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The Investigation of Metabolic Syndrome Among Middle-Aged Women, Kamyaran, Iran: A Cross-sectional Study

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Abstract

Objectives: Physical activity and nutrition can affect some serum markers associated with metabolic syndrome (MetS). We aimed to ascertain the prevalence and predictors of MetS among middle-aged women in this study.

Materials and Methods: This cross-sectional descriptive-analytical study was performed on 164 eligible middle-aged women. Sampling was performed by two-stage cluster random sampling among all the health care centers in Kamyaran, Iran. Data were collected through anthropometrics, Food Records, and International Physical Activity Questionnaires. Serum lipid profile and glycemic control indexes, calcium, and 25-hydroxy vitamin D3 were assayed. Blood pressure was measured. The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria were used to detection of MetS.

Results: Forty-one women (25.0%; 95% CI: 18.4% to 31.6%) had MetS. Fasting blood sugar (FBS) (adjusted odds ratio (aOR): 0.020; 95% CI: 1.001 to 1.039), triglyceride (aOR: 1.024; 95% CI: 1.015-1.033), low physical activity: walking (aOR: 0.999; 95% CI: 0.998 0.999), dietary iron (aOR: 1.059; 95% CI: 0.989- 1.134) and waist circumference (aOR: 1.062: 95% CI; 1.020 1.105) have been detected as the MetS predictors in this study.

Conclusions: Higher serum levels of FBS and triglyceride, higher iron intake and waist circumference, and low physical activity enhanced the chance of getting MetS.

Keywords: Metabolic syndrome, Women, Middle Aged, Prevalence, Predictor

Introduction

Metabolic syndrome (MetS) comprises a set of metabolic disturbances, including high blood pressure, high blood sugar (insulin resistance [IR] and increased blood insulin levels), excess accumulated fat around the abdomen and waist, increased triglyceride levels, and decreased high-density lipoprotein cholesterol (HDL-C) levels. Only one of these conditions does not imply having MetS (1), but it can increase the chances of developing cardiovascular diseases. MetS enhances the risk of cardiovascular disease and stroke due to high cholesterol and blood pressure and the hazard of type 2 diabetes due to IR (2).

The exact cause of MetS is unknown, but a combination of nutritional factors, physical activity, genetics, longevity, and ethnicity are effective (3-5). It can also be said that MetS is related to the body's metabolism and a condition called IR (6). A combination of genetic and environmental factors causes IR. IR causes hyperinsulinemia, exacerbation of hyperlipidemia, and hypertension (7). According to Adult Treatment Panel (ATP) III criteria, the person who has three of the five criteria of waist circumference equivalent to or greater than 88 cm in women and equivalent to or greater than 102 cm in men, fasting blood sugar (FBS) equivalent to or greater than 100 mg/dL, Triglycerides equivalent to or greater than 150 mg/dL, HDL cholesterol less than 50 mg/dL in women and less than 40 mg/dL in men, blood pressure equivalent to or greater than 130/85 mm Hg, are considered as MetS (8).

In the third National Cholesterol Education Program (NCEP) report on the cholesterol treatment program, the guidelines for the clinical distinction of MetS included three of the five criteria for abdominal obesity, hypertension, high triglyceride levels, low HDL cholesterol, and high FBS (8). Later, the International Diabetes Federation introduced abdominal obesity as the main and necessary indicator and two other criteria as the diagnostic criterion of MetS (9). The overall prevalence of MetS increased from 32.5% in 2011-2012 to 36.9% in 2015-2016 in the United States. It significantly increased among women, those aged 20 to 39 years, and Asian & Hispanic participants (10). A study of glucose and lipids in Tehran showed the prevalence of this syndrome to

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Key Messages

- Physical activity and nutrition can affect some of the serum markers associated with MetS in middle-aged women.
- Higher serum levels of FBS and triglyceride, higher iron intake, and waist circumference increased the chance of developing MetS.
- Low physical activity increases the chance of developing MetS.

be 33.7%, which increases with age (11). Given that the outbreak of MetS is increasing and this syndrome has a high ability to distinguish people at risk for cardiovascular disease and type 2 diabetes, it becomes a suitable tool to detect people at risk. (12).

