Journal of Health Sciences

RESEARCH ARTICLE Open Access

Prevalence and distribution of metabolic syndrome components among students at a public university in Central Java, Indonesia

Andi Daramusseng[1]*, Sulistiyani Sulistiyani[2], Suhartono Suhartono[2], Yusniar Hanani Darundiati[2]

[1]Doctoral Program in Public Health, Universitas Diponegoro, Semarang, Indonesia, [2]Department of Environmental Health, Public Health Faculty, Universitas Diponegoro, Semarang, Indonesia

ABSTRACT

Introduction: University students undergo lifestyle changes that may increase early cardiometabolic risk. This study estimated the prevalence of metabolic syndrome (MetS) and described its components among students at a public university in Central Java, Indonesia.

Methods: A cross-sectional study was conducted among students from May 2024 to April 2025. Data collection included structured questionnaires, anthropometric measurements, blood pressure (BP) assessment, and fasting blood biomarker analysis. MetS was defined using the International Diabetes Federation. Statistical analyses included the Mann–Whitney U and Pearson's χ^2 test.

Results: The prevalence of MetS was 21.9% (54/247). The most prevalent component was elevated waist circumference (54.3%), followed by low high-density lipoprotein cholesterol (HDL-C) levels (40.5%). Compared with women, men had significantly higher prevalences of elevated BP (prevalence ratio [PR] = 1.79; 95% confidence interval [CI] 1.15-2.77; p = 0.013), elevated triglycerides (PR = 2.00; 95% CI 1.06-3.77; p = 0.034), and elevated fasting plasma glucose (PR = 2.29; 95% CI 1.30-4.04; p = 0.005). Students with a body mass index (BMI) ≥25 kg/m^2 showed the largest PR for MetS (PR = 4.96; 95% CI 2.90-8.46; p < 0.001).

Conclusion: MetS was identified in 21.9% of the study population. Among the selected factors examined, BMI ≥25 kg/m^2 was associated with the largest unadjusted PR for MetS. Elevated waist circumference showed the highest prevalence among MetS components followed by low HDL-C levels. These findings suggest early cardiometabolic risk among students at the participating university. However, because the study was conducted at a single institution using non-probability sampling, the results may not generalize to all Indonesian university students.

Keywords: Indonesia; metabolic syndrome; university students; cardiometabolic risk

INTRODUCTION

University students aged 18-24 years constitute a critical young-adult population undergoing rapid developmental, psychosocial, and physiological transitions. During this period, dietary shifts toward energy-dense and ultra-processed foods, heightened academic stress, and reduced physical activity often converge to increase vulnerability to early cardiometabolic dysregulation (1-3).

Consistent with this, a cross-sectional study in Kenya reported that 72.8% of students consumed processed snacks during screen time and 61.3% engaged in insufficient physical activity, behaviors associated with higher odds of metabolic syndrome (MetS) (4). Similarly, a study conducted in China demonstrated that a Western-style dietary pattern combined with physical inactivity predicted a greater risk of MetS among young adults aged 18-35 years, whereas prudent dietary patterns showed a protective effect (5). These findings underscore the importance of examining not only the prevalence but also the component distribution of MetS across different student populations.

MetS has traditionally been considered a condition primarily affecting middle-aged and older adults, with an estimated prevalence of 20-30% (6). Nevertheless, recent surveillance studies have shown an increasing prevalence among adolescents and young adults (7,8). According to the International Diabetes Federation (IDF), the diagnosis of MetS requires the presence of central obesity plus any two of the following criteria: elevated triglycerides (TGs), reduced high-density lipoprotein cholesterol (HDL-C),

*Corresponding author: Andi Daramusseng, Doctoral Program in Public Health, Universitas Diponegoro, Semarang, Central Java, 50275, Indonesia. E-mail: andidaramusseng@gmail.com

Submitted: 04 October 2025/Accepted: 30 October 2026

DOI: https://doi.org/10.17532/jhsci.2026.2942

UNIVERSITY OF SARAJEVO
FACULTY OF HEALTH STUDIES

© 2026 Andi Daramusseng, *et al.*; licensee University of Sarajevo - Faculty of Health Studies. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

elevated blood pressure (BP), or elevated fasting plasma glucose (FPG), using ethnicity-specific waist circumference thresholds recommended for Asian populations (9).

