Proceedings of the International Conference of Public Health, Vol. 9, Issue. 1, 2024, pp.1-18

ISSN 2424-6735 online
DOI: https://doi.org/10.17501/24246735.2024.9106

CROSS-SECTIONAL POPULATION STUDIES: PREVALENCE OF METABOLIC SYNDROME AND ASSOCIATED RISK FACTORS AMONG MEN IN INDONESIA

Anggraini K[1,3*], Kamso S[2]

[1]*Doctoral Program, Faculty of Public Health, Universitas Indonesia, Indonesia*

[2]*Faculty of Public Health, Universitas Indonesia, Indonesia*

[3]*Faculty of Medicine, Universitas Trisakti, Indonesia*

Abstract: The prevalence of metabolic syndrome (MetS) is rapidly increasing globally. An individual with MetS faces a fivefold increased risk of developing Type II diabetes (T2DM). Indonesia is positioned fifth among the ten countries with the highest prevalence of diabetes patients globally. Diabetes mellitus is a chronic illness that ranks third in mortality in Indonesia. Men with prediabetes have a greater susceptibility to developing T2DM attributable to diminished insulin sensitivity compared to women. This research aimed to ascertain the prevalence and risk factors of MetS among males in Indonesia. The study employed a cross-sectional design involving 9,220 men aged 15 to 97 years, sourced from RISKESDAS 2018. MetS is defined based on 3 criteria (JIS, NCEP/ATPIII, IDF). The risk factors for MetS include body mass index, smoking index, physical activity, alcohol use, intake of unhealthy foods, and consumption of fruits and vegetables. Data analysis with the Chi-square test and multiple logistic regression. The highest prevalence of MetS was recorded using JIS criteria at 19.5%, followed by NCEP/ATP III and IDF criteria at 10.7% and 11.0%, respectively. The prevalence of MetS and its components rises with advancing age. Factors associated with MetS were ages 30-79 years, overweight status, Grade 1 obesity, Grade 2 obesity, Grade 3 obesity, a smoking index of 200-400, a smoking index > 400, moderate physical activity, and poor physical activity. Temuan penelitian ini akan membantu merancang program pencegahan untuk mengendalikan peningkatan prevalensi MetS pada pria di Indonesia.

Keywords: Sindrom metabolik, Indonesia, cross-sectional study, public health

1. Introduction

Metabolic syndrome (MetS) comprises a set of metabolic risk factors, including atherogenic dyslipidemia (characterized by elevated triglycerides and apolipoprotein B-containing lipoproteins, alongside reduced high-density lipoproteins [HDL]), hypertension, hyperglycemia, and prothrombotic and proinflammatory states. The prevalence of the Mets disease epidemic is rapidly escalating, with the adult population identified as Mets patients in most nations ranging from 20% to 30%(Grundy, 2008). The primary causes for an increase of the illness are obesity and a sedentary lifestyle, attributed to heightened intake of high-calorie, low-fiber fast food and diminished physical exercise resulting from mechanized transportation and sedentary leisure pursuits (Saklayen, 2018). A person with MetS has a twofold risk of acquiring cardiovascular disease and a fivefold greater risk of type 2 diabetes mellitus (T2DM) (Grundy, 2008).

*Corresponding Author's Email: *kirana_anggraeni@trisakti.ac.id*

Numerous studies clarify the pathophysiological causes of MetS, mainly caused by insulin resistance and hyperinsulinemia. Insulin resistance, measured as impaired fasting glucose (IFG) or impaired glucose tolerance (IGT). IFG is a state of relative basal insulin deficiency whereas IGT indicates a state of peripheral insulin resistance (Unwin et al., 2002). Research examining the impact of sex differences on insulin resistance indicates that obese adolescent boys exhibit a greater risk of developing insulin resistance and impaired fasting glucose (IFG) compared to their obese female counterparts. This disparity is attributed to the higher insulin sensitivity observed in females, which results from variations in metabolic regulation, encompassing lipolysis, glucose metabolism, and insulin action (Aldhoon-Hainerová et al., 2014). Individuals with both IFG and IGT exhibit an equivalent risk of progressing to T2DM. Individuals diagnosed with IFG are classified as having prediabetes and are considered to be at an elevated risk for the future development of T2DM (Unwin et al., 2002).

The prevalence of MetS exhibits significant variability across different populations, shaped by factors such as geography, age, gender, diagnostic criteria, race, socioeconomic status, and education level. Currently, two primary diagnostic criteria for MetS exist: one emphasizes the accumulation of risk factors, while the other centers on abdominal obesity. The final definition includes waist circumference (WC) as an essential element, whereas the initial definition does not.(K. Alberti et al., 2005; Grundy et al., 2005). In 2009, the International Diabetes Federation (IDF), the National Heart, Lung, and Blood Institute (NHLBI), the American Heart Association (AHA), and others aimed to standardize these criteria, leading to the conclusion that waist circumference is no longer a required element of the system. The criteria are referred to as Joint Interim Societies (JIS) or Harmonized criteria (K. G. M. M. Alberti et al., 2009). A comparative study of various MetS diagnostic criteria revealed that the JIS criteria significantly elevated the prevalence of MetS (Guo et al., 2016; Moy & Bulgiba, 2010; Subramani et al., 2019).

Indonesia is ranked fifth among the ten nations with the greatest prevalence of T2DM patients globally. T2DM is a chronic condition that ranks third in mortality in Indonesia. The incidence of MetS in Indonesia has risen from 21.6% in 2007 (Herningtyas & Ng, 2019) to 39.0% in the year 2013 (Sigit et al., 2020), exceeds the worldwide MetS prevalence (20-25%) (International Diabetes Federation, 2020). Pos Pembinaan Terpadu (POSBINDU) Non-Communicable Disease (NCD) represents a promotive and preventive initiative by the Indonesian government, initiated in 2014, aimed at the early detection and integrated management of risk factors associated with NCD. The conducted activities encompass interviews aimed at identifying hereditary and behavioral risk factors, measurement of abdominal circumference and body mass index, analysis of body fat, assessment of blood pressure, blood sugar, and blood lipids (total cholesterol and triglycerides), a basic lung function test using a peak flow meter, visual acetic acid inspection, counseling on diet, smoking, stress, exercise, and additional topics, as well as group counseling, sports or joint physical activities, and referrals to health centers.

In 2021, the IDF confirmed that the prevalence of T2DM in males (9.6%) exceeded that in women (9.0%) globally. (Federation, 2021). Current data regarding the prevalence and risk factors of MetS, particularly among men in Indonesia, remain unavailable. The study hypothesizes that the prevalence of MetS in Indonesian men, as measured by JIS criteria, exceeds that determined by IDF and NCEP ATP III criteria. Influential factors include body mass index, smoking index, physical activity, alcohol consumption, and levels of risky food and fruit and vegetable consumption. Current measurements of MetS prevalence are essential for evaluating government-promoted programs aimed at addressing

NCDs. They also inform the planning of public health strategies, particularly for men, to manage MetS risk and prevent the progression of MetS in relation to T2DM and cardiovascular disease incidence.

2.Materials and Methods

2.1Study design and population

This study is a cross-sectional analysis of the 2018 National Health Surveillance in Basic Health Research (RISKESDAS), undertaken by the Indonesian government every five years to assess the prevalence of infectious, metabolic, and degenerative disorders. The systematic random sample design, together with stratified, multi-stage, and probability proportional to size (PPS) methods, was employed to select households throughout 38 provinces in Indonesia. Weighting factors for all people have been computed to ensure that the sample accurately reflects the varying geographical densities among the 38 provinces, as well as the urban and rural distribution.

