Iran Red Crescent Med J. 2017 July; 19(7):e14934. doi: 10.5812/ircmj.14934.

Published online 2017 June 17. **Research Article**

The Incidence of Metabolic Syndrome and the Most Powerful Components as Predictors of Metabolic Syndrome in Central Iran: A 10-Year Follow-Up in a Cohort Study

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Received 2017 February 28; **Revised** 2017 April 30; **Accepted** 2017 April 29.

Abstract

Background: Metabolic Syndrome (MetS) is rapidly growing in today's world as an important predictor for type 2 diabetes and cardiovascular disease.
Objectives: The present study aimed at assessing the incidence of MetS and the most powerful components as predictors of MetS in a cohort study in central Iran.
Methods: This cohort study was a follow-up of participants (n = 2000 and aged 20 to 74 years), who were selected using multistage random cluster sampling method from urban areas of Yazd, Iran, during year 2005 and repeated in 2015. Metabolic Syndrome was defined using a modified version of National cholesterol education program adult treatment panel III (NCEP III) definition. To assess hazard ratio of components of MetS for crude and adjusted values in two models, Cox proportional hazard regression was used.
Results: Prevalence of MetS was 44.8% (n = 887) at baseline. Therefore, we followed subjects without MetS (n = 809) in 2015. After about 10 years, MetS was developed in 56.1% (n = 454) of subjects. Incidence of MetS in males and females was 56.1/1000 person-years and 58.7/1000 person-years, respectively. The analysis revealed that incidence of MetS significantly increased with age and higher level of socio-economic status and decreased with high level of education. In females and males the most powerful component for incidence of MetS was high fasting blood glucose (HR = 16.6, 95% CI: 1.91 - 22.82) and hypertriglyceridemia (HR = 1.64, 95% CI: 1.02 - 2.6), respectively.
Conclusions: The current study showed a high incidence of MetS in males and females residing in central Iran. Furthermore, community-based interventions that reduce MetS in the population are needed.

Keywords: Metabolic Syndrome, Incidence, Cohort Study

1. Background

Metabolic Syndrome (MetS) is a condition, which consists of clustering of components, including abdominal obesity, high blood glucose levels, elevated blood pressure, hypertriglyceridemia, and low high-density lipoprotein cholesterol (HDL-C) levels (1), which are among the established risk factors for cardiovascular diseases (CVDs) (2-4). People with 3 of these abnormal conditions were affected by MetS. Currently, the disease is rapidly increasing around the globe (5, 6) and the mortality rate in people with MetS was reported to be more than twice compared to those without MetS (7). According to the definition of MetS and cut-points, incidence of MetS will be different (8). However, there was no significant difference in detecting poor health in Iranian adult population between the widely used international and national criteria, including the national cholesterol education program adult treatment panel III (NCEP III), the international diabetes federation (IDF), the American heart association/national heart, lung, the blood institute (AHA/NHL), and the joint interim statement (2).

Based on the criteria developed by the international diabetes federation (IDF), about 40% of adults in the US have MetS. Furthermore, in a five-year follow-up study in Korea, the incidence of MetS was reported as 30/1000 person-years for males and 46.4/1000 person-years for females (5). In a study from Taiwan, after a 10-year follow-up, the incidence rate of MetS was reported as 24.2% (9). Also, the incidence of MetS increased significantly from 2005 to 2014 in both males and females in China (10). The majority of studies conducted in Iran have reported the prevalence of MetS, using a cross-sectional design, and a few studies have tried to assess its incidence. In Iran, more than 30% of the population was predicted to be affected by MetS, while it has been more prevalent in females (11). For instance, in a study by Hadaegh et al. after nine years of follow-up and using the joint interim statement, which is another definition of MetS, the incidence rate of MetS was reported as 55/1000 person-years in Tehran, the capital of Iran (12). In another study from Iran, the incidence of MetS was reported to be 18.4% in males and 23.1% in females, based on NCEP III definition (13). However, the reports on the occurrence of MetS using prospective design are scarce in central Iran. The present study aimed at determining the incidence of metabolic syndrome during about ten years following a large-scale study called Yazd healthy heart project (YHHP), which was previously conducted in Yazd city, located in central Iran.

2. Methods

2.1. Study Population

This study, as a cohort, tried to follow all participants of Yazd healthy heart project (YHHP) conducted in 2015 after about ten years. Yazd is the capital of Yazd province, located in central Iran. Based on prevalence of diabetes in Yazd (14%) in 2005, P = 20% and d = 0.02% was considered [n = (Z1-alpha/2)2 x p (1 - p). d2]. Based on type of sampling, sample size was multiplied by 1.25. Therefore, two thousand adults were selected using multistage random cluster sampling method from urban areas of Yazd, Iran, in YHHP. The power of study was 80% and alpha = 0.05 was considered. In YHHP, 100 clusters and 20 families from each cluster and one adult from each family were randomly selected (n = 2000, age 20 to 74 years). Because of some missing data, 21 subjects were excluded from the study (14).