The prevalence of MetS among university populations varies widely (10-41%), reflecting differences in risk profiles and measurement protocols, including central obesity cut-off values (10,11). However, national evidence specifically addressing MetS among university-aged young adults in Indonesia remains limited, and campus-based datasets are scarce, thereby constraining targeted prevention and pragmatic screening approaches (12-14).

Accordingly, this study aimed to estimate the prevalence of MetS and describe the distribution of its components among students at a public university in Central Java, Indonesia. In addition, this study examined selected demographic and anthropometric factors associated with MetS to provide evidence regarding the cardiometabolic risk profile of this population.

METHODS

This analytical cross-sectional study assessed the prevalence and component distribution of MetS among students at a public university in Central Java, Indonesia. The study was conducted at a public university in Central Java, Indonesia, from May 2024 to April 2025. Participants were purposively recruited from several faculties at the institution. This approach was intended to capture variation in academic backgrounds within the selected institution rather than to obtain a nationally representative sample. Consequently, the findings should be interpreted as specific to the study population and institutional context.

The study population comprised university students aged 18-24 years. The inclusion criteria were as follows: (1) aged 18-24 years; (2) non-smokers and alcohol abstainers; and (3) provided written informed consent. These criteria were applied to minimize potential confounding effects on metabolic biomarkers. A total of 247 participants were included to estimate the prevalence of MetS and its components.

Data collection followed a multi-phase protocol under trained supervision. Participants completed a structured questionnaire and underwent anthropometric assessment and fasting venous blood collection. Body weight, body fat percentage, and visceral fat were assessed using a Karada Scan Body Composition Monitor (HBF-375, OMRON; bioelectrical impedance analysis), while height was measured using a OneMed stadiometer (to 0.1 cm). Waist circumference was measured using a non-elastic measuring tape at the midpoint between the lowest rib and the iliac crest, with participants in a relaxed standing position. Body mass index (BMI) was calculated as kg/m^2 and categorized according to the Asia-Pacific standards: Underweight (<18.5), normal (18.5-22.9), overweight (23.0-24.9), and obese (≥25.0) (15). The original data collection protocol focused on demographic characteristics, family history, anthropometric measurements, BP, and fasting biochemical markers. Behavioral factors such as dietary patterns, physical activity levels, and sleep patterns were not included in the questionnaire and were therefore not available for analysis.

BP was measured using an automated OMRON device after ≥5 min of seated rest. Venous blood samples were collected between 07:00 and 10:00 following an overnight fast of ≥8 h. Fasting status was confirmed by participant self-report and verified by study staff. Phlebotomy procedures were performed by certified personnel under aseptic conditions, and the samples were processed at the Central Java Provincial Health Laboratory to determine FPG, TG, total cholesterol (TC), HDL-C, and low-density lipoprotein cholesterol (LDL-C) levels. These biochemical markers were prioritized because, when combined with anthropometric indices, they provide insight into the component distribution of MetS within this population.

MetS was diagnosed according to the IDF criteria: Central obesity (waist circumference ≥90 cm in men, ≥80 cm in women) plus at least two of the following criteria: TG ≥150 mg/dL or treatment; HDL-C <40 mg/dL (men) or <50 mg/dL (women) or treatment; BP ≥130/85 mmHg or previously diagnosed hypertension; and FPG ≥100 mg/dL or previously diagnosed type 2 diabetes (9). Asian-specific waist circumference thresholds were applied because they are commonly used in Indonesian research contexts.

The study protocol was reviewed and approved by the Ethics Committee (Approval No: 226/EA/KEPK-FKM/2024). Written informed consent was obtained from all participants before data collection. All study procedures conformed to the Declaration of Helsinki, including privacy protection and the right to withdraw without penalty.

The distribution of continuous variables was assessed using the Kolmogorov–Smirnov test. As several variables were not normally distributed, continuous data were summarized as the median, whereas categorical variables were presented as frequencies and percentages. Comparisons of continuous variables between two independent groups were performed using the Mann–Whitney U-test, while associations between categorical variables were assessed using Pearson's χ^2 test. Associations were expressed as prevalence ratios (PRs) with 95% confidence intervals (CIs). Statistical significance was defined as $p < 0.05$. All statistical analyses were performed using SPSS software.