2.2Data collection

Self-reported questionnaires were employed to evaluate data on age, smoking initiation age, daily cigarette consumption, alcohol intake, fruit and vegetable consumption habits, risky dietary behaviors, and physical activity levels. The smoking index is calculated by multiplying the daily cigarette consumption by the total years of smoking.

2.3Assessment of metabolic syndrome

The metabolic syndrome is defined by the criteria established by the IDF, ATP III, and JIS (K. Alberti et al., 2005; K. G. M. M. Alberti et al., 2009; Grundy et al., 2005) in Table 1.

Table 1. Definition and threshold values of MetS as established by various organizations

Parameter/criteria	JIS -2009	IDF-2005	NCEP ATP III-2001
Prerequisites for diagnosing MetS	Any three of the following	Abdominal obesity along with any other two	Any three of the following
Waist Cir. (cm	Men >90 Woman> 80	Men >90 Woman> 80	Men >102 Woman> 88
Blood pressure (mmHg)	≥130/85	≥130/85	>130/85
Fasting (mg/dl)	≥100	>100	>110
Triglyceride (mg/dl)	≥150	>150	≥150
HDL-C (mg/dl)	Men < 40 Woman<50	Men < 40 Woman< 50	Men<40 Woman< 50

Blood pressure is assessed using an OMRON™ digital sphygmomanometer on the left arm. Lipid profiles were assessed using standard clinical chemistry methods (autoanalyzer TRX 7010 ®, Tokyo Boeki Medical System, LTD. Japan), whereas the glucose profile was measured by a fingertip capillary blood test (Accu-Chek Performa, Roche Diagnostics GmbH, Mannheim, Germany). All participants fasted for a minimum of 8 hours before blood sample. Waist circumference is measured at the midpoint between the iliac crest and the lowest rib with a flexible steel measuring tape, achieving an accuracy of 0.1 cm.

2.4Analysis of data and prediction of risk factors

The data were analyzed utilizing IBM SPSS Statistics version 25.0. Continuous variables are characterized by the mean and standard deviation (Mean ± SD) as well as percentages (%). The Pearson Chi-Square test was performed to assess the influence of age on the components and risk factors of MetS. The analysis of factors related to MetS and its components was conducted using multivariate logistic regression analysis. A stepwise binary logistic regression model was employed to identify predictors of MetS. The values were assessed for significance at $P < 0.05$.

3.Results and Discussion

3.1Demographic, anthropometric, and biochemical characteristics of a population

The demographic, anthropometric, and biochemical characteristics of the study population from Riskesdas 2018 are presented in Table 2. Men with MetS exhibited significantly elevated mean values in age, abdominal circumference, BMI, systolic pressure, diastolic pressure, fasting blood sugar, and triglycerides, alongside reduced HDL levels compared to men without MetS.

Table 2: Demographic, anthropometric, and biochemical characteristics of study populations from Riskesdas 2018.

Characteristics	Total N=9220 n (%)	No Mets N=7424 n (%)	Mets N=1796 n (%)	P Value
Age	45,2±16,1	44,4 ± 16,6	49,0 ± 13,3	0,0001
Waist circumference (cm)	79,1±12,2	76,4 ± 10,5	90,3 ± 12,6	0,0001
BMI (kg/m^2)	22,6±4,1	21,8 ± 3,6	26,2 ± 4,5	0,0001
Systolic pressure (mmHg)	133,4±22,7	130,3 ± 21,2	146,4 ± 24,4	0,0001
Diastolic pressure (mmHg)	83,4±13,0	81,4 ± 12,1	91,8 ± 13,9	0,0001
Fasting blood sugar (mg/dl)	101,0±27,6	97,5 ± 22,4	115,6 ± 39,9	0,0001
Triglycerides (mg/dl)	132,3±96,5	110,4 ± 59,1	223,3 ± 152,1	0,0001
HDL cholesterol (mg/dl)	45,1±10,1	47,0 ± 9,8	37,4 ± 7,9	0,0001

Characteristics of 9220 men with and without MetS. BMI:Body Mass Index; HDL cholesterol *: High-Density Lipoprotein Cholesterol. Nilai yang signifikan secara statistik diberikan huruf tebal*

3.2The prevalence of MetS based on various criteria and fasting blood glucose levels

This cross-sectional study utilized three distinct criteria to evaluate the prevalence of MetS among 9,220 men in the Riskesdas 2018 dataset. The study population exhibited a highest prevalence rate of 19.05% according to JIS criteria, followed by 11.0% as per IDF criteria, and the lowest prevalence rate of 10.7% based on NCEP/ATP III criteria (Figure 1). The elevated prevalence of MetS according to the JIS criteria can be attributed to the removal of central obesity as a required component, a reduction in the threshold values for glucose levels and waist circumference, and the inclusion of three out of the five parameters specified in the JIS criteria. The NCEP/ATP III criteria, which employ a significantly elevated threshold for waist circumference and glucose levels, resulted in a comparatively low identification rate of MetS patients (Pokharel et al., 2014).

The worldwide prevalence of metabolic syndrome in males varies between 7.9% and 43% (Balkau, 2004; Gupta et al., 2003; Resnick, 2002). The Asia-Pacific region reports the highest prevalence of MetS in men in Malaysia, recorded at 40.2% according to JIS criteria (Mohamud et al., 2012), South Korea trailed with 29.0% according to JIS criteria (Lobene, 2023), China 24.6% according to NCEP ATP III criteria (Li et al., 2018), Mongolia 19,4% according to IDF criteria (Enkh-Oyun et al., 2015), Taiwan 19.5%, according to Taiwanese criteria (Hwang et al., 2006), Sri Lanka 18.4% according to IDF criteria (Katulanda et al., 2012), Philippines 17.5% according to NCEP/ATP III-AHA/NHLBI criteria (Morales et al., 2008) and Singapore 10-13% according to AHA/NHLBI and IDF criteria (Khoo et al., 2007). This study indicates that the prevalence of MetS among men in Indonesia is 19.05%, positioning it as the fourth lowest in the Asia-Pacific region.

The largest prevalence of MetS, according to fasting blood sugar levels (Figure 2), was observed in prediabetic males (JIS 52.0%, IDF 44.7%, NCEP/ATP III 38.1%). The rising incidence of MetS in ostensibly healthy individuals raises significant concerns about the potential danger of imminent diabetes development.

