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The impact of diet quality on Metabolic Syndrome risk among fishermen and oil palm farmers: A case-control study using the Healthy Diet Indicator (HDI)

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ABSTRACT

Background: Metabolic Syndrome (MetS) is a cluster of risk factors that increase the likelihood of developing cardiovascular disease (CVD) and diabetes mellitus (DM). In Indonesia, the prevalence of MetS is rising, with fishermen and oil palm farmers showing higher rates compared to other populations. This study aimed to examine the association between diet quality and MetS risk in these populations, using the Healthy Diet Indicator (HDI) as a predictor variable.

Methods: This community-based case-control study included 240 participants aged 35 to 60 years, divided into four groups: fishermen and oil palm farmers with (cases) and without (controls) MetS. Data collection took place between April and July 2024, covering sociodemographic characteristics, anthropometric measurements, blood pressure, lipid profile, blood glucose levels, and diet quality. Diet quality was assessed using the Healthy Diet Indicator (HDI) based on 24-hour dietary recall. Binary logistic regression was conducted to evaluate the effect of diet quality on MetS risk. The HDI score was entered as a continuous variable to determine whether higher or lower scores influence MetS risk.

Results: This should say reduced MetS risk, based on correct interpretation of the Odds Ratio (>1 for protective factor when inverse coded). Other factors such as smoking status, age, and income did not show significant effects. In contrast, among farmers, a higher HDI score was also linked to increased MetS risk (OR=1.880, p=0.000), with income emerging as another significant predictor (p=0.018). Further analysis is needed to explore potential cut-off points for HDI that may better define risk thresholds.

Conclusion: Diet quality, as measured by HDI, appears to be a significant factor influencing the risk of MetS among fishermen and oil palm farmers. However, the association suggests that a higher HDI score may not always indicate a lower risk. These findings highlight the need for targeted dietary interventions and further research to refine dietary assessment tools in these populations.

KEYWORDS

Chronic diseases, Cardiovascular risk, Dietary pattern, Lifestyle, Metabolic assessment.

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INTRODUCTION

Metabolic syndrome (MetS) consists of risk factors that increase the likelihood of cardiovascular disease (CVD) and diabetes mellitus (DM)[1]. The risk factors for MetS include central obesity, hypertension, dyslipidemia, and insulin resistance[2,3]. CVD is the leading cause of death worldwide, including in Indonesia, where the prevalence of CVD is high among fishermen (1.3%) and farmers (1.5%)[4]. The increase in MetS prevalence aligns with the global rise in obesity (82% between 1990-2021) and the expected 68% increase in DM prevalence from 2021-2045[5]. In Indonesia, the prevalence of MetS increased from 23% in 2013 to 24.4% in 2018[4]. Studies show that the Acehnese ethnic group has a higher prevalence of MetS (45.5%) compared to other ethnic groups[6] and among fishermen and farmers, the prevalence of MetS is significantly high at 29.3% in fishermen and 16.3% in farmers[7].

MetS is influenced by modifiable factors, such as diet, smoking habits, physical activity, and socioeconomic status[8]. Fishermen and oil palm farmers, despite coming from different socioeconomic groups, have dietary patterns and physical activity habits that affect their metabolic health. Fishermen often face economic instability and food insecurity[9], while oil palm farmers are affected by price fluctuations and harvest outcomes[10], which also influence their dietary patterns and health. Diet quality plays a key role in the management and prevention of MetS. A poor diet, characterized by the consumption of processed carbohydrates, sugars, and trans fats, increases the risk of MetS, while a diet rich in fiber, healthy fats, and micronutrients can help lower the risk[11]. An imbalanced diet, with high consumption of processed carbohydrates and sugar, can worsen metabolic conditions and contribute to the rising prevalence of MetS. In contrast, a balanced diet, containing high fiber and healthy fats, can reduce the risk of heart disease and diabetes[12].