RESULTS

A total of 247 students were included, comprising 53 men and 194 women. The median age was 21 years in both groups and did not differ significantly between sexes ($p = 0.335$). Most participants were enrolled in science-oriented fields, representing 77.4% of men and 68.6% of women. Field of study and family histories of obesity, diabetes mellitus, and hypertension did not differ significantly between sexes (all $p > 0.05$). Men had significantly higher median height, weight, waist circumference, systolic BP, and FPG values, whereas women had significantly higher median body fat percentage and HDL-C levels. No significant sex differences were observed in BMI, visceral fat score, TGs, LDL-C, TC, or diastolic BP (Table 1).

The overall prevalence of MetS was 21.9% with a numerically higher prevalence among men than women (30.2% vs. 19.6%), although the difference was not statistically significant (PR = 1.54; 95% CI, 0.94-2.54; $p = 0.098$). The most prevalent MetS component was elevated waist circumference (54.3%), followed by low HDL-C levels (40.5%). Compared with women, men had significantly

TABLE 1. Baseline Characteristics by Sex: Emphasis on Anthropometric and Lipid Profiles

Characteristic	Men (n=53)	Women (n=194)	*p*-value
Age, median (Q1-Q3)	21.0 (20.0-22.0)	21.0 (20.0-21.0)	0.335[a]
Field of study n (%)			0.213[b]
Science	41 (77.4)	133 (68.6)	
Non-science	12 (22.6)	61 (31.4)	
Family history n (%)			
Obesity	13 (24.5)	28 (14.4)	0.080[b]
Diabetes mellitus	13 (24.5)	44 (22.7)	0.777[b]
Hypertension	21 (39.6)	78 (40.2)	0.939[b]
Anthropometric, median (Q1-Q3)			
Height (cm)	167.5 (163.0-172.6)	155.7 (152.0-159.1)	<0.001[a]*
Weight (kg)	68.5 (58.0-78.2)	56.8 (48.0-66.3)	<0.001[a]*
BMI (kg/m^2)	23.5 (21.3-28.3)	23.0 (20.3-26.9)	0.224[a]
Body fat (%)	23.9 (17.3-30.3)	30.8 (25.6-34.5)	<0.001[a]*
Visceral fat score	5.5 (3.0-9.5)	6.0 (3.0-9.0)	0.622[a]
Waist circumference (cm)	86.9 (76.1-95.0)	80.8 (74-87.6)	0.020[a]*
Triglycerides (mg/dL), median (Q1-Q3)	98.3 (71.4-143.6)	96.0 (74.4-120.1)	0.427[a]
HDL-C (mg/dL), median (Q1-Q3)	41.0 (38.0-49.5)	51.0 (44.0-58.0)	<0.001[a]*
LDL-C (mg/dL), median (Q1-Q3)	91.8 (73.4-115.3)	92.3 (77.1-111.6)	0.765[a]
Total cholesterol (mg/dL), median (Q1-Q3)	154.9 (140.2-180.3)	164.9 (147.4-183.0)	0.122[a]
Blood pressure, median (Q1-Q3)			
Systolic blood pressure (mmHg)	123.0 (118.0-134.0)	115.0 (106.0-125.3)	<0.001[a]*
Diastolic blood pressure (mmHg)	77.0 (70.0-83.0)	75.0 (67.8-82.0)	0.178[a]
Fasting plasma glucose (mg/dL) median (Q1-Q3)	85.4 (81.2-103.5)	81.1 (74.9-89.6)	<0.001[a]*

[a]Mann–Whitney U test; [b]Pearson's χ^2 test; *P*<0.05. BMI: Body mass index, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol

higher prevalences of elevated BP (PR = 1.79; 95% CI 1.15-2.77; p = 0.013), elevated TGs (PR = 2.00; 95% CI 1.06-3.77; p = 0.034), and elevated FPG (PR = 2.29; 95% CI 1.30-4.04; p = 0.005). Other components did not differ significantly by sex (Table 2). Figure 1 shows that most students met one or two MetS criteria, whereas a higher proportion of men than women met three or more criteria (32.0% vs. 19.6%). However, the presence of three or more MetS criteria does not necessarily indicate an IDF-defined MetS diagnosis, as central obesity is a mandatory criterion under the IDF definition.