The levels of atherogenic lipoproteins, including triglycerides, low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL), total cholesterol, and diminished HDL levels increase in most people with MetS. This condition causes the onset and persistence of atherosclerosis and predisposes an individual to cardiovascular disease (13). Researchers believe that IR plays a key impress in the development of MetS. IR leads to type 2 diabetes and cardiovascular problems, fatty liver, atherosclerosis, polycystic ovary syndrome, hyperandrogenism, growth disorders, and reproductive disorders in women (14). Abdominal fatness, high blood pressure, and high cholesterol are directly associated with IR (15). Some environmental factors, for example, physical activity and nutrition, can affect some of the serum markers associated with MetS (2,16).

Due to changing people's lifestyles to a more sedentary status and changing nutritional behaviors (17), conducting up-to-date studies considering all relevant factors, especially in high-risk groups seems necessary. Thus, this study aimed to specify the prevalence and predictors of MetS among the proposed related factors according to the scientific literature (systolic and diastolic blood pressure, anthropometric indices including height, weight, body mass index (BMI), waist circumference, hip circumference, waist to hip ratio (WHR), serum indices including FBS, triglycerides, LDL, HDL, total cholesterol, calcium, insulin, homeostatic model assessment for insulin resistance (HOMA-IR), 25-hydroxy vitamin D3 (25 (OH) D), diet (energy, fat, carbohydrates, protein, fiber, and micronutrients), and physical activity) in middle-aged women in Kamyaran, Iran.

Materials and Methods

Study Design, Setting, and Participants

In this cross-sectional study, 164 middle-aged women (40-60 years) who were referred to Kamyaran health centers, Kamyaran, Iran from September 2018 to February 2019 were enrolled. Inclusion criteria were: middle-aged women having a family record in health centers of Kamyaran city, and having literacy of oneself or at least one family member. Exclusion criteria included certain diets (e.g., vegetarians), the happening of severe stressors like as the death of first-degree relatives during the last month, the prohibition of any physical activity according to the doctor's advice, chronic diseases including cardiovascular disease, diabetes, thyroid, irritable bowel syndrome, celiac disease, cancers, and restrictive lung diseases were recorded in the family records.

Sampling was performed by two-stage cluster sampling. Thus, out of 24 health care centers and 12 health care sub-centers in Kamyaran city, eight centers and four sub-centers (about one-third) were randomly selected using computer software (https://www.random.org/). Then, in the selected centers and sub-centers, the appropriate number of samples was calculated and determined according to the size of the primary sample as a quota for every center or sub-centers. The inventory of all middle-aged women covered by each center or sub-center was extracted, and individuals were sorted by number in the list. Afterward, using computer randomization software, the required number of samples (25% more than the original sample size was calculated due to the possibility of not being eligible) were randomly selected.

The researcher then used the phone numbers of the people in their health records and presented a brief explanation of the reasons and the method of the research. Individuals were also evaluated in terms of eligibility criteria during the same phone call. If eligible and desired, the person was asked to refer to the covered health center or sub-center on a specific date and time in a fast state to complete the questionnaires and give a blood sample for testing. The participants completed the questionnaires related to demographic characteristics in a reclusion environment in researcher's presence.

Sample Size

According to the study of Faam et al (18), and considering 95% confidence, 90% test power, two-sequence test, and using G*POWER software, the minimum sample size is based on Odds Ratio (95% CI) 2.08 (1.03-4.2) was equal to 109 cases and considering 1.5 design effect = 164 people.

Study Variables and Measurements

Physical Activity Questionnaire

A World Health Organization-short form of physical activity (2 questions for mild physical activity, 2 questions for moderate physical activity, 2 questions for severe physical activity, and 1 question for sitting) was applied to assess physical activity. Individuals mentioned their activity during the last 7 days in this study. Physical activity levels are introduced in the relevant metabolic equivalent. The reliability of this questionnaire has been described with a correlation coefficient of 0.86 in the Bashiri Moosavi et al. (19) study. Craig et al confirmed the validity and reliability of the tool (20).