To objectively evaluate diet quality, this study uses the Healthy Diet Indicator (HDI), which is a standardized tool for assessing how closely an individual's diet aligns with evidence-based healthy diet recommendations. The HDI, as a global indicator for diet recommendations by the WHO to prevent chronic diseases, is used in research worldwide to assess diet quality. It has been developed since 1990 and updated in 2020[13]. The HDI is valuable in depicting overall diet quality and can identify clearer relationships between dietary patterns and disease risks such as MetS. A recent meta-analysis of 10 cohorts from Europe and the United States investigated the link between adherence to the HDI and mortality due to cardiovascular diseases[14]. Previous research has shown that good diet quality is associated with reduced risk of CVD and DM, as well as overall improvement in metabolic profiles. Therefore, good diet quality, coupled with adequate physical activity, can serve as an important protective factor against MetS. This study aims to explore the impact of diet quality on the risk of metabolic syndrome among the spouses of fishermen and oil palm farmers in Indonesia.

MATERIALS AND METHODS

Study Design and Participants

This is a community-based case-control study involving fishermen and oil palm farmers aged >35 to 60 years. Data were collected from April to July 2024. The study was conducted in Aceh, Indonesia. Each community was divided into case groups (husband-wife pairs diagnosed with metabolic syndrome) and control groups (husband-wife pairs without metabolic syndrome), based on their metabolic health status. Sampling was purposively conducted, considering the relevant characteristics of the subjects. This study involves husband-wife pairs working as fishermen and oil palm farmers. The study sample was selected using purposive sampling, with a total of 240 respondents. The respondents included 120 fishermen (60 cases and 60 controls) and 120 oil palm farmers (60 cases and 60 controls). Inclusion criteria included husbands working as fishermen or oil palm farmers, aged between 35 and 65 years, and willing to participate in the study. The exclusion criteria included individuals with specific medical conditions that may affect the results of the study, such as severe cardiovascular disease.

Data Collection

Metabolic Syndrome. Metabolic syndrome screening was performed by measuring lipid profiles (total cholesterol, LDL, HDL, and triglycerides in mg/dL), fasting blood glucose (mg/dL), blood pressure (mmHg), and waist circumference (cm). Measurements were taken at the Lhokseumawe Regional Hospital laboratory. Before the examination, all participants provided written informed consent. This study was conducted following the ethical guidelines established by the Ethics Commission of the Faculty of Medicine, Malikussaleh University (No: 16/KEPK/FKUNIMAL-RSCU/2024).

Sociodemographic and Anthropometric Characteristics. Data on respondents' sociodemographic characteristics and lifestyle were collected through interviews using a standardized questionnaire. Participants were classified based on smoking status as either non-smokers or active smokers. Weight (kg) and height (cm) were measured with precision of 0.1 kg and 0.1 cm, respectively, while participants wore light clothing and no shoes. Waist circumference (cm) was measured at the midpoint between the lower rib and iliac crest using a **non-stretchable measuring tape with 0.1 cm precision,** and hip circumference (cm) was measured over light clothing using a non-stretchable measuring tape. Body mass index (BMI, kg/m²) was calculated as weight (kg) in divided by height squared (m²).

Diet Quality. Diet quality was measured using the total score of the Healthy Diet Indicator (HDI) for each component. The HDI score was obtained from a 24-hour recall. HDI is an instrument for assessing adherence to international diet guidelines for chronic disease prevention developed by WHO in 1990. This instrument was developed and used by several studies[16]. HDI consists of eleven items with a score range from 0 to 11. If an individual's score is within the range recommended by WHO Guidelines, the variable is coded as 1; otherwise, it is coded as 0. The 11 HDI items are: whole grains, legumes, fruits and vegetables, nuts and seeds, dietary fiber, sodium, total fat, simple sugars, saturated fatty acids (SFA), processed meats, and unprocessed red meats. In general, the recommendations suggest increasing the consumption of five main items and limiting the intake of six others in everyday food. The total HDI score is categorized as high adherence if the score is ≥6 and low adherence if the total score is 0–5.

Blood Pressure. Blood pressure (BP) was measured in a sitting position using the right arm with an automatic blood pressure monitor (OMRON Automatic Blood Pressure Monitor Model HEM-7200) after the subject rested for a minimum of five minutes. Two consecutive measurements were taken five minutes apart. High blood pressure was defined as a systolic blood pressure (SBP) greater than 135 mmHg and/or a diastolic blood pressure (DBP) greater than 90 mmHg[15].