Table 3 presents the unadjusted associations between MetS and the selected demographic and anthropometric factors available in the study dataset. Age and sex were not significantly associated with MetS. In contrast, BMI was significantly associated with MetS. Participants with a BMI ≥25 kg/m^2 had a MetS prevalence of 45.9% and a higher PR than participants with a BMI <25 kg/m^2 (PR = 4.96; 95% CI: 2.90-8.46; p < 0.001). Furthermore, students with MetS had significantly higher median BMI (27.9 [24.7-33.4] kg/m^2 vs. 22.2 [19.7-24.7] kg/m^2), body fat percentage (32.6% [28.6-36.5] vs. 28.7% [23.2-32.8]), and visceral fat score (10.0 [7.0-16.0] vs. 4.5 [2.5-8.0]) compared with those without MetS (all p < 0.001) (Table 4).

DISCUSSION

Based on the IDF criteria, the prevalence of MetS was 21.9% among students at the participating public university in Central Java, Indonesia. This campus population remains understudied in the regional literature. Beyond estimating prevalence, this study also described the component distribution of MetS, with elevated waist circumference representing the most prevalent component, followed by low HDL-C levels. This component profile provides additional evidence of early cardiometabolic risk among young adults in a university setting.

Although MetS prevalence was numerically higher among men than women (30.2% vs. 19.6%), the difference was not statistically significant (PR = 1.54; 95% CI, 0.94-2.54; p = 0.098) and should therefore be interpreted cautiously. The numerically higher MetS prevalence among men may partly reflect the clustering of specific metabolic abnormalities, as men had significantly higher prevalences of elevated BP, elevated TGs, and elevated FPG. In contrast, women had a higher prevalence of elevated waist circumference, while the prevalence of low HDL-C was comparable between sexes. A numerically higher prevalence among men has also been reported in university populations in Bangladesh and Brazil, whereas studies in Kenya and Iraq found higher prevalence among women (4,10,16,17). These inconsistent patterns may reflect differences in diagnostic criteria, population characteristics, ethnicity, lifestyle, and sex distribution across studies.

The observed component pattern may also reflect sex-related biological and methodological factors. Previous evidence suggests that vascular regulation, glucose metabolism, lipid profiles, and fat distribution may differ between men and women, while estrogen may support insulin sensitivity and higher HDL-C concentrations among women of reproductive age (18,19). However, the visceral fat score did not differ significantly between sexes in the present study; therefore, visceral adiposity cannot be considered an empirically supported explanation for the observed difference in MetS prevalence. The higher prevalence of elevated waist circumference among

TABLE 2. Prevalence of metabolic syndrome and its individual components by sex

Criteria	Men		Women		Total		*p*-value	PR (95% CI)
	Positive	Negative	Positive	Negative	Positive	Negative		
Metabolic syndrome	16 (30.2)	37 (69.8)	38 (19.6)	156 (80.4)	54 (21.9)	193 (78.1)	0.098	1.54 (0.94-2.54)
Elevated waist circumference	24 (45.3)	29 (54.7)	110 (56.7)	84 (43.3)	134 (54.3)	113 (45.7)	0.139	0.80 (0.58-1.10)
Elevated blood pressure	20 (37.7)	33 (62.3)	41 (21.1)	153 (78.9)	61 (24.7)	186 (75.3)	0.013*	1.79 (1.15-2.77)
Elevated triglycerides	12 (22.6)	41 (77.4)	22 (11.3)	172 (88.7)	34 (13.8)	213 (86.2)	0.034*	2.00 (1.06-3.77)
Low HDL-C	21 (39.6)	32 (60.4)	79 (40.7)	115 (59.3)	100 (40.5)	147 (59.5)	0.885	0.97 (0.67-1.41)
Elevated fasting plasma glucose	15 (28.3)	38 (71.7)	24 (12.4)	170 (87.6)	39 (15.8)	208 (84.2)	0.005*	2.29 (1.30-4.04)