Food Record Form

Food intake in this study was estimated by a standard 24-hour food registration form. Memory errors due to recording consumed food and its amounts at the time of taking this method are small. In this method, the nutrients supplied by the registered participants in the course of one non-working and two working days are recorded in a 3-day diet, including all the food and beverages used up by the participants (21). The recorded information was evaluated in terms of received calories, carbohydrates, fats, micronutrients, etc, using Nutritionist IV Software for Iranian food.

Anthropometric and Blood Pressure Assessments

Weight with minimum clothes and without shoes was measured and recorded using a Seca digital scale with an accuracy of 100 g. The height in standing position and while the shoulders, back of the head, and heels were in contact with the wall was assessed using a wall gauge with an accuracy of 0.1 cm. BMI was computed from the weight divided by height squared (kg/m^2). Waist circumference was also assessed in the narrowest area of the waist while the person was at the end of his normal exhalation. The most prominent part of it was considered and measured to assess the hip circumference. Measurement of waist and hip circumference was done using an inelastic tape meter without imposing any pressure on the body with a precision of 0.1 cm. To eliminate the inter-observer variation, one person performed all measurements. Blood pressure was measured after sitting for 15 minutes by the OMRON (Japan) digital fully automatic blood pressure monitor. Three measurements were performed in a sitting position using the appropriate cuff size on the right arm.

Biochemical Assessments

Five milliliters of the venous blood sample was taken within 10-12 hours of fasting from 9-12 o'clock in the morning. The blood sample was transferred into jelly tubes without anticoagulant and centrifuged at 3000 rpm for 10 minutes after transfer to the laboratory. Isolated sera were kept at -70°C until measurements.

Levels of serum biochemical parameters, including FBS, triglycerides, total cholesterol, LDL, HDL, and calcium, were assessed by spectrophotometry (the device with Alcyon 300 model with Pars Azmoon kit, (Tehran, Iran). Serum 25(OH)D level and serum insulin level were assessed by enzyme-linked immunosorbent assay using a Monobind kit (Iran). Blood LDL concentrations of patients were determined using the Friedewald-Fredrickson formula (22).

HOMA-IR (23) is the biological reaction to endogenous and exogenous insulin levels and is computed as follows:

*HOMA-IR: fasting glucose (mg/dL) * fasting insulin (mIU/L) /450*

Individuals who met three of the following five criteria based on NCEP ATP III criteria were included in the MetS group (10):

1. Waist circumference equivalent to or greater than 88 cm
2. FBS equivalent to or greater than 100 mg/dL
3. Triglycerides equal to or more than 150 mg/dL
4. HDL cholesterol downwards from 50 mg/dL
5. Blood pressure equal to or more than 130/85 mm Hg

Data Analysis

Data were analyzed using SPSS software (SPSS 21, SPSS Inc.). The Kolmogorov–Smirnov test was used to ascertain the normal distribution of continuous variables, descriptive statistics, including frequency distribution and percentage, as well as central and dispersion indexes like the mean and standard deviation (SD) and median (interquartile range) were applied to indicate the socio-demographic, anthropometric characteristics, serum indices, physical activity and nutritional elements (macro and micronutrients). Point prevalence was applied to express the outbreak of MetS, the proportion of women with MetS to women at hazard of MetS at a specific point in time.

Independent *t* test or Mann–Whitney U statistics were used to compare the mean score of blood pressure, anthropometric characteristics, nutritional elements, and serum indices (with normal distribution) and median (Interquartile range) of physical activity (without normal distribution) between women with and without MetS. To ascertain the predictors of MetS, all variables with $P<0.2$ were entered into the binary regression model with a backward strategy. Hosmer–Lemeshow test was used to test the fit of the model. $P<0.05$ was propounded statistically significant.