In the present study, the researchers followed the participants using Yazd Central Health records. In 2015, the subjects were invited to Yazd cardiovascular research center (YCRC) to be evaluated again by a trained researcher with good communication, and the data was gathered by trained observers. For those who were unable to come to the YCRC, data were collected over the phone. The Yazd Telecom databank was also used to find the phone numbers of the subjects, who could not be reached using phone numbers provided in 2005. The rest of people were invited by telephone and text messages. However, some subjects were lost to follow-up, due to migration and not answering the call. The process of participants' selection is depicted in Figure 1. As indicated, at the first phase in 2005, the study was initiated with 1979 subjects and prevalence of non-MetS was 55.2% (n = 1092). This study was performed for about 10 years (non-MetS), and 809 (74.1%) subjects were followed-up and there were 283 (25.9%) as subject attrition.

2.2. Ethics Statement

The study was approved by the ethics committee of Shahid Sadoughi University of Medical Sciences in Yazd, Iran (ethical code: 65306 on June 28, 2014). Informed written consent was obtained from all participants both at the baseline and follow-up phases.

2.3. Methods

In the first survey of YHHP in 2005, information on demographic data, anthropometric measurement, risk factors of cardiovascular disease (CVD) (such as having hypertension, diabetes, and hyperlipidemia or medication for each of them), smoking status, physical activity, socioeconomic status, and biochemical tests, including fasting blood sugar (FBS), level of triglyceride, and serum HDL-cholesterol were recorded. In 2015, biochemical tests were repeated. Venous blood was taken from participants by an experienced nurse and lab technician after 9 to 12 hours of fasting. Next, blood samples were centrifuged to separate the serum. A biochemical auto-analyzer, model BT 3000 (Italy) and PARS Azmoon Kits (Pars Azmoon Kit, Pars Azmoon Inc., Tehran, Iran) were used to assess fasting blood glucose and triglyceride. High-density lipoprotein cholesterol (HDL-C) was also measured using Bionic kits.

Height was measured without shoes using a stadiometer fixed on a wall and weight was measured with minimal clothing and using electronic scales (Omron Karada Body Scan and Scale, Model BF511, Omron Co. Osaka, Japan). Waist circumference was measured midway between the last rib and the iliac crest or in the upper iliac crest with a tape measure.

Blood pressure was taken twice after at least 5 minutes of rest in a seated position using an automatic digital blood pressure device (Automatic Blood Pressure Monitor, Model M6 Comfort, Omron Co. Osaka, Japan). All measurements were performed with standard and calibrated tools.

A modified version of NCEP-ATP III criteria for MetS was considered to define MetS (15). According to this definition,