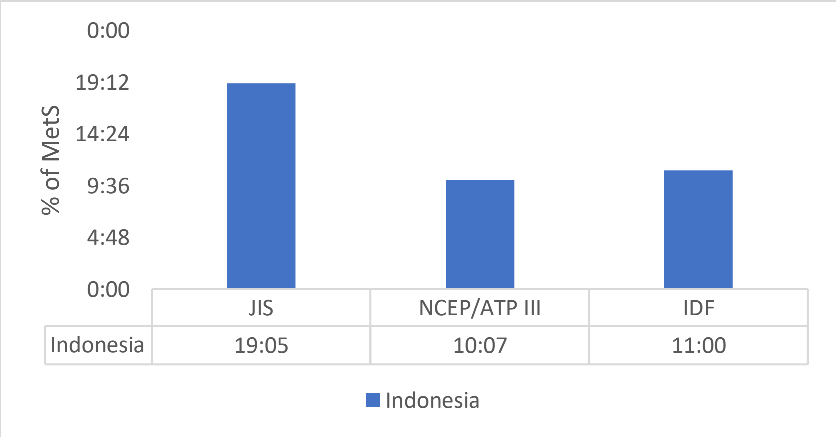


Figure 1: Prevalence of MetS based on diverse diagnostic criteria

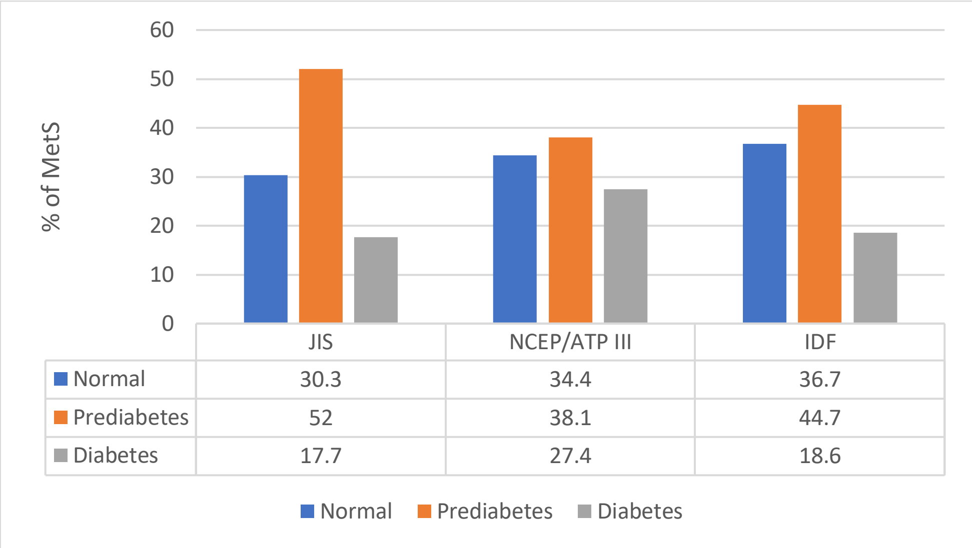


Figure 2: Prevalence of MetS based on fasting blood sugar levels across different diagnostic criteria

3.3The prevalence of MetS across different diagnostic criteria and age groups.

Figure 2 illustrates that the prevalence of males with MetS, irrespective of the criteria employed, exhibited the most significant rise at ages 40-49 and 50-59, namely 28.4% (JIS), 29.5% (NCEP/ATP III), and 30.5% (IDF), as well as 28.2% (JIS), 30% (NCEP/ATP III), and 28.6% (IDF), respectively. A prior analysis of the 2013 RISKESDAS survey data indicated a prevalence of metabolic syndrome of 28% among males aged 45-65 years, according to IDF and AHA/NHLBI criteria (Sigit et al., 2020).

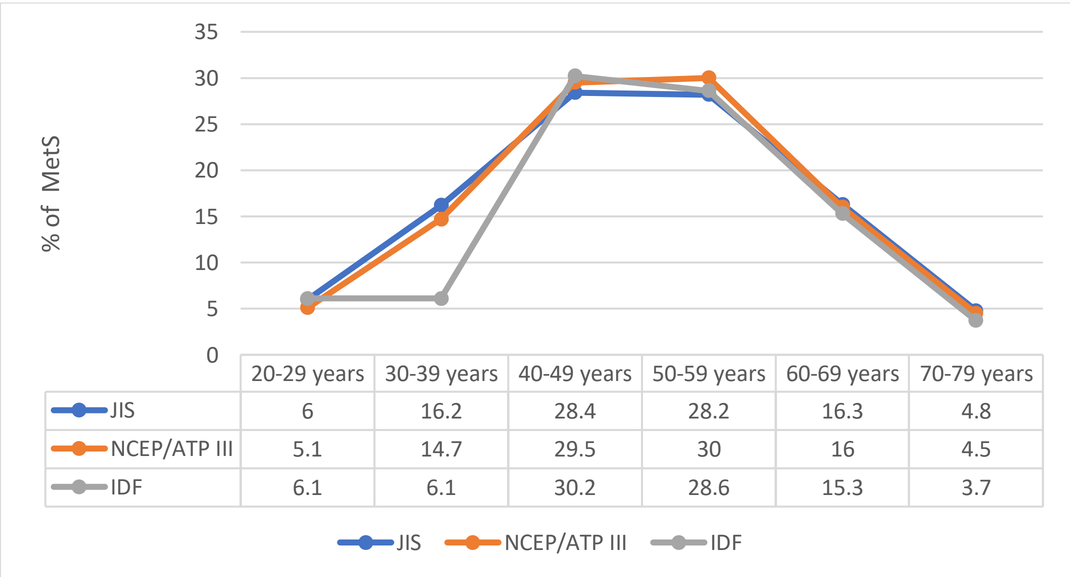


Figure 3: Prevalence of MetS by age according to various diagnostic criteria.

3.4Prevalence of MetS components and risk factors across various age groups based on JIS criteria

The data in Table 3 indicates that the prevalence of men with prediabetes, diabetes, prehypertension, Grade I hypertension, Grade II hypertension, Grade III hypertension, and dyslipidemia (characterized by decreased HDL and elevated triglycerides) significantly escalated starting at ages 30-39, peaked at ages 40-49 and 50-59, and subsequently declined at ages 60-69. The incidence of men exhibiting poor physical activity, a smoking index of 200-400, a smoking index above 400, as well as overweight and obesity level 1, dramatically escalated between the ages of 30-39, peaked at 40-49, and then declined throughout the ages of 60-69.

The elevated incidence of MetS and its components in individuals aged 40-49 and 50-59 may result from a confluence of risk factors, including tobacco use, elevated BMI, reduced physical activity, increased waist circumference, and diminished testosterone levels. Recent data indicates that reduced testosterone levels correlate with many cardiovascular risk factors, such as central obesity, insulin dysregulation, aberrant lipid profiles, and hypertension. (Kupelian et al., 2006). A reduction in testosterone levels may occur in males aged 40 to 70 years. (Shabsigh et al., 2005).

Table 3: Prevalence of MetS Components and Risk Factors by Age According to JIS Criteria