Results

This study was performed on 164 middle-aged women, of which 41 persons [25.0% (95% CI: 18.4% to 31.6%] had MetS. No significant discrepancy was shown between the two groups with and without MetS based on mean age, marital status, occupation, education, home activity, income level, and vitamin D supplements ($P>0.05$). The mean (standard deviation: SD) age in women with MetS was 49.3 (5.2), and in non-MetS was 49.6 (6.05). Most women in the group with and without MetS were married. Most of women with and without MetS were housewives. More than two third of women had primary education, and about half of them were housewives. Three fourth of women had income equivalent to expenditure (relatively sufficient) and received vitamin D supplementation (Table 1).

In terms of systolic and diastolic blood pressure, HDL, LDL, Ca, insulin, HOMA-IR index, mean serum level 25(OH)D, height, total energy, fat, protein, carbohydrates and fiber, total physical activity, low physical activity, moderate physical activity, and vigorous physical activity,

significant differences were not observed between women with and without MetS ($P>0.05$). Serum levels of FBS ($P=0.007$), triglyceride ($P<0.001$), total cholesterol ($P=0.044$), weight ($P=0.012$), BMI ($P=0.006$), hip circumference ($P=0.015$), waist circumference (p<0.001), WHR ($P=0.004$) and dietary iron ($P=0.015$) were significantly in proper ranges in the group without compared to with MetS (Table 2).

Mean weight, BMI, waist circumference, and hip circumference was significantly elevated in women with MetS. 53.7% of women with MetS and 37.4% of healthy women were in the obese group in terms of BMI. 73.2% of women with MetS vs. 47.2% of healthy women had more than 88 cm waist circumference.

The mean (SD) of iron in the diet of women was significantly higher in the MetS group (Table 2). In this study, FBS (adjusted Odds Ratio (aOR): 0.020; 95% CI: 1.001 to 1.039), triglyceride (aOR: 1.024; 95% CI: 1.015 to 1.033), low physical activity: walking (aOR: 0.999; 95% CI: 0.998 to 0.999), dietary iron (aOR: 1.059; 95% CI: 0.989 to 1.134) and waist circumference (aOR: 1.062: 95% CI; 1.020 to 1.105) remained in the last step of the logistic regression model and were detected as the MetS predictors (Table 3).

Table 4 shows the relationship between MetS components and serum 25(OH)D level with serum, anthropometric and physical activity indices.

According to its findings, diastolic blood pressure has a significant direct relationship with height, weight, and WHR. Serum FBS level has a significant direct relationship with the concentration of LDL, total cholesterol, and HOMA-IR. Serum triglyceride level has a significant direct relationship with total cholesterol. Serum HDL level has a significant inverse relationship with serum LDL level. Waist circumference has significant direct relationships with serum insulin level, HOMA-IR, weight, BMI, and hip circumference. Still, it has significant inverse relationships with WHR, total physical activity, low physical activity, and vigorous physical activity. Serum 25(OH)D levels are significantly oppositely related to serum insulin and HOMA-IR levels.

Discussion

This study demonstrated that 25% of studied middle-aged women had MetS. Serum levels of FBS, triglyceride, total cholesterol, weight, BMI, waist circumference, hip circumference, WHR, and dietary iron in women with MetS were significantly different from healthy women. The variables of FBS, triglyceride, low physical activity, iron intake, and waist circumference were detected as the predictors of MetS. So, with a high FBS and triglyceride concentration equal to 1 mg/dL, the chance of developing MetS increased by 2% and 2.4%, respectively. With a high Low physical activity equal to one Met-min/week, the odds of developing MetS reduced by 0.1%. Furthermore, by increasing the amount of iron intake by 1 g/d and waist circumference by 1cm, the chance of developing MetS increased by 6%

Table 1. Socio-Demographic Characteristics of Participants With and Without Metabolic Syndrome According to ATP III Criteria

