Observational Study

Medicine

OPEN

Metabolic syndrome among patients with type 2 diabetes in Jordan

A cross-sectional study

Dana Hyassat, MD, FACE, FRCP[a], Ala'a Al-Refai, MSc[a], Yousef S. Khader, ScD, FFPH, MSPH, MHPE, MSc[b], Malik E. Juweid, MD, ABNM[a,c], Saja AlSharaydeh, MD[a], Nadera Layyous, MD[a], Husam Aljabiry, MD[a], Ahmad AlDurgham, MD[a], Laith Z. Baqain[d], Joud Abu Summaqa, MD[a], Rana Al-Shimi, MD[a], Fatima Mohammad Atieh[e], Awn Mahasneh, MD[a], Shaker Alaraj, MD[a], Alanoud Al-wakfi, MD[a], Omar Mahafza, MD[a], Mohammad EL-Khateeb, PhD[a], Kamel Ajlouni, MD, DRL, FACP, FACE, FRCP[a,*]

Abstract

Metabolic syndrome is a major public health problem worldwide and an independent predictor of cardiovascular disease in patients with type 2 diabetes (T2DM). This study aimed to determine the prevalence of metabolic syndrome and its individual components among Jordanian patients with T2DM. A cross-sectional design was conducted among T2DM patients at the National Center for Diabetes, Endocrinology and Genetics in Jordan. Data were collected using a structured questionnaire and clinical data extracted from medical records. The National Cholesterol Education Program-Adult Treatment Panel III (ATP III) and International Diabetes Federation (IDF) diagnostic criteria were used to define metabolic syndrome. Among 1017 participants aged between 22 and 90 years, the overall prevalence of IDF defined metabolic syndrome was 84.2% (72.5% and 96.2% among males and females, respectively). Using ATP III criteria, overall prevalence was 79.1% (77.4% and 80.8% among males and females, respectively). Advancing age, female gender, nonadherence to a diet regimen, sedentary lifestyle or insufficient physical activity, and duration of diabetes ≥10 years were significantly associated with increased odds of metabolic syndrome, regardless of the definition used. Current smoking status and family history of cardiovascular diseases were significantly associated with increased likelihood of ATP III defined metabolic syndrome. The prevalence of metabolic syndrome among Jordanian patients with T2DM is extremely high. The main modifiable risk factors of metabolic syndrome among these patients include nonadherence to a diet regimen, insufficient physical activity, being overweight/obese and smoking. It is recommended that healthcare providers counsel patients on the importance of maintaining physical activity, smoking cessation, and adherence to a diet regimen.

List of Abbreviations: ATP III = adult treatment panel III, BMI = body mass index, BP = blood pressure, FBG = fasting blood glucose, HDL = high-density lipoprotein, IDF = international diabetes federation, IPAQ = international physical activity questionnaire, NCDEG = national center for diabetes, endocrinology and genetics, NCEP = national cholesterol education program, SPSS = statistical program for social sciences, STROBE = strengthening the reporting of observational studies in epidemiology, T2DM = type 2 diabetes mellitus, TG = triglycerides.

Keywords: diabetes, Jordan, metabolic syndrome, physical activity, prevalence

1. Introduction

Metabolic syndrome is typically defined as the cluster of abnormally high blood pressure (BP), increased fasting blood glucose (FBG), visceral obesity, high serum triglycerides (TG), and low serum high-density lipoprotein (HDL); the latter 2 being part of the atherogenic dyslipidemia triad.[1] It is associated with increased risk of type 2 diabetes mellitus (T2DM), stroke, congestive heart disease, myocardial infarction, and cardiovascular and all-cause mortality.[2,3] Metabolic syndrome is a major public health concern worldwide with prevalence rates ranging from as low as 10% to as high as 84% depending on the definition used and ethnic group.[1,4] In Jordan, the age-adjusted prevalence of metabolic syndrome was estimated at 44%

The authors have no funding and conflict of interest to disclose.

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

[a] The National Center for Diabetes, Endocrinology, and Genetics, The University of Jordan, Amman, Jordan, [b] Jordan University of Science and Technology (JUST), [c] Department of Radiology and Nuclear medicine, The University of Jordan, Amman, Jordan, [d] School of Medicine, University College Dublin, Dublin, Ireland,[e] School of Medicine, Royal College of Surgeons in Ireland, Bahrain.