	Riskesdas 2018						
	JIS						
	20-29 year	**30-39 year**	**40-49 year**	**50-59 year**	**60-69 year**	**70-79 year**	**p-value**
Diabetes Status							
Normal	**42 (7,9)**	**115 (21,7)**	**169 (31,8)**	**122 (23,0)**	**71 (13,4)**	**12 (2,3)**	**0.0001**
Prediabetes	**62 (6,9)**	**145 (16,0)**	**257 (28,4)**	**246 (27,2)**	**143 (15,8)**	**52 (5,7)**	
Diabetes	**3 (1,0)**	**23 (7,3)**	**70 (22,4)**	**126 (40,3)**	**71 (22,7)**	**20 (6,4)**	
Hypertensive Status							
Normal	**11 (6,5)**	**49 (29,0)**	**49 (29,0)**	**34 (20,1)**	**21 (12,4)**	**5 (3,0)**	**0.0001**
Prehypertension	**32 (12,8)**	**62 (24,8)**	**72 (28,8)**	**60 (24,0)**	**19 (7,6)**	**5 (2,0)**	
Hypertension I	**15 (6,0)**	**33 (13,1)**	**81 (32,1)**	**85 (33,7)**	**33 (13,1)**	**5 (2,0)**	
Hypertension II	**0 (0,0)**	**5 (6,0)**	**30 (36,1)**	**28 (33,7)**	**18 (21,7)**	**2 (2,4)**	
Hypertension III	**1 (1,0)**	**7 (7,0)**	**34 (34,0)**	**30 (30,0)**	**19 (19,0)**	**9 (9,0)**	
Isolated Systolic Hypertension	**8 (3,4)**	**11 (4,6)**	**42 (17,6)**	**88 (37,0)**	**60 (25,2)**	**29 (12,2)**	
Central Obesity Status							
<90cm	45 (6,1)	120 (16,4)	188 (25,7)	203 (27,7)	130 (17,8)	46 (6,3)	0.057
≥90cm	62 (6,1)	163 (16,0)	308 (30,3)	291 (28,6)	155 (15,2)	38 (3,7)	
HDL Cholestrol							
Normal	**107 (6,2)**	**282 (16,4)**	**491 (28,6)**	**481 (28,0)**	**279 (16,2)**	**79 (4,6)**	**0.0001**
Lower	**0 (0,0)**	**1 (3,3)**	**5 (16,7)**	**13 (43,3)**	**6 (20,0)**	**5 (16,7)**	
Triglycerides							
Normal	**27 (7,2)**	**43 (11,5)**	**89 (23,8)**	**113 (30,2)**	**74 (19,8)**	**28 (7,5)**	**0.0001**
High	**80 (5,8)**	**240 (17,5)**	**407 (29,6)**	**381 (27,7)**	**211 (15,3)**	**56 (4,1)**	
Alcohol Consumption							
Low	8 (25,0)	8 (25,0)	7 (21,9)	6 (18,8)	3 (9,4)	0	0.686
Moderate	4 (13,8)	8 (27,6)	11 (37,9)	5 (17,2)	1 (3,4)	0	
High	1 (25,0)	2 (50,0)	0 (0,0)	1 (25,0)	0 (0,0)	0	
Level Of Physical Activity							
Low	**16 (5,7)**	**46 (16,4)**	**59 (21,1)**	**79 (28,2)**	**59 (21,1)**	**21 (7,5)**	**0.0001**

Moderate	**45 (5,7)**	**119 (15,1)**	**226 (28,6)**	**221 (28,0)**	**129 (16,3)**	**50 (6,3)**	
High	**46 (6,8)**	**118 (17,4)**	**211 (31,1)**	**194 (28,6)**	**97 (14,3)**	**13 (1,9)**	
Fruit Consumption Level							
Low	68 (6,7)	170 (16,7)	294 (28,9)	282 (27,8)	156 (15,4)	46 (4,5)	0.574
Moderate	8 (4,0)	37 (18,7)	59 (29,8)	53 (26,8)	32 (16,2)	9 (4,5)	
High	18 (5,6)	40 (12,5)	93 (29,0)	103 (32,1)	55 (17,1)	12 (3,7)	
Vegetable consumption level							
Low	23 (5,0)	86 (18,8)	121 (26,4)	135 (29,5)	65 (14,2)	28 (6,1)	0.123
Moderate	22 (8,0)	47 (17,1)	81 (29,5)	64 (23,3)	50 (18,2)	11 (4,0)	
High	61 (6,4)	140 (14,6)	283 (29,5)	277 (28,9)	161 (16,8)	38 (4,0)	
Levels of consumption for high-risk foods							
Low	0 (0,0)	3 (13,0)	4 (17,4)	7 (30,4)	6 (26,1)	3 (13,0)	0.062
Moderate	46 (7,9)	96 (16,4)	144 (24,7)	166 (28,4)	101 (17,3)	31 (5,3)	
High	61 (5,4)	184 (16,1)	348 (30,5)	320 (28,1)	178 (15,6)	49 (4,3)	
Smoking Index							
< 200	**23 (5,5)**	**75 (17,8)**	**117 (27,7)**	**115 (27,3)**	**75 (17,8)**	**17 (4,0)**	**0.002**
200-400	**23 (5,8)**	**86 (21,7)**	**124 (31,3)**	**101 (25,5)**	**47 (11,9)**	**15 (3,8)**	
>400	**8 (3,8)**	**18 (8,5)**	**59 (28,0)**	**74 (35,1)**	**41 (19,4)**	**11 (5,2)**	
BMI							
<18,4	**1 (2,5)**	**2 (5,0)**	**6 (15,0)**	**13 (32,5)**	**11 (27,5)**	**7 (17,5)**	**0.0001**
18,5-24,9	**31 (5,0)**	**90 (14,4)**	**145 (23,3)**	**181 (29,1)**	**130 (20,9)**	**46 (7,4)**	
25-29,9	**51 (6,7)**	**124 (16,2)**	**234 (30,6)**	**222 (29,1)**	**106 (13,9)**	**27 (3,5)**	
30,0-34,9	**19 (7,9)**	**42 (17,5)**	**87 (36,3)**	**62 (25,8)**	**26 (10,8)**	**4 (1,7)**	
35,0-39,9	**3 (7,9)**	**11 (28,9)**	**11 (28,9)**	**7 (18,4)**	**6 (15,8)**	**0 (0,0)**	
>40	**0 (0,0)**	**10 (55,6)**	**6 (33,3)**	**2 (11,1)**	**0 (0,0)**	**0 (0,0)**	

The value is expressed as a percentage (%). The Pearson chi-squared test was utilized to compare the prevalence of MetS components across various age groups. HDL: High-Density Lipoprotein, JIS: Joint Interim Societies. Significant results are highlighted in bold.

3.5Factors associated with MetS in Indonesian men based on JIS criteria from the 2018 Riskesdas survey

Furthermore, multivariate analysis of logistic regression prediction models will be conducted on all variables that are statistically significant in the univariate study. In the multivariate analysis, elevated age, raised BMI, heightened smoking index, and reduced physical activity were statistically significant concerning MetS (Table 4).

Table 4: Factors associated with mets in Indonesian men according to JIS criteria from Riskesdas 2018.

	Univariat OR	**95 CI**	**p-value**	**Multivariat** aOR**	**95% CI**	***P* value**
Age						
20-29 year	1.00	-	-	1.00	-	-
30-39 year	**1.91**	**1.50-2.42**	**0.0001**	**1.825**	**1.252-2.662**	**0.002**

40-49 year	**2.73**	**2.18-3.42**	**0.0001**	**2.512**	**1.755-3.597**	**0.000**
50-59 year	**2.94**	**2.35-3.68**	**0.0001**	**3.081**	**2.144-4.428**	**0.000**
60-69 year	**2.44**	**1.92-3.10**	**0.0001**	**2.601**	**1.759-3.846**	**0.000**
70-79 year	**1.89**	**1.39-2.57**	**0.0001**	**2.125**	**1.250-3.613**	**0.005**
BMI						
18,5-24,9	1.00	-	-	1.00	-	-
<u><</u>18,4	**0.33**	**0.24-0.45**	**0.0001**	**0.325**	**0.202-0.525**	**0.000**
25-29,9	**6.13**	**5.41-6.95**	**0.000**	**5.622**	**4.691-6.739**	**0.000**
30,0-34,9	**13.17**	**10.57-16.41**	**0.000**	**13.807**	**9.745-19.563**	**0.000**
35,0-39,9	**12.31**	**7.40-20.48**	**0.000**	**18.900**	**7.232-49.391**	**0.000**
<u>></u>40	**17.76**	**7.69-41.00**	**0.000**	**8.438**	**2.595-27.440**	**0.000**
Smoking Index						
< 200	1.00	-	-	1.00	-	-
200-400	1.18	1.01-1.37	0.033	1.184	0.984-1.425	0.073
>400	**1.92**	**1.59-2.32**	**0.0001**	**1.540**	**1.216-1.951**	**0.000**
Level of physical activity						
High	1.00	-	-	1.00	-	-
Low	**1.48**	**1.27-1.72**	**0.0001**	**1.425**	**1.190-1.707**	**0.000**
Moderate	**1.46**	**1.31-1.64**	**0.0001**	**1.529**	**1.174-1.992**	**0.002**