Pearson's χ^2 test was used to compare proportions. PR: Prevalence ratio, CI: Confidence interval, HDL-C: High-density lipoprotein cholesterol. *p<0.05

TABLE 3. Unadjusted associations between metabolic syndrome and selected demographic and anthropometric factors

Demographic and Anthropometric Factors	Metabolic Syndrome		*p*- value	PR (95% CI)
	Yes (n=54)	No (n=193)		
Age			0.128	0.69 (0.42-1.12)
18-20	20 (17.5)	94 (82.5)		
21-24	34 (25.6)	99 (74.4)		
Sex			0.098	1.54 (0.94-2.54)
Men	16 (30.2)	37 (69.8)		
Women	38 (19.6)	156 (80.4)		
BMI (kg/m^2)			<0.001*	4.96 (2.90-8.46)
≥25	39 (45.9)	46 (54.1)		
<25	15 (9.3)	147 (90.7)		

Pearson's χ^2 test was used to compare proportions. PR: Prevalence ratio, CI: Confidence interval, BMI: Body mass index. *p<0.05

TABLE 4. Anthropometric characteristics of students with and without metabolic syndrome

Variable	Metabolic Syndrome		*p*-value
	Yes (n=54)	No (n=193)	
Body mass index (kg/m^2)	27.9 (24.7-33.4)	22.2 (19.7-24.7)	<0.001*
Body fat (%)	32.6 (28.6-36.5)	28.7 (23.2-32.8)	<0.001*
Visceral fat score	10.0 (7.0-16.0)	4.5 (2.5-8.0)	<0.001*

Data are presented as median (Q1–Q3) and compared using the Mann–Whitney U-test. *p<0.05

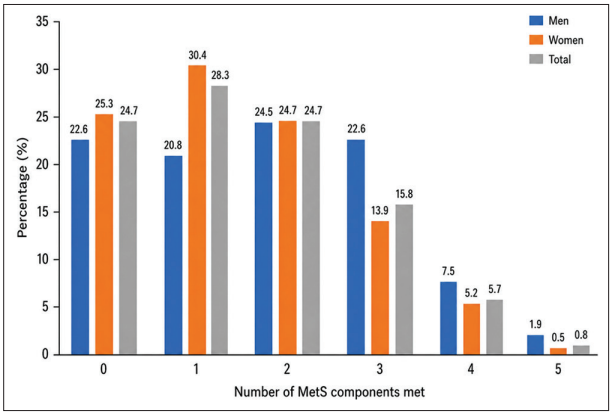

FIGURE 1. Distribution of the number of metabolic syndrome components met by sex.

women (56.7% vs. 45.3%), despite their lower median waist circumference, is likely influenced by the sex-specific IDF thresholds of ≥80 cm for women and ≥90 cm for men. Similarly, the comparable prevalence of low HDL-C despite higher median HDL-C concentrations among women may partly reflect the higher diagnostic threshold applied to women (<50 mg/dL vs. <40 mg/dL in men). Dietary intake, physical activity, sedentary behavior, psychological stress, and sleep patterns were not measured. Therefore, their contribution to the observed sex differences could not be determined. The smaller number of male participants may also have reduced the precision of the sex-specific estimates.

Consistent with previous research, the prevalence observed in this study was higher than that reported in the United States (0.3-6.8%), Brazil (18.3%), and Kenya (1.9%), but lower than in Bangladesh (27.7%) and Iraq (41.3%) (4,10,16,17,20,21). The findings are also consistent with reports from Thailand (19.7-27%) and national estimates among Indonesian adults (21.7%) (14,22,23), indicating that cardiometabolic risk may already be present during the university years.

The MetS prevalence observed in this study reflects the cardiometabolic profile of students at the participating public university and should not be interpreted as a national estimate for Indonesian university students. Geographic location, socioeconomic background, academic environment, food availability, physical activity opportunities, and student characteristics may vary across Indonesian universities and may result in different prevalence estimates.

The observed inter-regional differences may reflect structural, behavioral, and biological determinants, including urbanization, energy-dense dietary patterns, reduced physical activity associated with academic pressure or digital engagement, and ethnic predisposition to visceral adiposity and insulin resistance (24,25). However, the present findings indicate that the critical issue extends beyond prevalence alone to the specific distribution of MetS components, which may contribute to different long-term trajectories of cardiometabolic disease among students in different university and regional settings.