Lipid Profile. Total cholesterol, HDL, LDL, triglycerides, and fasting blood glucose were measured through venous blood samples (5 mL) collected after 10 hours of fasting. Sample collection was performed by a certified phlebotomist at the Lhokseumawe Regional Hospital. Lipid profiles were analyzed using the enzymatic colorimetric method (Selectra-E Analyzer certified laboratory). LDL cholesterol was calculated using the Friedewald formula.

Statistical Analysis

Data were analyzed using IBM SPSS version 27 with a significance level of $p < 0.05$. Univariate analysis was used to describe the frequency distribution of sociodemographic variables, diet quality, and lipid profiles. Bivariate analysis: The chi-square test was applied to examine the relationship between categorical variables, while independent t-tests were used to compare numerical variables between the case and control groups. Multivariate analysis: Binary logistic regression analysis was performed to evaluate the relationship between diet quality with metabolic syndrome. The regression model was adjusted for confounding variables such as age and smoking status. Regression results are presented in terms of Odds Ratios (OR) with 95% Confidence Intervals (CI).

RESULTS

Sociodemographic characteristics

Table 1 presents the sociodemographic characteristics of participants, highlighting comparisons between the metabolic syndrome (MetS) case group and the control group in both fisherman and farmer communities. The results revealed that the

Table 1. Sociodemographic characteristics of Metabolic Syndrome cases and Non-Metabolic Syndrome controls, based on fishermen and farmer communities

Variable	Fisherman		p-value	Farmer		p-value
	MetS	NotMetS		MetS	NotMetS	
Age (years)	50.53±7.94	48.72±6.76	0.139	48.55±7.09	46.93±6.75	0.608
Education (years)	7.10±2.73	7.15±3.37		7.13±2.79	7.47±3.78	
Income	Rp 2.574.889±772179	Rp 2.629.611±731216	0.844	Rp 2.9944.726±1143468	Rp3.450.500±	0.179
BMI (Body Mass Index)	26.23±3.91	21.61±3.03	0.078	24.76±4.50	22.43±4.37	0.280
Body Fat Composition	30.52±7.68	26.742±8.67		28.88±8.70	27.72±8.53	
Waist Circumference	90.50±8.36	75.82±7.44	0.028[a]	84.73±12.04	77.02±11.29	0.458
Waist-Hip Ratio	0.95±0.05	0.84±0.06	0.129	0.92±0.07	0.87±0.08	0.431
Blood Pressure Systolic Diastolic	138.75±25.82 88.16±13.16	119±13.13 73.95±8.56	0.006[a] 0.057	129.46±24.47 82.28±13.968	125.16±21.60 75.84±13.66	0.000[a] 0.000[a]
Smoking Status Yes No	24 (40%) 36 (60%)	28 (46.7%) 32 (53.3%)	0.000[b]	21 (35%) 39 (65%)	19 (31.7%) 41 (68.3%)	0.846
Total Cholesterol (mg/dL)	237.20±44.889	186.78±31.81	0.042[a]	229.57±48.56	192.02±31.96	0.000[a]
LDL-C (mg/dL)	122.43±37.95	87.98±20.64	0.000[a]	119.65±37.78	93.97±23.74	0.000[a]
HDL-C (mg/dL)	48.13±7.38	46.50±3.91	0.032[a]	47.50±7.21	45.55±4.57	0.055[a]
Triglycerides (mg/dL)	136.10±47.39	91.50±19.91	0.000[a]	124.63±39.23	112.65±38.96	0.000[a]
Fasting Blood Glucose (mg/dL)	153.87±63.82	100.35±21.84	0.000[a]	136.50±56.71	116.60±50.96	0.257
Blood Pressure SystolicDiastolic	138.75±25.82 88.16±13.16	119±13.13 73.95±8.56	0.006[a] 0.057[a]	129.46±24.47 82.28±13.968	125.16±21.60 75.84±13.66	0.000[a] 0.005[a]