Logistic regression Model based on the JIS criteria for 9220 men with and without MetS
*** adjusted for age, BMI, level of physical activity, and smoking index. Results of significance are highlighted in bold.*

3.5.1 Age Group

The risk of MetS generally rises with advancing age. The 30-39 year age group exhibited a notable increase in risk, with an odds ratio of 1.91 (p = 0.0001). The risk notably escalated in older age groups, particularly within the 50-59 year group, where the odds ratio reached 2.94 (p=0.0001). In the 70-79 year age group, while the risk remains elevated, the odds ratio decreases to 1.89 (p=0.0001).

3.5.2 Body Mass Index

Risiko MetS cenderung meningkat seiring bertambahnya indeks massa tubuh. BMI 30,0-34,9 dan BMI 35,0-39,9 menunjukkan peningkatan risiko MetS yang signifikan dengan OR sebesar 13,17 (p = 0,0000) dan 12,31 (p=0.000), tertinggi pada BMI <u>></u>40 dengan OR sebesar 17,76 (p = 0,0000).

3.5.3 Smoking Index

The risk of MetS rises with an increasing smoking index. The smoking index of 200-400 and greater than 400 demonstrated a significant elevation in the risk of MetS, with odds ratios of 1.18 (p < 0.05) and 1.92 (p = 0.0001), respectively.

3.5.4 Level of Physical Activity

Moderate and low levels of physical activity correlate with a markedly elevated risk of MetS. In comparison to the high physical activity group, those with moderate and low physical activity exhibited a notable increase in the risk of MetS, with odds ratios of 1.48 (p<0.0001) and 1.46 (p<0.0001), respectively.

3.6 Graded association between advancing age and the prevalence of components associated with MetS.

Figure 4 depicts a graded correlation between advancing age and the prevalence of MetS components. Advancing age markedly influences waist circumference, fasting blood glucose, triglycerides, and HDL cholesterol, beginning at 30-39 years, peaking at 40-49 years and 50-59 years. Prior research indicates that obese teenage boys exhibit a greater risk of developing insulin resistance and impaired fasting glucose (IFG) than their obese adolescent female counterparts. This results from greater insulin sensitivity in women compared to males, along with variances in metabolic control attributable to differences in muscle mass, adipocytes, and hormonal levels between the sexes. Women possess a greater percentage of body fat, predominantly localized in the lower body, exhibit lower lean body mass, contain more subcutaneous adipose tissue (located in the abdomen and gluteofemoral regions), and demonstrate higher insulin sensitivity. Conversely, men accumulate more visceral fat in the abdomen or upper body, have higher lean body mass, and exhibit reduced sensitivity to insulin action. Men with IFG are classified as prediabetic and are at elevated risk of progressing to T2DM in the future (Unwin et al., 2002). This highlights the significance of MetS preventive initiatives beginning in youth.

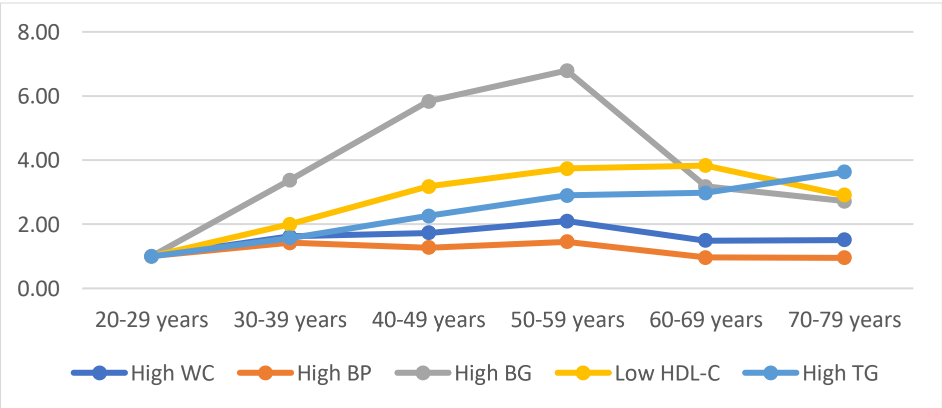


Figure 4: Graded association between advancing age and the prevalence of MetS components. WC, waist circumference; HDL-C, high-density lipoprotein-cholesterol; BP, blood pressure; BG, blood glucose; TG, triglyceride.

3.7 Graded relationship between BMI increase and the prevalence of components associated with MetS.

Figure 5 depicts a graded correlation between elevated BMI and the prevalence of MetS components. A BMI greater than 25 signifies a notable rise in the prevalence of all components of MetS. The findings align with prior research.(Aminuddin et al., 2013; Jahangiry et al., 2019; Manaf et al., 2021; Tsai et al., 2011). In individuals with obesity, adipose cells release free fatty acids and cytokines, including tumor necrosis factor-alpha (TNF-a). These substances inhibit phosphatidylinositol-3-kinase-dependent signaling pathways, resulting in decreased glucose uptake in the liver and skeletal muscles.(Arner, 2002; Cornier et al., 2008). This condition leads to hyperglycemia or diabetes. As individuals age, blood vessels often undergo a gradual loss of elasticity, an increase in resistance, and a reduction in blood flow. When circulation is inadequate, lipids tend to build up in the stomach and release free fatty acids into the serum, leading to heightened insulin resistance and an elevation in serum triglycerides (Ai et al., 2010).

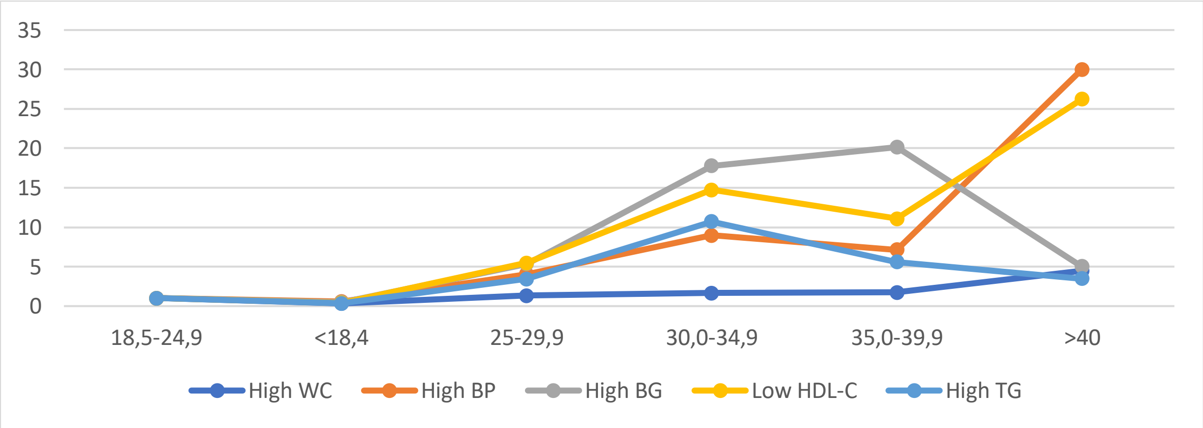


Figure 5: Graded association between BMI and the prevalence of MetS components. WC, waist circumference; HDL-C, high-density lipoprotein-cholesterol; BP, blood pressure; BG, blood glucose; TG, triglyceride.