Consistent with previous research, among the selected variables examined in the unadjusted analysis, BMI ≥25 kg/m^2 showed the largest PR for MetS (PR = 4.96) (24,26). The high prevalence of elevated waist circumference and low HDL-C in the overall study population suggests that BMI alone may not fully characterize cardiometabolic risk. This interpretation is further supported by the higher body fat percentage and visceral fat scores observed among students with MetS, indicating that MetS was associated with greater adiposity and less favorable fat distribution. Mechanistically, excess adiposity contributes to insulin resistance and chronic low-grade inflammation, which subsequently promote dyslipidemia, elevated BP, and hyperglycemia, the

core components of MetS (27,28). Overall, these findings suggest that both general and central adiposity are relevant for characterizing cardiometabolic risk in this population.

Strengths of this study include standardized biomarker assessments and data collection conducted by trained field staff, which enhanced measurement consistency and internal validity. Several limitations should also be acknowledged. First, the cross-sectional design precludes causal inference and does not allow assessment of temporality. Second, the use of purposive sampling at a single public university in Central Java substantially limits external generalizability. The study sample may differ from students attending private universities, vocational institutions, religious universities, or universities located in other regions of Indonesia. Therefore, the findings cannot be considered representative of the national university student population. Third, the sex imbalance among participants (53 men vs. 194 women) may have reduced the precision of estimates for outcomes influenced by biological or behavioral differences between sexes. Fourth, dietary patterns, Western-style food intake, physical activity, sedentary behavior, and sleep patterns were not included in the original data collection protocol. These variables were therefore unavailable for analysis and may have acted as unmeasured confounders. Consequently, the reported PRs should be interpreted as unadjusted associations rather than independent or causal effects. Nevertheless, their absence did not directly affect MetS classification, which was based on objectively measured IDF criteria.

The findings of this study have practical implications for university health programs. Because BMI alone may not fully capture central adiposity and lipid abnormalities, university health programs may consider incorporating waist circumference and lipid profile assessments alongside BMI measurement. This combined approach may facilitate earlier identification of students with cardiometabolic risk. From a public health and allied health perspective, such findings may guide targeted health promotion through lifestyle counseling, healthier campus food environments, expanded opportunities for physical activity, and cardiometabolic risk education within student health services (29-32). Although dietary intake, physical activity, sleep patterns, and environmental exposures were not measured in this study, these factors remain plausible contributors to metabolic dysregulation and should be considered in future university-based prevention initiatives.

Future studies should use longitudinal, multicenter designs with more balanced samples and validated measures of diet, physical activity, sedentary behavior, and sleep. Such measurements would permit more comprehensive adjustment for potential confounding factors and clarify whether the observed sex differences reflect biological, behavioral, or methodological influences. These studies are needed to determine whether central obesity and low HDL-C persist over time and predict subsequent diabetes or cardiovascular disease.

CONCLUSION

MetS prevalence was 21.9% (54/247). Elevated waist circumference was the most prevalent component, followed by low HDL-C. Among the selected factors examined in the unadjusted analysis, BMI ≥25 kg/m^2 showed the largest PR for MetS. These findings indicate the presence of metabolic risk among students at the participating university and provide additional evidence regarding the distribution of MetS components in this population.

ACKNOWLEDGMENTS

The authors would like to express their sincere appreciation to the Indonesian Education Scholarship, the Center for Higher Education Funding and Assessment, Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, and the Endowment Fund for Education Agency, Ministry of Finance of the Republic of Indonesia, for supporting this research (Grant Number 202209090864). The authors also thank all study participants and institutional partners for their valuable contributions.

FUNDING

This study was funded by Indonesian Education Scholarship, the Center for Higher Education Funding and Assessment, Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, and the Endowment Fund for Education Agency, Ministry of Finance of the Republic of Indonesia (Grant Number 202209090864).