** Correspondence: Kamel M. Ajlouni, National Center for Diabetes, Endocrinology and Genetics, The University of Jordan, P.O. Box 13165, Amman 11942, Jordan (e-mail: ajlouni@ju.edu.jo).*

How to cite this article: Hyassat D, Al-Refai A, Khader YS, Juweid ME, AlSharaydeh S, Layyous N, Aljabiry H, AlDurgham A, Baqain LZ, Abu Summaqa J, Al-Shimi R, Atieh FM, Mahasneh A, Alaraj S, Al-wakfi A, Mahafza O, EL-Khateeb M, Ajlouni K. Metabolic syndrome among patients with type 2 diabetes in Jordan: A cross-sectional study. Medicine 2024;103:46(e40602).

Received: 6 September 2024 / Received in final form: 29 October 2024 / Accepted: 31 October 2024

http://dx.doi.org/10.1097/MD.0000000000040602

according to the International Diabetes Federation (IDF) criteria and 39.9% according to the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria,[5] which was in the upper range compared to other regional populations.[6–9] The literature on metabolic syndrome in diabetic patients in Jordan is relatively limited given its high prevalence in the general population, so this study was conducted to determine the prevalence and factors associated with metabolic syndrome and its individual elements in patients diagnosed with T2DM in Jordan.

2. Methods

2.1. Study design

A cross-sectional design was conducted among patients diagnosed with T2DM at the National Center for Diabetes, Endocrinology and Genetics (NCDEG) in Jordan. To reduce bias, a systematic sampling method was employed. T2DM patients aged 20 years and above who attended the NCDEG during a period of 3 months in 2020 were invited to participate in this study. Type 1 diabetic patients and pregnant women were excluded. The present study was approved by the NCDEG Ethics' Committee, and it adhered to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.[10]

2.2. Data collection

A structured face-to-face interview questionnaire inquired about age, gender, monthly income, family history of cardiovascular diseases, cigarette smoking, physical activity and frequency of adherence to a diet regimen. Clinical data were obtained from the medical records of participants.

2.3. Measurements

Anthropometric measurements including weight, height, and waist circumference were measured while the subjects were wearing light clothing and no shoes. Waist circumference was measured at the end of a normal expiration using a non-stretchable tape held in a horizontal plane around the abdomen at the level of the iliac crest. Systolic and diastolic BPs were taken while the subjects were seated and the arm was kept at the heart level, after at least 5 minutes of rest, using a standardized mercury sphygmomanometer.

2.4. Variable definitions

Diabetes mellitus was diagnosed if patients had a FBG ≥ 126 mg/dL (7.0 mmol/L) on 2 occasions or if the patient had a random plasma glucose ≥ 200 mg/dL (11.1 mmol/L) in the presence of classical symptoms of hyperglycemia, or if glycosylated hemoglobin ($HbA1_c$) was ≥6.5%. Diabetes was considered controlled if the patient had a $HbA1_c$ < 7.0%. Metabolic syndrome in a patient with diabetes was defined according to NCEP ATP III if he or she fulfills 2 or more of the followings: abdominal obesity defined as a waist circumference ≥ 102 cm in men and ≥ 88 cm in women, TG ≥ 150 mg/dL, HDL cholesterol < 40 mg/dL for males and < 50 mg/dL for females, systolic BP ≥ 130 mm Hg and/or diastolic BP ≥ 85 mm Hg.[11] According to the IDF criteria,[12] a patient with diabetes had metabolic syndrome in the presence of central obesity defined as a waist circumference ≥ 94 cm in men and ≥80 cm in women. Body Mass Index (BMI) is expressed as the quotient between weight (kg) and height squared (m^2).

Patients were classified according to BMI following the recommendation of the World Health Organization as adopted by the American Diabetes Association.[13] Physical activity was assessed according to a modified International Physical Activity Questionnaire (IPAQ),[14] which classifies individuals into sedentary if the participant did not engage in physical activity for at least 10 continuous minutes during the week; Insufficiently active if the participant engaged in a physical activity for at least 10 continuous minutes per week and up to 150 minutes per week, but insufficient to be classified as active; Active if the participant engaged in a moderate activity or walking for ≥5 d/wk and ≥30 minutes per session; and very active if the participant engaged in vigorous activity for ≥5 d/wk and ≥30 minutes per session.