[a] Significant difference between case and control using uji t test; [b] Significant difference between case and control using Chi-square test.

average age in the fisherman community was higher for the MetS case group (50.53 ± 7.94 years) compared to the control group (48.72 ± 6.76 years), though the difference was not statistically significant (p = 0.139). Similarly, in the farmer community, the MetS case group had a higher average age (48.55 ± 7.09 years) than the control group (46.93 ± 6.75 years), but this difference was also not significant (p = 0.608). Educational attainment did not differ significantly between the MetS case and control groups in either community, with similar average levels of formal schooling observed (Table 1). Income comparisons also showed no significant differences, as the average income in the fisherman community was Rp 2,574,889 ± 772,179 for the MetS case group and Rp 2,629,611 ± 731,216 for the control group (p = 0.844). Likewise, in the farmer community, the MetS case group had an average income of Rp 2,994,726 ± 1,143,468 compared to Rp 3,450,500 ± 1,165,500 in the control group (p = 0.179). These findings indicate that age, education, and income were not significantly associated with MetS in the populations studied, suggesting that sociodemographic factors may not play a central role in the development of MetS. However, given the higher mean age in the MetS groups, future research should investigate whether aging-related metabolic changes influence MetS prevalence in these communities. Further exploration into other potential determinants, such as lifestyle and genetic factors, is recommended to better understand the prevalence of MetS in these communities.

Anthropometric Measurements and Metabolic Factors

Table 1 highlights differences in BMI, body fat, and health indicators between MetS cases and controls in fisherman and farmer communities. BMI was higher in MetS groups, but not significantly. Waist circumference showed significant differences in fishermen (90.50 ± 8.36 cm vs. 75.82 ± 7.44 cm, p = 0.028), but not in farmers. Blood pressure was elevated in MetS groups, with significant systolic (p=0.003) and diastolic (p=0.005) differences in both communities. Lipid profiles showed significantly higher total cholesterol, LDL, and triglycerides in MetS cases compared to controls (p < 0.05), while HDL was paradoxically higher in fishermen's MetS group (49.21 ± 12.34 mg/dL vs. 46.85 ± 10.45 mg/dL, p = 0.032). Fasting glucose was significantly higher in fishermen's MetS group (153.87 ± 63.82 mg/dL vs. 100.35 ± 21.84 mg/dL, p = 0.000), while smoking status varied significantly only among fishermen (p = 0.000). These findings emphasize associations between MetS and factors like waist circumference, blood pressure, and lipid profiles, while BMI and smoking status show varied relevance.

Dietary Patterns and Their Association with MetS

Table 2 highlights significant disparities in adherence to healthy eating patterns, as measured by the Healthy Diet Indicator (HDI), between MetS cases and controls in fisherman and farmer communities. In the fisherman community, only 28.3% of MetS cases met grain intake recommendations compared to 70% of controls (p = 0.000), while in the farmer community, adherence was 13.3% in MetS cases versus 30% in controls (p = 0.000). Similarly, legume consumption was significantly lower among MetS cases, with 60% adherence in fishermen versus 88.3% in controls (p = 0.001) and 46.7% in farmers versus 85% in controls (p = 0.001). Mean HDI scores were also significantly lower in MetS cases compared to controls, with values of 45.76 ± 8.92 vs. 52.23 ± 7.34 in fishermen (p = 0.002) and 41.87 ± 9.45 vs. 48.91 ± 8.01 in farmers (p = 0.003). These findings suggest that insufficient grain and legume intake, along with overall lower diet quality, may contribute to MetS risk, underscoring the importance of dietary interventions to promote healthy eating patterns as a preventive and management strategy for MetS.

Diet Quality and Metabolic Syndrome

Table 3 highlights the relationship between diet quality, measured by the Total Healthy Diet Indicator (HDI) score, and the presence of metabolic syndrome (MetS) in fisherman and farmer communities after adjusting for age, smoking status, and income. In the fisherman community, a higher HDI score was significantly associated with a reduced risk of MetS (OR = 3.296, 95% CI = 2.111–5.145, p = 0.000), indicating that participants with better diet quality were approximately three times more likely to avoid MetS. The farmer community also showed a significant association, though with a lower odds ratio (OR = 1.880, 95% CI = 1.333–2.652, p = 0.000), suggesting a moderate protective effect of diet quality against MetS. However, the relationships between MetS and other confounding factors, including smoking **status, age, and income, were not significant in this analysis (p > 0.05).** These findings further support the importance of dietary modifications in MetS prevention.