DECLARATION OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

1. Buková A, Tomková P, Uher I, Kimáková T, Vojtaško Ľ, Salonna F. Selected lifestyle factors as students transition from secondary school to university in Slovakia. Front Public Health 2024;12:1461989.
   https://doi.org/10.3389/fpubh.2024.1461989
2. Gutiérrez-Espinoza H, Cassola-Cajiao M, Garzón-Ulloa E, Celi-Lalama D, Araya-Quintanilla F, Valenzuela-Fuenzalida J, et al. Changes in the lifestyle behavior and anthropometrics of university students after the first year: A one-year prospective observational study. Front Sports Act Living 2025;7:1499828.
   https://doi.org/10.3389/fspor.2025.1499828
3. Shatwan IM, Alzharani MA. Association between perceived stress, emotional eating, and adherence to healthy eating patterns among Saudi college students: A cross-sectional study. J Health Popul Nutr 2024;43(1):144.
   https://doi.org/10.1186/s41043-024-00637-w
4. Mbugua SM, Kimani ST, Munyoki G. Metabolic syndrome and its components among university students in Kenya. BMC Public Health 2017;17(1):909.
   https://doi.org/10.1186/s12889-017-4936-x
5. Liu J, Lu W, Lv Q, Wang Y, Xu X, He Y, et al. Impact of dietary patterns on metabolic syndrome in young adults: A cross-sectional study. Nutrients 2024;16(17):2890.
   https://doi.org/10.3390/nu16172890
6. Grundy SM. Metabolic syndrome pandemic. Arterioscler Thromb Vasc Biol 2008;28(4):629-36.
   https://doi.org/10.1161/ATVBAHA.107.151092
7. Noubiap JJ, Nansseu JR, Lontchi-Yimagou E, Nkeck JR, Nyaga UF, Ngouo AT, et al. Global, regional, and country estimates of metabolic syndrome burden in children and adolescents in 2020: A systematic review and modelling analysis. Lancet Child Adolesc Health 2022;6(3):158-70.
   https://doi.org/10.1016/S2352-4642(21)00374-6
8. Jamali Z, Ayoobi F, Jalali Z, Bidaki R, Lotfi MA, Esmaeili-Nadimi A, et al. Metabolic syndrome: A population-based study of prevalence and risk factors. Sci Rep 2024;14(1):3987.
   https://doi.org/10.1038/s41598-024-54367-4
9. International Diabetes Federation. The IDF Consensus Worldwide Definition of the Metabolic Syndrome. Belgium: International Diabetes Federation; 2006.
10. Zamil AH, Amin SS. The prevalence of metabolic syndrome among university students

in Wasit, Iraq. Saudi Med J 2022;43(11):1240-7.

https://doi.org/10.15537/smj.2022.43.11.20220558

11. Keown TL, Smith CB, Harris MS. Metabolic syndrome among college students. J Nurse Practitioner 2009;5(10):754-9.

https://doi.org/10.1016/j.nurpra.2009.02.013

12. International Diabetes Federation. IDF Diabetes Atlas 9th edition. Belgium: International Diabetes Federation; 2019.

13. International Diabetes Federation. IDF Diabetes Atlas 10th ed. Belgium: International Diabetes Federation; 2021.

14. Herningtyas EH, Ng TS. Prevalence and distribution of metabolic syndrome and its components among provinces and ethnic groups in Indonesia. BMC Public Health 2019;19(1):377.

https://doi.org/10.1186/s12889-019-6711-7

15. Lim JU, Lee JH, Kim JS, Hwang Y 2nd, Kim TH, Lim SY, et al. Comparison of World Health Organization and Asia-Pacific body mass index classifications in COPD patients. Int J Chron Obstruct Pulmon Dis 2017;12:2465-75.

https://doi.org/10.2147/COPD.S141295

16. Barbosa JB, Dos Santos AM, Barbosa MM, Barbosa MM, De Carvalho CA, De Fonseca PC, et al. Metabolic syndrome, insulin resistance and other cardiovascular risk factors in university students. Cien Saude Colet 2016;21(4):1123-36.

https://doi.org/10.1590/1413-81232015214.10472015

17. Ali N, Samadder M, Shourove JH, Taher A, Islam F. Prevalence and factors associated with metabolic syndrome in university students and academic staff in Bangladesh. Sci Rep 2023;13(1):19912.