3.8 Graded relationship between elevated smoking index and prevalence of metabolic syndrome components

Figure 6 depicts the hierarchical correlation between the escalation of the smoking index and the prevalence of MetS components. A smoking index greater than 200 signifies a substantial rise in the prevalence of all components of Metabolic Syndrome (MetS). This data aligns with prior research, indicating that smoking is linked to elevated total cholesterol and low-density lipoprotein levels, while decreasing high-density lipoprotein, which is protective for the heart. Ceasing smoking was correlated with a reduction in the probability of MetS after a specific duration. (Ai et al., 2010).

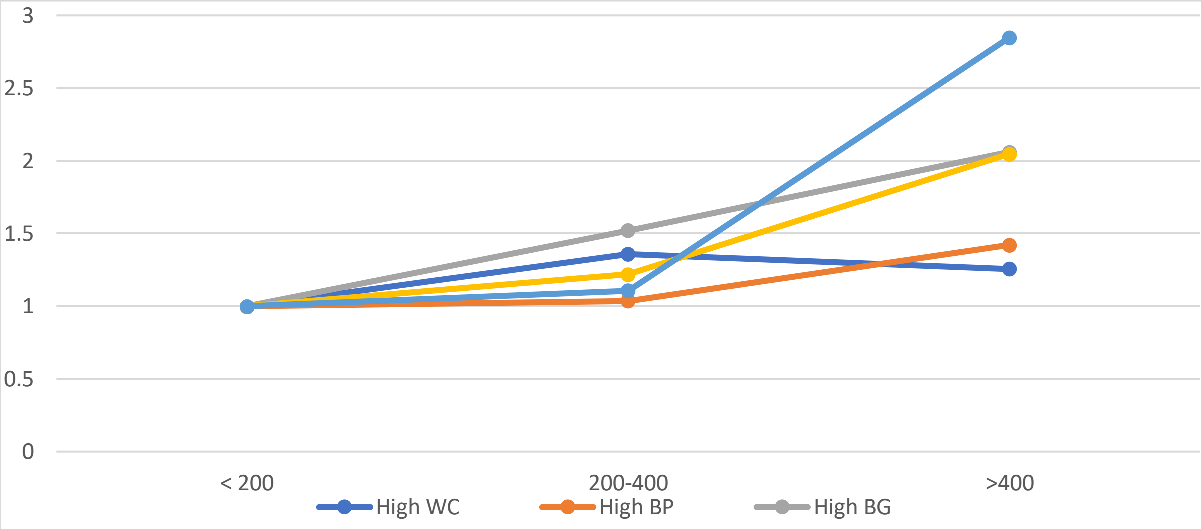
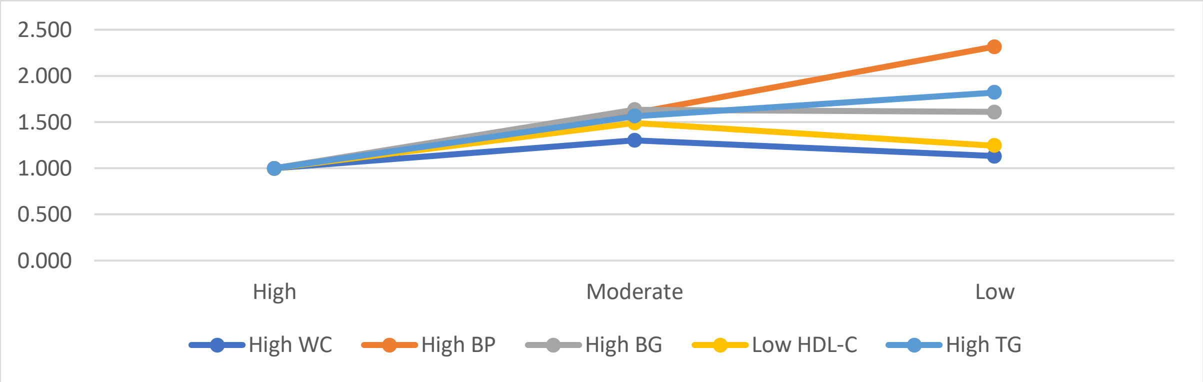


Figure 6: Graded association between ssmoking index and the prevalence of MetS components. WC, waist circumference; HDL-C, high-density lipoprotein-cholesterol; BP, blood pressure; BG, blood glucose; TG, triglyceride.

3.9 Graded association between physical activity with the prevalence of MetS and its components.

Figure 7 depicts the hierarchical correlation between reduced physical activity and the prevalence of the MetS component. Moderate and low physical activity demonstrated a notable rise in the prevalence of all components of MetS. A low degree of physical fitness is a primary risk factor for MetS and overall mortality (Hong et al., 2014; M.J. et al., 2016) Regular exercise exerts an anti-inflammatory effect linked to a reduction in visceral fat mass, which subsequently lowers the release of proinflammatory adipokines (Gleeson et al., 2011). Physical exercise has been demonstrated to stimulate anti-inflammatory cytokines, including soluble IL-1 receptor antagonist (IL-1RA) and IL-10 receptor antagonists, while diminishing the synthesis of pro-inflammatory cytokines IL-1β and TNF-α (Allen et al., 2015). Regular exercise has demonstrated the capacity of cells to more effectively detoxify substantial quantities of reactive oxygen species in both individuals and the elderly (Simioni et al., 2018).



Gambar 7: Graded association between physical activity and the prevalence of MetS components. WC, waist circumference; HDL-C, high-density lipoprotein-cholesterol; BP, blood pressure; BG, blood glucose; TG, triglyceride.

4. Limitations

This study presents several limitations. The study constitutes a retrospective observational analysis utilizing existing databases from a defined period, rather than involving long-term repeated observations. Secondly, smoking behavior and alcohol consumption were assessed through self-reported measures in the study, which may be influenced by social desirability bias. This situation is plausible, as Indonesia is influenced by cultural and religious norms that may lead respondents in the current sample to under-report alcohol consumption due to stringent social ethics or societal stigmatization. Third, the Riskesdas 2018 data set lacked information on potential confounding factors such as testosterone levels, vigorous sports participation, and recreational activities. Fourth, the initial assessment of MetS parameters by first responders may result in an increased prevalence of hypertension, diabetes, and dyslipidemia. In respondents whose medical problems were managed by compliance with antihypertensive medications, oral hypoglycemic agents, or behavioral treatments, a reduction in the prevalence rates of hypertension, diabetes, or hyperlipidemia would be observed at the time of the research. Fifth, our sample from the 2018 Riskesdas survey may not adequately represent Indonesia's actual population.