Frequency of adherence to a diet regimen was defined as the number of times where a patient followed an eating plan prescribed by a dietitian or treating physician over the past week and was classified as follows: regular if the patient followed the eating plan 4 to 7 days during the previous week, semiregular if the patient followed the eating plan for 1 to 3 days during the previous week, and nonadherence to any diet regimen.

2.5. Data analysis

Data were analyzed using the Statistical Program for Social Sciences (SPSS) version 20.[15] Frequency distribution was used for categorical variables. The Chi-square test was used to examine the relationship between categorical variables. Multiple logistic regression analysis was used to determine the independent effect of each of the independent variables on metabolic syndrome. A *P*-value of ≤.05 was considered statistically significant.

3. Results

3.1. Patients' characteristics

A total of 1017 participants aged between 22 and 90 years with a mean age (SD) of 58.2 (10.5) years were included in this study. The socio-demographic and clinical characteristics of the study's population are presented in Table 1. The majority (81%) of patients were 50 years of age or older and 49% were females. Nearly half the participants (51%) had a sedentary life and 35% were not adherent to any diet regimen. The proportion of patients with a family history of cardiovascular diseases was 28.9%. More than half (59%) of the patients were obese and 32% were overweight. About 41% of the diabetic participants had $HbA1_c$ of <7%.

3.2. Prevalence of metabolic syndrome and its components

The overall prevalence of the IDF defined metabolic syndrome was 84.2% (72.5% among males and 96.2% among females). Using ATP III criteria, the overall prevalence of the metabolic syndrome was 79.1% (77.4% among males and 80.8% among females). Table 1 shows the prevalence of metabolic syndrome according to age using both IDF and ATP III criteria. According to the ATP III criteria, the most common metabolic abnormality in females was abnormal waist circumference (87.2%) followed by high BP (75.4%), low HDL (68.8%), and high TG levels (58.4%) (Table 2). In males, the most common metabolic abnormality was high BP (79.7%), followed by low HDL (79.5%), high TG level (69.4%) and abnormal waist circumference (44.9%). Three percent of the patients had diabetes mellitus only, 17.8% had 2 metabolic abnormalities, 14.4% had 3 metabolic abnormalities, 23.8% had 4 metabolic abnormalities and 40.9% had all the components of metabolic syndrome.

3.3. Factors associated with metabolic syndrome

Advanced age, female gender, nonadherence to a diet regimen, sedentary lifestyle or insufficient physical activity, and a

duration of diabetes ≥ 10 years were significantly associated with increased odds of metabolic syndrome, regardless of the definition used (Table 3). Current smoking status and family history of cardiovascular diseases were significantly associated with increased likelihood of ATP III defined metabolic syndrome.

4. Discussion

The prevalence of metabolic syndrome among Jordanian diabetics was 79.1% and 84.2% according to ATP III and IDF criteria, respectively. A study in Italy reported a lower prevalence (68.4% ATP III and 73% IDF),[16] while studies in Spain (78.2% ATP III, 89.5% IDF)[17] and Malaysia (96.1% ATP III, 84.8% IDF)[18] reported higher rates of metabolic syndrome in 1 of the criteria. The variations in prevalence rates may be due to differences in definition criteria, ethnic variations or the combination of genetics and environmental factors, such as obesity and diminished physical activity.[19,20] The prevalence of metabolic syndrome in our sample increased with age, a finding that was consistent with most studies in the literature.[21,22] Age-related changes in fat distribution, body size, and insulin sensitivity likely contribute to the increased prevalence of metabolic syndrome with age.[23,24] Moreover, prevalence was higher in women than in men, which could be because a high percentage of women had abdominal obesity. Similar results were found in India, Iran and Albania where diabetic women had higher rates of metabolic syndrome with central obesity being the main risk factors.[23,25,26] However, studies in the United States and Japan reported higher rates of metabolic syndrome in men than in women.[27,28]