https://doi.org/10.1038/s41598-023-46943-x

18. Pradhan AD. Sex differences in the metabolic syndrome: Implications for cardiovascular health in women. Clin Chem 2014;60(1):44-52.

https://doi.org/10.1373/clinchem.2013.202549

19. Shank LM, Higgins Neyland MK, Lavender JM, Schindler R, Solomon S, Hennigan K, et al. Sex differences in metabolic syndrome components in adolescent military dependents at high□risk for adult obesity. Pediatr Obes 2020;15(8):e12638.

https://doi.org/10.1111/ijpo.12638

20. Yahia N, Brown CA, Snyder E, Cumper S, Langolf A, Trayer C, et al. Prevalence of metabolic syndrome and its individual components among midwestern university students. J Community Health 2017;42(4):674-87.

https://doi.org/10.1007/s10900-016-0304-5

21. Dalleck LC, Kjelland EM. The prevalence of metabolic syndrome and metabolic syndrome risk factors in college-aged students. Med Sci Sports Exerc 2011;43(5):788.

https://doi.org/10.1249/01.mss.0000402191.71830.05

22. Ngoc HN, Kriengsinyos W, Rojroongwasinkul N, Aekplakorn W. Prevalence of metabolic syndrome and its prediction by simple adiposity indices in Thai adults. J Health Sci Med Res 2021;39(4):331-43.

https://doi.org/10.31584/jhsmr.2021791

23. Tangjittipokin W, Srisawat L, Teerawattanapong N, Narkdontri T, Homsanit M, Plengvidhya N. Prevalence and characteristics of prediabetes and metabolic syndrome in seemingly healthy persons at a health check-up clinic. J Multidiscip Healthc 2022;15:1585-94.

https://doi.org/10.2147/JMDH.S374164

24. Dejhalla E, Zavidić T, Popović B, Čulina T. Prevalence of metabolic syndrome among students: Associations with dietary habits, physical activity, and sociodemographic factors. J Clin Med 2025;14(13):4389.

https://doi.org/10.3390/jcm14134389

25. Ranasinghe P, Mathangasinghe Y, Jayawardena R, Hills AP, Misra A. Prevalence and trends of metabolic syndrome among adults in the Asia-Pacific region: A systematic review. BMC Public Health 2017;17(1):101.

https://doi.org/10.1186/s12889-017-4041-1

26. Rahmawati ND, Andriani H, Wirawan F, Farsia L, Waits A, Karim Taufiqurahman KA. Body mass index as a dominant risk factor for metabolic syndrome among Indonesian adults: A 6-year prospective cohort study of non-communicable diseases. BMC Nutr 2024;10(1):43.

https://doi.org/10.1186/s40795-024-00856-8

27. Atawia RT, Bunch KL, Toque HA, Caldwell RB, Caldwell RW. Mechanisms of obesity-induced metabolic and vascular dysfunctions. Front Biosci (Landmark Ed) 2019;24:890.

https://doi.org/10.2741/4758

28. Jin X, Qiu T, Li L, Yu R, Chen X, Li C, et al. Pathophysiology of obesity and its associated diseases. Acta Pharm Sin B 2023;13(6):2403-24.

https://doi.org/10.1016/j.apsb.2023.01.012

29. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Musaiger AO. Physical activity, sedentary behaviors and dietary habits among Saudi adolescents relative to age, gender and region. Int J Behav Nutr Phys Act 2011;8(1):140.

https://doi.org/10.1186/1479-5868-8-140

30. González-Casanova JE, Pertuz-Cruz SL, Caicedo-Ortega NH, Rojas-Gomez DM. Adipogenesis regulation and endocrine disruptors: Emerging insights in obesity. Biomed Res Int 2020;2020:7453786.

https://doi.org/10.1155/2020/7453786

31. Bulsiewicz WJ. The importance of dietary fiber for metabolic health. Am J Lifestyle Med 2023;17(5):639-48.

https://doi.org/10.1177/15598276231167778

32. Leitzmann M. Physical activity, sedentary behaviour, and obesity. In: Romieu I, Dossus L, Willett WC, editor. Energy Balance and Obesity. IARC Working Group Reports, No. 10. Lyon, FR: International Agency for Research on Cancer; 2017.