5.Conclusion

The assessment of MetS using JIS criteria yielded the greatest prevalence at 19.50% compared to other criteria. The incidence of males with MetS, irrespective of the criterion applied, exhibited the most significant rise at ages 40-49 years (28.4% JIS criteria, 29.5% NCEP/ATP III criteria, 30.5% IDF criteria) and at ages 50-59 years (28.2% JIS criteria, 30% NCEP/ATP III criteria, 28.6% IDF criteria). Key variables associated with MetS in the whole sample included age between 30 and 79 years, overweight status, obesity levels I, II, and III, a smoking index of 200-400, a smoking index beyond 400, moderate physical activity, and poor physical activity. These variables elevate the risk of MetS by augmenting waist size, blood pressure, fasting blood glucose, and triglyceride levels, while diminishing HDL levels. Intervention for MetS may start at age 30 and continue until age 79, focusing on lifestyle modifications, particularly dietary adjustments that involve decreasing the consumption of high-fat and high-glucose fast food items. The Dietary Approaches to Stop Hypertension (DASH) is a diet characterized by low sodium content and a high intake of fiber vegetables and fruits. DASH is low in saturated fat and cholesterol. Augmenting nitrate consumption by 250 mg per day or more via high-nitrate foods, such as around 80 g of beets or less than one cup of fresh spinach daily, might mitigate the risk of salt-induced hypertension. Enhanced physical activity, achieved through a blend of continuous exercise and interval training, should be tailored to individual physical capabilities to facilitate weight reduction to an optimal level. Health promotion initiatives targeting smoking prevention and cessation can be implemented via social marketing, mass media campaigns, motivational interviewing, peer education, community mobilization, media advocacy, and contextual interventions. Longitudinal studies are advised to ascertain the causative impact of these risk variables for metabolic syndrome, cardiovascular events, and T2DM.

6. Ethics approval and data access permissions

The Riskesdas protocol obtained ethical approval from the Ethics Commission of Balitbangkes, identified by the number LB02.01/3/KE 024/2018. The Ministry of Health of the Republic of Indonesia has approved the use of the Riskesdas 2018 data sheet, with the approval number 24076A80A49D4219.

References

Ai, M., Otokozawa, S., Asztalos, B. F., Ito, Y., Nakajima, K., White, C. C., Cupples, L. A., Wilson, P. W., & Schaefer, E. J. (2010). Small dense LDL cholesterol and coronary heart disease: Results from the Framingham offspring study. Clinical Chemistry, 56(6). https://doi.org/10.1373/clinchem.2009.137489

Alberti, K. G. M. M., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., Fruchart, J. C., James, W. P. T., Loria, C. M., & Smith, S. C. (2009). Harmonizing the metabolic syndrome: A joint interim statement of the international diabetes federation task force on epidemiology and prevention; National heart, lung, and blood institute; American heart association; World heart federation; International atherosclerosis society; And international association for the study of obesity. In Circulation (Vol. 120, Issue 16). https://doi.org/10.1161/CIRCULATIONAHA.109.192644

Alberti, K., Zimmet, P., & Shaw, J. (2005). IDF Epidemiology Task Force Consensus Group. The metabolic syndrome: a new worldwide definition. The Lancet, 366.

Aldhoon-Hainerová, I., Zamrazilová, H., Dušátková, L., Sedláčková, B., Hlavatý, P., Hill, M., Hampl, R., Kunešová, M., & Hainer, V. (2014). Glucose homeostasis and insulin resistance: Prevalence, gender differences and predictors in adolescents. Diabetology and Metabolic Syndrome, 6(1). https://doi.org/10.1186/1758-5996-6-100

Allen, J., Sun, Y., & Woods, J. A. (2015). Exercise and the Regulation of Inflammatory Responses. Progress in Molecular Biology and Translational Science, 135. https://doi.org/10.1016/bs.pmbts.2015.07.003

Aminuddin, A., Zakaria, Z., Fuad, A. F., Kamsiah, J., Othman, F., Das, S., Kamisah, Y., Qodriyah, H. S., Jubri, Z., Nordin, N. A. M., & Ngah, W. Z. (2013). High C reactive protein associated with increased pulse wave velocity among urban men with metabolic syndrome in Malaysia. Saudi Medical Journal, 34(3).

Arner, P. (2002). Insulin resistance in type 2 diabetes: Role of fatty acids. Diabetes/Metabolism Research and Reviews, 18(SUPPL. 2). https://doi.org/10.1002/dmrr.254

Balkau, B. (2004). Smoking, type 2 diabetes and metabolic syndrome. In Diabetes and Metabolism (Vol. 30, Issue 2). https://doi.org/10.1016/S1262-3636(07)70096-4

Cornier, M. A., Dabelea, D., Hernandez, T. L., Lindstrom, R. C., Steig, A. J., Stob, N. R., Van Pelt, R. E., Wang, H., & Eckel, R. H. (2008). The metabolic syndrome. In Endocrine Reviews (Vol. 29, Issue 7). https://doi.org/10.1210/er.2008-0024

Enkh-Oyun, T., Kotani, K., Davaalkham, D., Davaa, G., Ganchimeg, U., Angarmurun, D., Khuderchuluun, N., Batzorig, B., Tsuboi, S., Ae, R., Aoyama, Y., & Nakamura, Y. (2015). Epidemiologic features of metabolic syndrome in a general mongolian population. Metabolic Syndrome and Related Disorders, 13(4). https://doi.org/10.1089/met.2014.0067

Federation, I. D. (2021). IDF Diabetes Atlas Tenth edition 2021. International Diabetes Federation.

Gleeson, M., Bishop, N. C., Stensel, D. J., Lindley, M. R., Mastana, S. S., & Nimmo, M. A. (2011). The anti-inflammatory effects of exercise: Mechanisms and implications for the prevention and treatment of disease. In Nature Reviews Immunology (Vol. 11, Issue 9). https://doi.org/10.1038/nri3041

Grundy, S. M. (2008). Metabolic syndrome pandemic. In Arteriosclerosis, Thrombosis, and Vascular Biology (Vol. 28, Issue 4). https://doi.org/10.1161/ATVBAHA.107.151092

Grundy, S. M., Cleeman, J. I., Daniels, S. R., Donato, K. A., Eckel, R. H., Franklin, B. A., Gordon, D. J., Krauss, R. M., Savage, P. J., Smith, S. C., Spertus, J. A., & Costa, F. (2005). Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute scientific statement. In Circulation (Vol. 112, Issue 17). https://doi.org/10.1161/CIRCULATIONAHA.105.169404

Guo, H., Liu, J., Zhang, J., Ma, R., Ding, Y., Zhang, M., He, J., Xu, S., Li, S., Yan, Y., Mu, L., Rui, D., Niu, Q., & Guo, S. (2016). The prevalence of metabolic syndrome using three different diagnostic criteria among low earning nomadic kazakhs in the far northwest of China: New cut-off points of waist circumference to diagnose mets and its implications. PLoS ONE, 11(2). https://doi.org/10.1371/journal.pone.0148976

Gupta, A., Gupta, R., Sarna, M., Rastogi, S., Gupta, V. P., & Kothari, K. (2003). Prevalence of diabetes, impaired fasting glucose and insulin resistance syndrome in an urban Indian population. Diabetes Research and Clinical Practice, 61(1). https://doi.org/10.1016/S0168-8227(03)00085-8

Herningtyas, E. H., & Ng, T. S. (2019). Prevalence and distribution of metabolic syndrome and its components among provinces and ethnic groups in Indonesia. BMC Public Health, 19(1). https://doi.org/10.1186/s12889-019-6711-7

Hong, S., Lee, J., Park, J., Lee, M., Kim, J. Y., Kim, K. C., Kim, S. H., Im, J. A., Chu, S. H., Suh, S. H., Kim, S. H., & Jeon, J. Y. (2014). Association between cardiorespiratory fitness and the prevalence of metabolic syndrome among Korean adults: A cross sectional study. BMC Public Health, 14(1). https://doi.org/10.1186/1471-2458-14-481

Hwang, L. C., Bai, C. H., & Chen, C. J. (2006). Prevalence of obesity and metabolic syndrome in Taiwan. Journal of the Formosan Medical Association, 105(8). https://doi.org/10.1016/S0929-6646(09)60161-3

International Diabetes Federation. (2020). IDF Consensus Worldwide Definition of the Metabolic Syndrome. Digestive Diseases, 28(1).