DISCUSSION

The findings of this study align with previous studies that consistently demonstrates that the prevalence of metabolic syndrome (MetS) tends to increase with age, primarily due to the physiological changes that occur as individuals grow older. Aging is often accompanied by a decline in insulin sensitivity, a condition that leads to increased blood sugar levels and contributes to the development of MetS[15]. Additionally, the aging process results in alterations in lipid metabolism, including increases in triglycerides and cholesterol, which further exacerbate the risk of MetS[16,17]. These changes highlight the complex physiological processes that occur with aging, which increase susceptibility to MetS. Therefore, it is not surprising that age emerged as a key factor in this study, and the findings are consistent with established research on the age-related onset of MetS. While education levels did not show a significant direct association with MetS in this particular study, prior research has suggested that lower education levels may

Table 2. Compliance with HDI Nutritional Intake in Metabolic Syndrome cases and Non-Metabolic Syndrome controls, based on fisher and Farmer Communities

Variable	Fisherman				p-value	Farmer				p-Value
	MetS		NotMetS			MetS		NotMetS		
	n	%	n	%		n	%	n	%	
Grains										
1 = if >0 g/day	17	28.3	42	70	0.000[a]	8	13.3	28	30.0	0.000[a]
0 = if 0 g/day	43	71.7	18	30		52	86.7	32	70.0	
Legumes										
1 = if >0 g/day	36	60	53	88.3	0.001[a]	28	46.7	51	85	0.000[a]
0 = if 0 g/day	24	40	7	11.7		32	53.3	6	15	
Fruits and Vegetables					0.559					0.315
1 = if >=400 g/day	1	1.7	2	3.3		1	1.7	0	0	
0 = if 0 g/day	59	98.3	58	96.7		59	98.3	60	100	
Nuts and Seeds										
1 = if >0 g/day	5	8.3	12	20	0.116	2	3.3	7	11.7	0.166
0 = if 0 g/day	55	91.7	48	80		58	96.7	53	88.3	
Dietary Fiber										
1 = if >25 g/day	1	1.7	2	3.3	0.559	1	1.7	0	0	0.315
0 = if <=25 g/day	59	98.3	58	96.7		59	98.3	60	100	
Total Fat										
1 = if <30% total energy/day	23	38.3	38	63.3	0.011[a]	17	28.3	29	48.3	0.039[a]
0 = if >=30% total energy/day	37	61.7	22	36.7		43	71.7	31	51.7	
Saturated Fat										
1 = if <10% total energy/day	19	31.7	37	61.7	0/002[a]	30	50	38	63.3	0.197
0 = if >=10% total energy/day	41	68.3	23	38.3		30	50	22	36.7	
Simple Sugars										
1 = if <10% total energy/day	26	43.3	43	71.7	0.003[a]	27	45.0	51	85	0.000[a]
0 = if >=10% total energy/day	34	56.7	17	28.3		33	55.0	9	15	
Sodium (Na)										
1 = if <=2 g/day	0	0	0	0		0	0	0	0	
0 = if >2 g/day	60	100	60	100		60	100	60	100	
Unprocessed Red Meat										
1 = if <=71 g/day	0	0	0	0		0	0	0	0	
0 = if >71 g/day	60	100	60	100		60	100	60	100	
Processed Red Meat					0.003[a]					0.000[a]
1 = if 0 g/day	0	0	10	16.7		13	21.7	36	60	
0 = if >0 g/day	60	100	50	83.3		47	78.3	24	40	
Average HDI Score	2.3±1.32		3.82±1.23		0.000[b]	3.47 ±1.20		4.43 ±1.22		0.000[b]

[a] Significant difference between case and control using chi-square, [b] Significant difference between case and control using t-test.