The odds' ratio for metabolic syndrome was significantly increased in participants who were non-adherent to a diet regimen or had a sedentary lifestyle. Xu et al and Zhu et al had concurring results where they found that the odds' ratio for metabolic syndrome was significantly lower in men who were physically active.[29,30] Moderate physical activity is beneficial to promote weight loss in obese individuals and positively modifies components of metabolic syndrome including promoting loss of abdominal fat, reduction of BP, as well as improvement of insulin sensitivity and lipid profiles in such patients.[31] Also in our study, patients with T2DM duration of ≥ 10 years were found to have higher odds of developing metabolic syndrome. Mogre et al found that diabetic patients with a T2DM duration of more than 5 years had 11.3 times higher odds of developing metabolic syndrome.[32] This is inconsistent with the findings of Shimajiri et al and Abdul-Ghani et al which indicated that the prevalence of metabolic syndrome decreased with increasing durations of diabetes due to medical intervention to reduce BMI and improve metabolic control in addition to better awareness with the longer durations of diabetes.[27,33]

Like many prior studies,[34,35] we found active smoking to be a significant independent risk factor for metabolic syndrome. Smoking is known to increase insulin resistance in a dose-dependent manner, both directly through hormone activation and indirectly via visceral obesity. As prediabetes and diabetes rates rise, reducing or quitting smoking could be crucial for those at risk, marking it as an important part of any diabetes prevention and treatment strategy.[36] Data from 4043 participants in the Korea National Health and Nutrition Examination (Survey between 2016 and 2018) identified continuous smokers as having 1.7 to 2.0 higher odds of insulin resistance compared to nonsmokers. Notably, continuous smoking for periods as short as 40 days correlated with increased insulin resistance.[37]

Our data supports the notion that overweight, obesity and a positive family history of cardiovascular diseases are strong risk factors for metabolic syndrome. Kip et al[38] reported that metabolic status was strongly related to BMI which is consistent with multiple other studies on various ethnic populations.[22,26] This is likely due to the well-documented notion of adipose tissue as an active endocrine organ which releases numerous cytokines and bioactive mediators responsible for inflammation, coagulation, fibrinolysis, insulin resistance, diabetes, atherosclerosis and some forms of cancers.[4,39]

This study confirms the wide prevalence of metabolic syndrome in diabetic patients in Jordan and underscores the importance of implementing targeted lifestyle changes to address the main modifiable risk factors early on to minimize its harmful sequela.[40,41] Limitations of our study include its retrospective nature and the fact that it included only 1 center. However, it is important to note that the NCDEG attracts T2DM patients

Table 1

Socio-demographic, clinical and relevant characteristics of the study participants.

Variable	N	%
Age (yr)		
<50	197	19.4
50 to 59	350	34.4
60 to 69	294	28.9
≥70	176	17.3
Gender		
Male	517	50.8
Female	500	49.2
Family income (JD)		
<500	374	36.8
500 to 1000	451	44.3
>1000	192	18.9
Frequency of adherence to diet regimen		
4 to 7 times/wk	172	16.9
1 to 3 times/wk	485	47.7
Not adherent	360	35.4
Physical activity		
Sedentary	523	51.4
Insufficiently active	391	38.4
Active	103	10.1
Cigarette smoking		
Nonsmoker	735	72.3
Ex-smoker	96	9.4
Current smoker	186	18.3
Body mass index (BMI)		
Normal	93	9.1
Overweight	320	31.5
Obesity	604	59.4
Duration of diabetes (yr)		
<5	409	40.2
5 to 9	186	18.3
≥10	422	41.5
Glycemic control		
≥7%	601	59.1
< 7%	416	40.9

Abbreviation: JD: Jordanian dinar.

Table 2

Frequencies of metabolic syndrome components among patients with type 2 diabetes according to gender.

Variable	Males N (%)	Females N (%)	Total N (%)
Abnormal waist circumference (ATP III criteria)	232 (44.9%)	436 (87.2%)	668 (65.7%)
Abnormal waist circumference (IDF criteria)	375 (72.5%)	481 (96.2%)	856 (84.2%)
High blood pressure	412 (79.7%)	377 (75.4%)	789 (77.6%)
Elevated triglyceride	359 (69.4%)	292 (58.4%)	651 (64.0%)
Low HDL	411 (79.5%)	344 (68.8%)	755 (74.2%)

Abbreviations: ATP III: adult treatment panel III; IDF: international diabetes federation; HDL: high-density lipoprotein.