Jahangiry, L., Khosravi-Far, L., Sarbakhsh, P., Kousha, A., Entezarmahdi, R., & Ponnet, K. (2019). Prevalence of metabolic syndrome and its determinants among iranian adults: Evidence of IraPEN survey on a bi-ethnic population. Scientific Reports, 9(1). https://doi.org/10.1038/s41598-019-44486-8

Katulanda, P., Ranasinghe, P., Jayawardana, R., Sheriff, R., & Matthews, D. R. (2012). Metabolic syndrome among Sri Lankan adults: Prevalence, patterns and correlates. Diabetology and Metabolic Syndrome, 4(1). https://doi.org/10.1186/1758-5996-4-24

Khoo, C. M., Liew, C. F., Chew, S. K., & Tai, E. S. (2007). The impact of central obesity as a prerequisite for the diagnosis of metabolic syndrome. Obesity, 15(1). https://doi.org/10.1038/oby.2007.559

Kupelian, V., Shabsigh, R., Araujo, A. B., O’Donnell, A. B., & McKinlay, J. B. (2006). Erectile Dysfunction as a Predictor of the Metabolic Syndrome in Aging Men: Results From the Massachusetts Male Aging Study. Journal of Urology, 176(1). https://doi.org/10.1016/S0022-5347(06)00503-9

Li, Y., Zhao, L., Yu, D., Wang, Z., & Ding, G. (2018). Metabolic syndrome prevalence and its risk factors among adults in China: A nationally representative cross-sectional study. PLoS ONE, 13(6). https://doi.org/10.1371/journal.pone.0199293

Lobene, A. J. (2023). The Increasing Prevalence of Metabolic Syndrome in Korea. JACC: Asia, 3(3). https://doi.org/10.1016/j.jacasi.2023.05.004

Manaf, M. R. A., Nawi, A. M., Tauhid, N. M., Othman, H., Rahman, M. R. A., Yusoff, H. M., Safian, N., Ng, P. Y., Manaf, Z. A., Kadir, N. B. A., Yanasegaran, K., Basir, S. M. A., Ramakrishnappa, S., & Ganasegeran, K. (2021). Prevalence of metabolic syndrome and its associated risk factors among staffs in a Malaysian public university. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-87248-1

M.J., B., R.K., H., Z., D., D.I., F., S.P., W., K., N., R.S., B., C.A., B., J.K., E., & S.J., K. (2016). Age-dependent prognostic value of exercise capacity and derivation of fitne-aociated biologic age. In Heart (Vol. 102, Issue 6).

Mohamud, W. N. W., Ismail, A. al S., Khir, A. S. M., Ismail, I. S., Musa, K. I., Kadir, K. A., Kamaruddin, N. A., Yaacob, N. A., Mustafa, N., Ali, O., Isa, S. H. M., & Bebakar, W. M. W. (2012). Prevalence of metabolic syndrome and its risk factors in adult Malaysians: Results of a nationwide survey. In Diabetes Research and Clinical Practice (Vol. 96, Issue 1). https://doi.org/10.1016/j.diabres.2011.11.020

Morales, D. D., Punzalan, F. E. R., Paz-Pacheco, E., Sy, R. G., & Duante, C. A. (2008). Metabolic syndrome in the Philippine general population: Prevalence and risk for atherosclerotic cardiovascular disease and diabetes mellitus. Diabetes and Vascular Disease Research, 5(1). https://doi.org/10.3132/dvdr.2008.007

Moy, F. M., & Bulgiba, A. (2010). The modified NCEP ATP III criteria maybe better than the IDF criteria in diagnosing Metabolic Syndrome among Malays in Kuala Lumpur. BMC Public Health, 10. https://doi.org/10.1186/1471-2458-10-678

Pokharel, D. R., Khadka, D., Sigdel, M., Yadav, N. K., Acharya, S., Kafle, R. C., & Shukla, P. S. (2014). Prevalence of metabolic syndrome in Nepalese type 2 diabetic patients according to WHO, NCEP ATP III, IDF and Harmonized criteria. Journal of Diabetes and Metabolic Disorders, 13(1). https://doi.org/10.1186/s40200-014-0104-3

Resnick, H. E. (2002). Metabolic syndrome in American Indians. In Diabetes care (Vol. 25, Issue 7). https://doi.org/10.2337/diacare.25.7.1246

Saklayen, M. G. (2018). The Global Epidemic of the Metabolic Syndrome. In Current Hypertension Reports (Vol. 20, Issue 2). https://doi.org/10.1007/s11906-018-0812-z

Shabsigh, R., Katz, M., Yan, G., & Makhsida, N. (2005). Cardiovascular issues in hypogonadism and testosterone therapy. American Journal of Cardiology, 96(12 SUPPL. 2). https://doi.org/10.1016/j.amjcard.2005.10.009

Sigit, F. S., Tahapary, D. L., Trompet, S., Sartono, E., Willems Van Dijk, K., Rosendaal, F. R., & De Mutsert, R. (2020). The prevalence of metabolic syndrome and its association with body fat distribution in middle-aged individuals from Indonesia and the Netherlands: A cross-sectional analysis of two population-based studies. Diabetology and Metabolic Syndrome, 12(1). https://doi.org/10.1186/s13098-019-0503-1

Simioni, C., Zauli, G., Martelli, A. M., Vitale, M., Sacchetti, G., Gonelli, A., & Neri, L. M. (2018). Oxidative stress: Role of physical exercise and antioxidant nutraceuticals in adulthood and aging. In Oncotarget (Vol. 9, Issue 24). https://doi.org/10.18632/oncotarget.24729

Subramani, S. K., Mahajan, S., Chauhan, P., Yadav, D., Mishra, M., Pakkirisamy, U., & Prasad, G. B. K. S. (2019). Prevalence of metabolic syndrome in Gwalior region of Central India: A comparative study using NCEP ATP III, IDF and Harmonized criteria. Diabetes and Metabolic Syndrome: Clinical Research and Reviews, 13(1). https://doi.org/10.1016/j.dsx.2018.12.003

Tsai, T. Y., Cheng, J. F., & Lai, Y. M. (2011). Prevalence of metabolic syndrome and related factors in taiwanese high-tech industry workers. Clinics, 66(9). https://doi.org/10.1590/S1807-59322011000900004

Unwin, N., Shaw, J., Zimmet, P., & Alberti, K. G. M. M. (2002). Impaired glucose tolerance and impaired fasting glycaemia: The current status on definition and intervention. Diabetic Medicine, 19(9). https://doi.org/10.1046/j.1464-5491.2002.00835.x