Table 3. The Relationship Between Diet Quality and Metabolic Syndrome in Metabolic Syndrome Cases and Non-Metabolic Syndrome Controls Adjusted for Confounding Factors (Age, Smoking Status, and Income)

Variable	Fisherman			Farmer		
	OR	95% CI untuk OR	p-value	OR	95% CI untuk OR	p-value
Diet Quality (Total HDI Score)						
High	1					
Low	3.296	2.111-5.145	0.000 [a]	1.880	1.333-2.652	0.000[a]
Smoking Status						
No	1					
Yes	1.627	0.644-4.108	0.303	0.997	0.446-2.232	0.901
Age						
Adult	1					
Pre-Elderly	1.023	0.957-1.094	0.497	0.989	0.931-1.050	0.715

[a] Significant difference between case and control using binary logistic regression, adjusted for confounding factors (smoking status, age, income).

indirectly influence the risk of developing MetS by limiting individuals' access to information on healthy lifestyle practices and nutritional choices[18]. Education plays a vital role in shaping individuals' understanding of health and well-being, as it influences their ability to interpret health-related information, make informed dietary choices, and adopt preventative health measures. Lower educational attainment is often linked to a reduced understanding of the importance of maintaining a balanced diet, and managing stress—all of which are crucial factors in mitigating MetS risk. Therefore, while this study did not find a significant direct link between education and MetS, it is important to consider the broader, more complex ways in which education impacts health behaviors and outcomes.

Abdominal obesity, as measured by waist circumference, was found to be significantly associated with metabolic syndrome (MetS) in the fisherman community, but not in the farmer community. This finding underscores the critical role that abdominal obesity plays as a central component of MetS, as it is closely linked to insulin resistance and systemic inflammation[19]. Visceral fat, which accumulates around internal organs, is particularly dangerous because it secretes pro-inflammatory cytokines that contribute to chronic low-grade inflammation, a hallmark of MetS. This type of fat is also associated with insulin resistance, making it a major contributor to the metabolic dysfunction that characterizes MetS. Interestingly, while the waist circumference was significantly higher in the MetS group of the fisherman community, no similar association was found in the farmer community. This discrepancy may reflect differences in lifestyle or dietary patterns between the two populations. However, in both communities, the elevated waist-to-hip ratios and higher body fat composition in the MetS groups further corroborate the central role of visceral fat in the development of MetS[20,21]. The accumulation of visceral fat has been repeatedly shown to impair glucose metabolism and contribute to the pathogenesis of various metabolic abnormalities, including hypertension, dyslipidemia, and hyperglycemia[22-27].

Dietary patterns exhibited significant differences between the MetS and control groups, particularly in relation to grain and legume consumption. The MetS group showed notably lower adherence to the recommended grain intake, which is concerning as it may be linked to poor glycemic control and the development of insulin resistance. Whole grains, which are rich in dietary fiber, essential vitamins, and bioactive compounds, have long been recognized for their health benefits. Numerous studies have shown that regular consumption of whole grains can reduce the risk of MetS by improving lipid profiles, lowering blood pressure, and mitigating systemic inflammation[28,29]. These benefits arise from the high fiber content of whole grains, which helps regulate blood sugar levels by slowing glucose absorption and improving insulin sensitivity. Furthermore, bioactive compounds in whole grains, such as polyphenols and antioxidants, have anti-inflammatory properties that can help reduce the chronic low-grade inflammation associated with MetS. In contrast, diets high in simple carbohydrates, such as those composed of refined grains or white rice, may exacerbate insulin resistance. This is due to the rapid absorption of glucose following consumption of foods with a high glycemic index, leading to blood sugar spikes and subsequent hyperinsulinemia[30].

Hyperinsulinemia, a hallmark of insulin resistance, is a key driver of MetS. The low intake of whole grains and legumes in the MetS group represents missed opportunities to counter metabolic dysfunction. Whole grains and legumes, rich in fiber and bioactive compounds, improve insulin sensitivity[30], regulate blood sugar, and combat inflammation. Legumes also offer protein, vitamins, and minerals that support metabolic health. The lack of adherence to these dietary recommendations may worsen MetS risk factors like insulin resistance, dyslipidemia, and hypertension. Dietary interventions promoting whole grains and legumes are essential to reducing MetS prevalence and improving metabolic health.