Table 3

Logistic regression analysis of factors associated with metabolic syndrome in patients with type 2 diabetes.

	ATP III		IDF	
Variables	**OR (95% CI)**	***P*-value**	**OR (95% CI)**	***P*-value**
Age group				
<50	1		1	
50 to 59 yr	2.11 (1.31–3.41)	*.002*	1.50 (0.98–2.29)	.06
60 to 69 yr	2.35 (1.36–4.04)	*.002*	1.69 (1.03–2.75)	.04
>70 yr	4.27 (2.07–8.80)	*<.001*	1.98 (1.09–3.59)	.02
Gender				
Male	1		1	
Female	1.78 (1.17–2.71)	*.006*	3.20 (2.21–4.62)	*<.001*
Frequency of adherence to diet regimen				
4 to 7 times/wk	1		1	
1 to 3 times/wk	1.29 (0.81–2.06)	.28	1.16 (0.75–1.78)	>.49
Not adherent	4.14 (2.14–7.98)	*<.001*	3.60 (2.06–6.29)	*<.001*
Physical activity				
Sedentary	4.05 (2.17–7.53)	*<.001*	2.65 (1.52–4.63)	*.001*
Insufficiently active	2.19 (1.27–3.78)	*.005*	1.69 (1.03–2.80)	*.04*
Active	1		1	
Cigarette smoking				
Nonsmoker	1		1	
Ex-smoker	1.61 (0.77–3.34)	>.19	1.03 (0.58–1.84)	.90
Current Smoker	2.64 (1.51–4.61)	*.001*	0.90 (0.59–1.39)	.65
Family history of cardiovascular diseases				
Yes	1.25 (1.05–2.24)	*.03*	0.97 (0.69–1.36)	.89
No	1		1	
Duration of diabetes type 2 (yr)				
<5	1		1	
5 to 9	1.39 (0.84–2.33)	.20	0.99 (0.84–2.33)	.96
≥10	2.09 (1.24–3.5)	*.006*	1.81 (1.24–3.50)	*.01*
Body mass index				
Normal	1			
Overweight	1.85 (1.03–3.29)	*.04*		
Obese	5.29 (2.95–9.51)	*<.001*		

Abbreviation: ATP III: adult treatment panel III; IDF: international diabetes federation.

from all over the country, so the data obtained are likely to be representative of the Jordanian population.

5. Conclusion

The prevalence of metabolic syndrome among diabetic patients in Jordan is extremely high. The main modifiable risk factors of metabolic syndrome among these patients include nonadherence to a diet regimen, insufficient physical activity, overweight or obesity and smoking. We recommend that healthcare providers counsel patients on the importance of maintaining physical activity, quitting smoking, and adhering to a diet regimen. Overweight and obese patients should be educated about maintaining healthy weights to prevent clustering of cardiovascular risk factors.

Author contributions

Conceptualization: Ala'a Al-Refai, Saja AlSharaydeh, Rana Al-Shimi.
Data curation: Ala'a Al-Refai, Saja AlSharaydeh, Rana Al-Shimi.
Formal analysis: Yousef S Khader, Laith Z. Baqain.
Investigation: Ala'a Al-Refai, Yousef S Khader, Nadera Layyous, Joud Abu Summaqa, Mohammad EL-Khateeb.
Methodology: Dana Hyassat, Awn Mahasneh, Shaker Alaraj, Mohammad EL-Khateeb.
Project administration: Omar Mahafza, Mohammad EL-Khateeb, Kamel Ajlouni.
Resources: Dana Hyassat, Malik E. Juweid, Nadera Layyous, Husam Aljabiry, Ahmad AlDurgham, Joud Abu Summaqa, Fatima Mohammad Atieh, Awn Mahasneh, Mohammad EL-Khateeb.
Software: Dana Hyassat, Yousef S Khader, Malik E. Juweid, Husam Aljabiry, Ahmad AlDurgham, Fatima Mohammad Atieh.
Supervision: Mohammad EL-Khateeb, Kamel Ajlouni.
Validation: Fatima Mohammad Atieh, Kamel Ajlouni.
Visualization: Alanoud Al-wakfi, Kamel Ajlouni.
Writing – original draft: Dana Hyassat, Alanoud Al-wakfi, Mohammad EL-Khateeb.
Writing – review & editing: Malik E. Juweid, Laith Z. Baqain, Awn Mahasneh, Shaker Alaraj, Omar Mahafza, Kamel Ajlouni.

