] who reported no association between BMI and fasting blood glucose (p=0.24) among medical students with predominantly normal BMI. Factors such as diet, sex, age, and genetic predisposition may influence fasting blood glucose levels. Young adults with functional insulin regulation often maintain normal fasting blood glucose regardless of BMI. Differences in results may be caused by variations in blood sampling methods and BMI categorization.

This study found no association between BMI and HDL levels (p=0.066). These findings align with a study by Swathi *et al.*,[34] that found no association between BMI and lipid profiles in medical students (p=0.51). Conversely, Mishra *et al.*,[35] reported a significant negative correlation between BMI and HDL levels (p=0.008; r= -0.202) in young adults, suggesting that increased BMI may lower HDL levels due to pro-inflammatory cytokines that disrupt lipid metabolism. Low HDL cholesterol can increase heart risk, with other contributing factors such as diet, exercise, and genetic factors.

Limitations

This study has several limitations, including: 1) the study employed a cross-sectional design, which does not allow for the determination of causal relationships between variables; 2) the study was conducted in a single study center, limiting the generalization of the findings to broader populations; 3) sleep quality was measured via self-report questionnaire (PSQI), which may be subject to recall or response bias; 4) no further analysis was conducted on other factors that could influence metabolic syndrome risk factors, such

as respondents' lifestyle behaviors; 5) respondents in this study have a limited sample size and an imbalance in the number of genders, which is dominated by females.

CONCLUSION

The results found that there is no association between sleep quality and metabolic syndrome risk factors. However, there is a significant association between BMI with waist circumference and blood pressure, and no association was found between BMI with fasting blood glucose and HDL levels. Maybe we could suggest practical recommendations, such as BMI screening among medical students.

ACKNOWLEDGEMENT

The authors gratefully acknowledge that the study was supported by the staff of KALGen Innolab Clinic Laboratory for the data collection.

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