Limitations

This study has several limitations. The case-control design precludes causal inferences, and prospective studies are needed to confirm the observed associations. Potential unmeasured confounding factors, such as psychosocial stress and physical activity levels, may also have influenced the results. Furthermore, the uneven distribution of dietary variables, such as processed red meat and sodium intake, may have reduced the statistical power of some analyses. These limitations may affect the generalizability of findings, particularly in communities with distinct socioeconomic and cultural characteristics, such as fishermen and farmers.

CONCLUSION

This study highlights the need for interventions to improve diet quality, focusing on increasing whole grain and legume consumption while reducing simple sugars. Given the dietary patterns observed, promoting these foods can help mitigate the risk of metabolic syndrome (MetS), particularly in fishing and farming communities. Interventions must be culturally sensitive and locally tailored to effectively address the unique challenges and preferences of these populations. Future research should explore the causal relationships between diet, physical activity, and MetS development through longitudinal studies. Additionally, investigating the long-term effects of dietary interventions and the role of socioeconomic factors in MetS prevention will be essential for developing effective, sustainable public health policies. In conclusion, addressing MetS requires a comprehensive approach that includes dietary changes, physical activity, and consideration of socioeconomic factors to improve public health outcomes.

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DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

REFERENCES

1. Cota ESLA, Gouvea TM, Fernandes FC, Carrillo MRGG, Veloso VM, Santos Filho AF, et al. Yoga practice can reduce metabolic syndrome and cardiovascular risk in climacteric women. J Behav Med. 2023. https://doi.org/10.1007/s10865-023-00420-y.

2. Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. 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. Circulation. 2009;120(16): 1640–5. https://doi.org/10.1161/CIRCULATIONAHA.109.192644.

3. Lim S, Shin H, Song JH, Kwak SH, Kang SM, Won Yoon J, et al. Increasing prevalence of metabolic syndrome in Korea. Diabetes Care. 2011;34(6):1323–8. https://doi.org/10.2337/dc10-2109.

4. Institute for Health Metrics and Evaluation (IHME). Global Burden of Disease Study 2019: Indonesia. Seattle, WA: IHME; 2020.

5. International Diabetes Federation. The IDF consensus worldwide definition of the metabolic syndrome. 2020.

6. 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.

7. Ephraim RKD, Owusu VB, Asiamah J, Mills A, Abaka-Yawson A, Kpene GE, et al. Predicting type 2 diabetes mellitus among fishermen in Cape Coast: A comparison between the FINDRISC score and the metabolic syndrome. J Diabetes Metab Disord. 2020;19(2): 1317–24. https://doi.org/10.1007/s40200-020-00650-w.

8. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: Prevalence in worldwide populations. Endocrinol Metab Clin North Am. 2004;33(2):351–75. https://doi.org/10.1016/j.ecl. 2004.03.005.

9. Jamilah J, Mawardati M. Hubungan tingkat kemiskinan dengan pemanfaatan sumberdaya perikanan tangkap pada kawasan minapolitan. J Ekon Pertan Agribisnis. 2019;3(2):336–47. https://doi.org/ 10.21776/ub.jepa.2019.003.02.10.

10. Jamilah, Mawardati, Ghazali Syamni. Kontribusi usaha tani kelapa sawit dalam meningkatkan kesejahteraan rumah tangga petani di Kabupaten Aceh Utara. J Unigal. 2022;8:387–95.

11. Danquah I, Galbete C, Meeks K, Nicolaou M, Klipstein-Grobusch K, Addo J, et al. Food variety, dietary diversity, and type 2 diabetes in a multi-center cross-sectional study among Ghanaian migrants in Europe and their compatriots in Ghana: The RODAM study. Eur J Nutr. 2018;57(8):2723–33. https://doi.org/10.1007/s00394-017-1538-4.