References

[1] Grundy SM. Metabolic syndrome pandemic. Arterioscler Thromb Vasc Biol. 2008;28:629–36.
[2] Grundy SM, Cleeman JI, Daniels SR, et al; American Heart Association. Diagnosis and management of the metabolic syndrome. Circulation. 2005;112:2735–52.
[3] Shen R, Guo X, Zou T, Ma L. Modifiable risk factors and metabolic health in risk of cardiovascular disease among US adults: a nationwide cross-sectional study. Int J Cardiol Cardiovasc Risk Prev. 2024;22:200283.
[4] O'Neill S, O'Driscoll L. Metabolic syndrome: a closer look at the growing epidemic and its associated pathologies. Obes Rev. 2015;16:1–12.
[5] Ajlouni K, Khader Y, Alyousfi M, Al Nsour M, Batieha A, Jaddou H. Metabolic syndrome amongst adults in Jordan: prevalence, trend, and its association with socio-demographic characteristics. Diabetol Metab Syndr. 2020;12:100.
[6] Hajat C, Shather Z. Prevalence of metabolic syndrome and prediction of diabetes using IDF versus ATPIII criteria in a Middle East population. Diabetes Res Clin Pract. 2012;98:481–6.

[7] El-Aty MA, Mabry R, Morsi M, Al-Lawati J, Al-Riyami A, El-Sayed M. Metabolic syndrome and its components: secondary analysis of the World Health Survey, Oman. Sultan Qaboos Univ Med J. 2014;14:e460–467.
[8] Shin S, Jee H. Prevalence of metabolic syndrome in the Gulf Cooperation Council countries: meta-analysis of cross-sectional studies. J Exerc Rehabil. 2020;16:27–35.
[9] Damiri B, Badran L, Safadi D, et al. Metabolic syndrome and related risk factors among adults in the northern West Bank, a cross-sectional study. Int Health. 2019;14:339–45.
[10] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ. 2007;335:806–8.
[11] Expert Panel on Detection E and Treatment of High Blood Cholesterol in Adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). JAMA. 2001;285:2486–97.
[12] Alberti KGM, Zimmet P, Shaw J; IDF Epidemiology Task Force Consensus Group. The metabolic syndrome – a new worldwide definition. Lancet. 2005;366:1059–62.
[13] The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Follow-up report on the diagnosis of diabetes mellitus. Diabetes Care. 2003;26:3160–7.
[14] Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35:1381–95.
[15] IBM Corporation. IBM SPSS Statistics for Windows. Published online 2011:1–5.
[16] Monami M, Marchionni N, Masotti G, Mannucci E. IDF and ATP-III definitions of metabolic syndrome in the prediction of all-cause mortality in type 2 diabetic patients. Diabetes Obes Metab. 2007;9:350–3.
[17] Rodríguez A, Polavieja P, Reviriego J, Serrano Rios M. Prevalence of metabolic syndrome and consistency in its diagnosis in type 2 diabetic patients in Spain. Endocrinol Nutr. 2010;57:60–70.
[18] Tan MC, Ng OC, Wong TW, Joseph A, Chan YM, Hejar AR. Prevalence of metabolic syndrome in type 2 diabetic patients: a comparative study using WHO, NCEP ATP III, IDF and Harmonized definitions. Health. 2013;05:1689–96.
[19] Bovolini A, Garcia J, Andrade MA, Duarte JA. Metabolic syndrome pathophysiology and predisposing factors. Int J Sports Med. 2021;42:199–214.
[20] Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the us population from the Third National Health and Nutrition Examination Survey, 1988-1994. Arch Intern Med. 2003;163:427–36.
[21] Kim TH, Kim DJ, Lim S, et al. Prevalence of the metabolic syndrome in type 2 diabetic patients. Korean Diabetes J. 2009;33:40.
[22] Yao F, Bo Y, Zhao L, et al. Prevalence and influencing factors of metabolic syndrome among adults in China from 2015 to 2017. Nutrients. 2021;13:4475.