Variable	Metabolic Syndrome (n = 41)	Non-metabolic Syndrome (n = 123)	*P* Value
Age (y), Mean ± SD	49.3 ± 5.2	49.6 ±6.05	0.82[a]
Marital status, No. (%)			
Married	41 (100.0)	119 (96.7)	0.51[c]
Unmarried/widow	0 (0.0)	4 (3.3)	
Job, No. (%)			
Housewife	34 (82.9)	111 (90.2)	
Works in the home	3 (7.3)	8 (6.5)	0.24[b]
Works outside the home	4 (9.8)	4 (3.3)	
Educational status, No. (%)			
Primary school	30 (73.2)	74 (60.2)	
Secondary school	5 (12.2)	32 (26.0)	0.18[d]
High school and above	6 (14.6)	17 (13.8)	
Home activity, No. (%)			
Housekeeping	23 (56.1)	61 (49.6)	
Housekeeping and exercise (> 150 min)	14 (34.1)	35 (28.5)	0.33[b]
Housekeeping and exercise (< 150 min)	4 (9.8)	23 (18.6)	
None	0 (0.0)	4 (3.3)	
Family income, No. (%)			
Insufficient	8 (19.5)	21 (17.1)	
Relatively sufficient	31 (75.6)	94 (76.4)	0.89[d]
Sufficient	2 (4.9)	8 (6.5)	
Taking vitamin D supplement, No. (%)			
Yes	31 (75.6)	97 (78.9)	0.66[c]
No	10 (24.4)	26 (21.1)	

[a] Independent *t* test; [b] Chi-square test; [c] Fisher exact test;, [d] Linear by linear chi-square test.

Table 2. Anthropometric, Blood Pressure, Dietary Intake, and Serum Parameters of Participants With and Without Metabolic Syndrome According to NCEP ATP III Criteria

Variable	Metabolic Syndrome (n = 41)	Non-metabolic Syndrome (n = 123)	*P* Value
Systolic blood pressure (mm Hg), Mean ± SD	109.75 ± 9.93	110.69 ± 8.83	0.57[a]
Diastolic blood pressure (mm Hg), Mean ± SD	69.26 ± 7.20	68.33 ± 7.34	0.48[a]
FBS (mg/dL), Mean ± SD	103.00 ± 34.36	86.94 ± 22.80	0.01[a]
TG (mg/dL), Mean ± SD	234.61 ± 110.45	127.69 ± 49.14	<0.001[a]
HDL-C (mg/dL), Mean ± SD	40.09 ± 8.79	42.14 ± 12.09	0.25[a]
LDL-C (mg/dL), Mean ± SD	115.71 ± 43.85	121.20 ± 35.18	0.47[a]
Total cholesterol(mg/dL), Mean ± SD	202.73 ± 41.89	188.78 ± 36.83	0.04[a]
Ca (mg/dL), Mean ± SD	8.74 ± 0.66	8.67 ± 0.64	0.54[a]
Insulin (uIU/mL), Mean ± SD	9.31 ± 5.89	9.81 ± 6.99	0.68[a]
HOMA-IR, Mean ± SD	2.29 ± 1.84	2.13 ± 1.60	0.57[a]
25 (OH) D (ng/mL), Mean ± SD	30.60 ± 11.81	31.06 ± 12.60	0.83[a]
Height (cm), Mean ± SD	155.58 ± 6.91	155.65 ± 5.38	0.95[a]
Weight (kg), Mean ± SD	74.92 ± 13.76	68.86 ± 13.08	0.01[a]
BMI (Kg/m^2), Mean ± SD	30.94 ± 5.63	28.40 ± 4.84	0.01[a]
Underweight, No. (%)	0 (0.0)	0 (0.0)	
Normal, No. (%)	7 (17.0)	32 (26.0)	
Over weight, No. (%)	12 (29.3)	45 (36.6)	
Obese, No. (%)	22 (53.7)	49 (37.4)	
Waist circumference (cm), Mean ± SD	96.97 ± 12.97	88.41 ± 12.19	<0.001[a]
Waist circumference more than 88, No. (%)	30 (73.2)	58 (47.2)	<0.001[b]
Hip circumference (cm), Mean ± SD	102.34 ± 12.12	96.80 ± 12.55	0.01[a]
WHR, Mean ± SD	0.94 ± 0.06	0.91 ± 0.06	0.004[a]
WHR more than 0.85, No. (%)	35 (85.4)	102 (82.9)	<0.001[b]
Total energy (kcal/day)/dietary intake, Mean ± SD	3144.68 ± 1151.20	2900.80 ± 845.36	0.15[a]
Total fat (g/d), Mean ± SD	201.54 ± 114.71	189.78 ± 87.74	0.49[a]
Carbohydrates (g/d), Mean ± SD	431.19 ± 178.07	386.40 ± 129.02	0.14[a]
Protein (g/d), Mean ± SD	122.71 ± 43.49	120.18 ± 48.12	0.76[a]
Total fibers (g/d), Mean ± SD	31.44 ± 16.32	27.45 ± 11.16	0.15[a]
Iron intake (g/d), Mean ± SD	22.72 ± 7.44	19.83 ± 6.21	0.01[a]
Physical activity (Met-min/wk), Median (IQR)			
Total	2933 (1766.0)	2793 (1490.5)	0.367[c]
Low	676.5 (1155.0)	462 (594.0)	0.18[c]
Moderate	2140.00 (1110.0)	2040.00 (840.0)	0.78[c]
Vigorous	0.00 (880.0)	0.00 (720.0)	0.657[c]