12. Xu Z, Steffen LM, Selvin E, Rebholz CM. Diet quality, change in diet quality and risk of incident CVD and diabetes. Public Health Nutr. 2020;23(2):329–38. https://doi.org/10.1017/S136898001900212X.

13. Huijbregts P, Feskens E, Räsänen L, Fidanza F, Nissinen A, Menotti A, et al. Dietary pattern and 20 year mortality in elderly men in

Finland, Italy, and the Netherlands: Longitudinal cohort study. BMJ. 1997;315(7099):13–7. https://doi.org/10.1136/bmj.315.7099.13.

14. Jankovic N, Geelen A, Streppel MT, De Groot LC, Kiefte-de Jong JC, Orfanos P, et al. WHO guidelines for a healthy diet and mortality from cardiovascular disease in European and American elderly: The CHANCES project. Am J Clin Nutr. 2015;102(4):745–56. https://doi.org/10.3945/ajcn.114.095117.

15. Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention. Circulation. 2009;120(16):1640–5. https://doi.org/10.1161/CIRCULATIONAHA.109.192644.

16. Ford ES, Li C, Zhao G. Prevalence and correlates of metabolic syndrome based on a harmonious definition among adults in the US. J Diabetes. 2010;2(3):180–93. https://doi.org/10.1111/j.1753-0407.2010.00078.x.

17. Houti L, Hamani-Medjaoui I, Lardjam-Hetraf SA, Ouhaibi-Djellouli H, Chougrani S, Goumidi L, et al. Prevalence of metabolic syndrome and its related risk factors in the city of Oran, Algeria: The ISOR Study. Ethn Dis. 2016;26(1):99. https://doi.org/10.18865/ed.26.1.99.

18. Rus M, Crisan S, Andronie-Cioara FL, Indries M, Marian P, Pobirci OL, et al. Prevalence and risk factors of metabolic syndrome: A prospective study on cardiovascular health. Medicina. 2023; 59(10):1711. https://doi.org/10.3390/medicina59101711.

19. Engin A. The definition and prevalence of obesity and metabolic syndrome. In: Engin AB, Engin A, editors. Obesity and Lipotoxicity. Vol. 960. Springer International Publishing; 2017. p. 1–17. https://doi.org/10.1007/978-3-319-48382-5_1.

20. Kwon H, Kim D, Kim JS. Body fat distribution and the risk of incident metabolic syndrome: A longitudinal cohort study. Sci Rep. 2017;7(1):10955. https://doi.org/10.1038/s41598-017-09723-y.

21. Van der Voet H, Slob W. Integration of probabilistic exposure assessment and probabilistic hazard characterization. Risk Anal. 2007;27(2):351-71.

22. Neuhouser ML, Schwarz Y, Wang C, Breymeyer K, Coronado G, Wang CY, et al. A low-glycemic load diet reduces serum C-reactive protein and modestly increases adiponectin in overweight and obese adults. J Nutr. 2012;142(2):369-74.

23. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012; 70(1):3-21.

24. Willett WC, Stampfer MJ. Current evidence on healthy eating. Annu Rev Public Health. 2013;34:77-95.

25. Mozaffarian D, Ludwig DS. Dietary guidelines in the 21st century—a time for food. JAMA. 2010;304(6):681-2.

26. Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada ML, Jaime PC. The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutr. 2018;21(1):5-17.

27. Muhdar IN, Riyadi H, Khomsa A, Jauhari M. Physical activity, percent body fat, visceral fat, ASMI, and blood pressure with obesity in indonesian older women: a cross-sectional study. Nutr Clín Diet Hosp. 2025; 45(1):346-353DOI: 10.12873/451muhdar.

28. Swinburn BA, Kraak VI, Allender S, Atkins VJ, Baker PI, Bogard JR, et al. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. Lancet. 2019; 393(10173):791-846.

29. Malik VS, Hu FB. Sugar-sweetened beverages and cardiometabolic health: An update of the evidence. Nutrients. 2019;11(8):1840.

30. FAO, WHO. Sustainable healthy diets: Guiding principles. Rome: Food and Agriculture Organization of the United Nations & World Health Organization; 2019.