[23] Shehu A, Thengjilli E, Doko A, Toti F. The prevalence of metabolic syndrome in patients with diagnosed type 2 diabetes. Endocr Abstr. 2015;37:EP350.
[24] Zhang K, Ma Y, Luo Y, et al. Metabolic diseases and healthy aging: identifying environmental and behavioral risk factors and promoting public health. Front Public Health. 2023;11:1.
[25] Surana SP, Shah DB, Gala K, et al. Prevalence of metabolic syndrome in an urban Indian diabetic population using the NCEP ATP III guidelines. J Assoc Physicians India. 2008;56:865–8.
[26] Asghar S, Asghar S, Shahid S, Fatima M, Bukhari SMH, Nadeem Siddiqui S. Metabolic syndrome in type 2 diabetes mellitus patients: prevalence, risk factors, and associated microvascular complications. Cureus. 2023;15:5.
[27] Shimajiri Y, Tsunoda K, Furuta M, et al. Prevalence of metabolic syndrome in Japanese type 2 diabetic patients and its significance for chronic vascular complications. Diabetes Res Clin Pract. 2008;79:310–7.
[28] Liang X, Or B, Tsoi MF, Cheung CL, Cheung BMY. Prevalence of metabolic syndrome in the United States National Health and Nutrition Examination Survey 2011–18. Postgrad Med J. 2023;99:985–92.
[29] Xu H, Song Y, You NC, et al. Prevalence and clustering of metabolic risk factors for type 2 diabetes among Chinese adults in Shanghai, China. BMC Public Health. 2010;10:1–8.
[30] Zhu S, St-Onge MP, Heshka S, Heymsfield SB. Lifestyle behaviors associated with lower risk of having the metabolic syndrome. Metab Clin Exp. 2004;53:1503–11.
[31] Chomiuk T, Niezgoda N, Mamcarz A, Śliż D. Physical activity in metabolic syndrome. Front Physiol. 2024;15:1365761.
[32] Mogre V, Salifu ZS, Abedandi R. Prevalence, components and associated demographic and lifestyle factors of the metabolic syndrome in type 2 diabetes mellitus. J Diabetes Metab Disord. 2014;13:80.
[33] Abdul-Ghani M, Nawaf G, Nawaf F, Itzhak B, Minuchin O, Vardi P. Increased prevalence of microvascular complications in type 2 diabetes patients with the metabolic syndrome. Isr Med Assoc J. 2006;8:378–82.
[34] Sun K, Liu J, Ning G. Active smoking and risk of metabolic syndrome: a meta-analysis of prospective studies. PLoS One. 2012;7:e47791.
[35] Zhong H, Ni X, Chen R, Hou X. Smoking contribution to the global burden of metabolic disorder: a cluster analysis. Med Clin. 2024;163:14–20.
[36] Artese A, Stamford BA, Moffatt RJ. Cigarette smoking: an accessory to the development of insulin resistance. Am J Lifestyle Med. 2019;13:602–5.
[37] Cho SH, Jeong SH, Shin J, Park S, Jang SI. Short-term smoking increases the risk of insulin resistance. Sci Rep. 2022;12:3550.
[38] Kip KE, Marroquin OC, Kelley DE, et al. Clinical importance of obesity versus the metabolic syndrome in cardiovascular risk in women: a report from the Women's Ischemia Syndrome Evaluation (WISE) Study. Circulation. 2004;109:706–13.
[39] Lau DCW, Dhillon B, Yan H, Szmitko PE, Verma S. Adipokines: molecular links between obesity and atheroslcerosis. Am J Physiol Heart Circ Physiol. 2005;288:H2031–41.
[40] Namen M van, Prendergast L, Peiris C. Supervised lifestyle intervention for people with metabolic syndrome improves outcomes and reduces individual risk factors of metabolic syndrome: a systematic review and meta-analysis. Metab Clin Exp. 2019;101:1.
[41] Peiris CL, van Namen M, O'Donoghue G. Education-based, lifestyle intervention programs with unsupervised exercise improve outcomes in adults with metabolic syndrome. A systematic review and meta-analysis. Rev Endocr Metab Disord. 2021;22:877–90.