FBS: fasting blood sugar; TG: triglyceride; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; ca: Calcium; HOMA-IR: Homeostatic Model Assessment for Insulin Resistance; 25 (OH) D: 25-hydroxy vitamin D3; BMI: body mass index; WHR: waist-to-hip ratio; IQR: interquartile range.

[a]Independent *t* test; [b] Fisher exact test; [c] Mann–Whitney U test.

Table 3. Logistic Regression Model for Adjusted Odds Ratio With 95% Confidence Interval for Predictors of Metabolic Syndrome

Variables	Adjusted Odds Ratio	95% Confidence Interval		*P* Value
		Lower Limit	Upper Limit	
FBS (mg/dL)	1.020	1.001	1.039	0.04
TG (mg/dL)	1.024	1.015	1.033	<0.001
Low physical activity (Met-min/wk)	0.999	0.998	0.999	0.02
Iron intake (g/d)	1.059	0.989	1.134	0.1
Waist circumference (cm)	1.062	1.020	1.105	0.01

FBS: Fasting blood sugar; TG: Triglyceride

The backward strategy was used; Age, educational status, and job adjusted as confounders.

Hosmer-Lemeshow test: Chi-square=2.902, *df* = 8, *P* value = 0.940.

The other cross-sectional study in this regard showed that the prevalence of MetS was 25% and was associated with pro-inflammatory nutrition, university degree, central obesity, moderate physical activity, snacking between meals, hypertension, hypertriglyceridemia, low HDL-cholesterol. The study findings are consistent with our findings that the higher triglyceride level and waist circumference and the lower physical activity increased the chance of developing MetS (24).

The prevalence of MetS in south of Iran was reported to

Table 4. Correlation between MetS Components and Serum 25 (OH) D Levels With Physical Activity, Serum Metabolic, and Anthropometric Indices

Variables	r (Correlation Coefficient)							*P* value						
	SBP	DBP	FBS	TG	HDL	WC	25(OH)D	SBP	DBP	FBS	TG	HDL	WC	25(OH)D
LDL	0.025	-0.027	0.221	-0.131	-0.194	0.059	0.060	0.75	0.73	**0.01**	0.09	**0.01**	0.45	0.45
TC	-0.007	-0.060	0.365	0.305	0.106	0.124	0.067	0.93	0.44	**<0.001**	**<0.001**	0.17	0.11	0.39
Ca	-0.087	-0.023	0.132	0.086	0.086	-0.092	0.064	0.27	0.77	0.09	0.27	0.27	0.24	0.42
Insulin	-0.046	0.076	0.026	0.099	-0.085	-0.183	0.183	0.55	0.33	0.74	0.28	0.28	**0.02**	**0.02**
HOMA index	-0.066	0.046	0.322	-0.147	-0.042	-0.195	0.154	0.40	0.56	**<0.001**	0.06	0.59	**0.01**	**0.04**
Height	0.129	0.213	0.022	-0.018	-0.052	0.059	-0.022	0.10	**0.01**	0.78	0.82	0.51	0.45	0.78
Weight	0.144	0.189	0.056	0.099	0.078	0.648	0.135	0.066	**0.015**	0.479	0.21	0.32	**<0.001**	0.08
BMI	0.105	0.153	0.052	0.102	0.136	0.637	0.133	0.181	0.050	0.510	0.19	0.08	**<0.001**	0.09
WC	0.029	-0.079	-0.029	0.138	0.026	1	0.120	0.716	0.347	0.709	0.08	0.74	-	0.13
HC	-0.004	0.021	-0.003	0.116	-0.040	0.864	0.110	0.960	0.794	0.973	0.14	0.61	**<0.001**	0.16
WHR	0.079	0.180	-0.060	0.052	0.119	0.429	0.045	0.313	**0.021**	0.448	0.51	0.13	**<0.001**	0.56
TPA	0.007	-0.055	-0.057	-0.003	-0.140	-0.243	-0.100	0.927	0.482	0.466	0.97	0.07	**0.002**	0.20
LPA	0.112	0.048	-0.106	-0.015	-0.138	-0.256	-0.115	0.152	0.538	0.175	0.85	0.08	**0.001**	0.14
MPA	-0.109	-0.092	-0.022	0.006	-0.087	-0.114	-0.092	0.163	0.241	0.783	0.94	0.27	0.15	0.24
VPA	0.046	-0.064	-0.003	-0.002	-0.088	-0.18-	-0.008	0.558	0.416	0.968	0.98	0.26	**0.020**	0.922

All correlation was determined by Pearson correlation coefficient except for physical activity, which determined by Spearman rho due to non-normal distribution SBP: systolic blood pressure; DBP: diastolic blood pressure; FBS, fasting blood sugar; TG: triglyceride.; HDL: high-density lipoprotein cholesterol; WC: Waist circumference; 25 (OH)D: 25-hydroxy vitamin D3; LDL: low-density lipoprotein cholesterol; TC: total cholesterol; Ca: calcium; HOMA, Homeostatic Model Assessment; BMI: body mass index; HC: hip circumference; WHR: waist hip ratio; TPA: total physical activity; LPA: low physical activity; MPA: moderate physical activity; VPA: vigorous physical activity.

be 37%, 33.82%, and 33.13% based on IDF, ATP III, and an Iranian definition, respectively (25). Another longitudinal study assessed the prevalence of MetS to be 33.3%, which was significantly greater in women than men (39.9% vs. 25.9%) (26). The reason for this high rate in two studies in opposition to our study could be owing to lack of adequate education, differences in setting, lifestyle and nutrition, differences in the criteria for diagnosing MetS, or due to genetic factors, but it is consistent with the American Health Association, which reports a prevalence of MetS in adults of about 23% (10).

According to the findings of a cross-sectional study, triglyceride levels, HDL cholesterol, mild to moderate physical activity, weight, waist circumference, and BMI in women with MetS were significantly different from healthy women. Triglycerides, HDL, physical activity, sex, and microalbuminuria were predictors of MetS (27). The results of this study are in accordance with our findings that the higher triglyceride level and the lower physical activity increased the chance of developing MetS. Another descriptive cross-sectional study showed that lipid disorder was the most common disorder observed in obese children with MetS (28). In our study, serum triglyceride levels were the strongest predictors of MetS. Cohort studies aimed at determining the risk factors for MetS in Iranian women showed that weight gain, increased BMI, body weight change, and body fat dissemination are significantly associated with the hazard of MetS (29). A cohort study illustrated a significant direct relationship between carbohydrate and fat intake (calories) and the risk of MetS. In this study, blood pressure, waist circumference, and triglycerides were predictors of MetS and the strongest indicator for predicting MetS was waist circumference (30). In our study, triglycerides and waist circumference were the strongest predictors of MetS. Another prospective study showed that weight, waist circumference, BMI, systolic and diastolic blood pressure, FBS, triglycerides, and HDL were significantly higher in the group with MetS than in the healthy group. Triglyceride, waist circumference, and HDL indices were predictors of MetS(31). Cross-sectional studies aimed at the predictive effect of non-HDL cholesterol on the presence of MetS concluded that BMI, waist circumference, systolic and diastolic blood pressure, LDL, cholesterol, HDL, triglyceride, and non HDL cholesterol in people with MetS were significantly different from healthy people. In this study, people with MetS had a higher level of non-HDL cholesterol, which was a predictor (25). In our study, serum total cholesterol level was higher significantly in the MetS group.

A cross-sectional study showed that women with MetS had significantly increased BMI, waist circumference, WHR, systolic and diastolic blood pressure, FBS, fasting insulin, total cholesterol, LDL cholesterol, triglycerides, and less HDL cholesterol than healthy women. BMI and fasting blood insulin levels were more important (32). Two review studies which investigated the relationship between MetS and serum ferritin levels, demonstrated that elevated serum ferritin levels were significantly correlated with MetS (33). This is consistent with our study. Regarding the

relationship between MetS and physical activity, a review study found that high physical activity at leisure would reduce the risk of MetS. In contrast, moderate physical did not reduce this risk significantly (34). The difference in our results may be attributed our participants to the low rate of vigorous physical activity.

One of the leading reasons of MetS is IR. In IR, cellular do not respond to insulin naturally, and glucose does not arrive in the cells. IR itself will increase serum FBS so that as the intensity of IR increases, the serum FBS levels will enhance. In this case, the body keeps secrete more insulin, and the amount of insulin in the blood increases; this insulin will increase triglycerides and other blood fats. This lipid disorder is one of the most common disorders seen in MetS (6, 7). Studies have shown that exercise or regular daily activity reduces the risk of MetS. Physical activity will cause positive changes in reducing the risk factors for MetS, especially in the waist circumference (35). In other words, increasing serum iron and ferritin levels through the construction of free radicals causes oxidative stress and chronic inflammation; this chronic inflammation causes the abnormal response of pancreatic beta cells and reduces insulin secretion, thus stimulating IR (36). In other words, getting more iron justifies the inflammatory conditions in MetS.

Limitations of the Sttudy

The present study also had some limitations. It was a descriptive-analytical cross-sectional study, and these types of studies do not show the exact cause-and-effect relationship. Therefore, interventional studies in this field are recommended. This study was not performed on a large population, and it is suggested that an investigation be conducted on the people of the entire city or in the whole country. Another thing is that several predictors of MetS, including FBS, triglycerides, and waist circumference, were indicators for the diagnosis of MetS. This factor will make the factors of MetS superior in predicting it. In this study, people with cardiovascular disease, diabetes, and stroke were excluded from the study, and this factor can affect the development of MetS.

Conclusions

FBS, triglyceride, low physical activity, iron intake, and waist circumference were the predictors of MetS. Higher serum levels of FBS and triglyceride, higher iron intake and waist circumference, and lower levels of low physical activity (walking) enhance the chance of developing MetS. Therefore, for the diagnosis of MetS, measuring FBS, triglycerides, and waist circumference are preferable. Improving physical activity and controlling dietary iron intake is suggested to prevent MetS. Interventions to increase physical activity, weight control, and dietary iron intake can reduce the incidence of MetS. Therefore, it is suggested that the mentioned factors be examined through a clinical trial.

Authors' Contribution

The conception and design of the study: AFKh, PY. Acquisition of data: AFKh, PY, JAH, NGA. Analysis and interpretation of data AFKh, PG, JAH, KHN. Drafting the article or revising it critically for important intellectual content: AFKh, KHN, JAH, PG, NGA, PY. Final approval of the version to be submitted: AFKh, KHN, JAH, PG, NGA, PY.

Conflict of Interests

Authors have no conflict of interest.

Ethical Issues

The current study has been approved by the Research Committee of Tabriz University of Medical Sciences, Tabriz, Iran (Code: IR.TBZMED.REC.1396522). Comprehensive information about the reasons for performing the research, benefits, results, keeping information confidential, and how to conduct the research was prepared to the individual. The informed consent form was obtained from the participants.

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