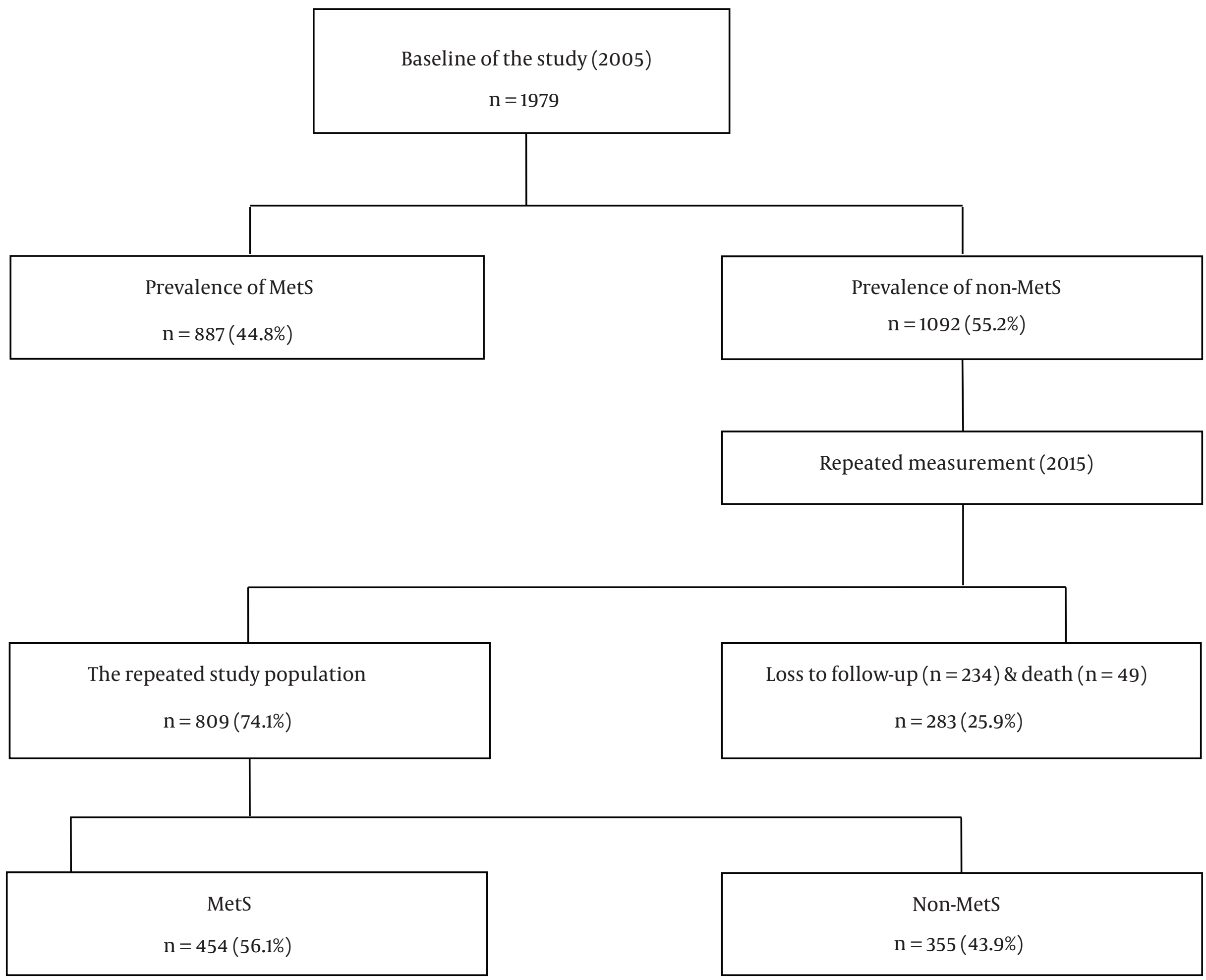

Figure 1. Flow Diagram Showing the Process of Participants Attending the 10-Years Follow-Up Study

having 3 out of 5 of the following metabolic abnormalities were considered as MetS: hypertension (blood pressure ≥ 130/85 mmHg or antihypertensive drug consumption), hyperglycemia (serum fasting blood glucose (FBG) ≥ 100 mg/dL or taking antidiabetic drugs), hypertriglyceridemia (serum triglyceride ≥ 150 mg/dL), low serum HDL-cholesterol (< 40 mg/dL in males and < 50 mg/dL in females or pharmacologic treatment for both TG and HDL-C) (5, 15, 16) and abdominal obesity based on proposed national definitions for Iranians (waist circumference ≥ 91.5 cm in males and ≥ 85.5 cm in females, according to a study done by Esteghamati et al. (17). Socioeconomic status was divided to 3 groups; low, moderate, and high based on income level, private car and home area. Education level was divided to 3 groups of low, intermediate, and high, based on primary, diploma, and academic education. Also, physical activity was divided to 3 groups of low, moderate, and vigorous.

2.4. Statistical Analysis

Statistical analysis was done using the statistical package for social sciences (SPSS 19, IBM Corporation, New York, USA). Descriptive statistics were used to interpret continuous variables and categorical variables using mean and its corresponding standard deviation (SD) and proportion. For quantitative variables and for using the Student's test, the Kolmogorov-Smirnov (K-S) test was used to check normality of data. Student's t test and chi-square test were used for comparison of continuous and categorical data, respectively. Significance level was considered as a P value of less than 0.05.

According to the age distribution of Yazd urban population and also the world health organization (WHO) age standardization method using world reference population (18), the incidence of MetS in the survey was calculated for the entire population as well as males and females, separately.

Cox proportional hazard model was used to find hazard ratio of MetS, according to age (categorized), gender (male/female), smoking status (smoker/non-smoker), socioeconomic status (low/moderate/high), physical activity (low/moderate/vigorous), and education (low, intermediate, and high), in the entire population as well as either gender. The proportional hazard assumption was checked by calculating the time dependent covariate and including it in the Cox proportional hazards model.

To find the hazard ratio of components of MetS in crude, model I (adjusted for age and gender, and other 4 components of MetS) and model II (adjusted for age, gender, and other 4 components of MetS, smoking, socioeconomic status, physical activity, and education) of Cox proportional hazard model was used for the total population as well as for either genders.

3. Results

The comparison of baseline characteristics of participants, who were lost to follow-up and those, who had data in the follow-up survey, is shown in Table 1. Subjects in the follow-up group were significantly younger (P = 0.016) and weighed more than the loss to follow-up group (P = 0.006). There were no significant differences in body mass index (BMI), systolic blood pressure, diastolic blood pressure, fasting blood sugar, triglyceride, HDL-cholesterol, waist circumference, gender, and physical activity between follow-up and loss to follow-up groups. Furthermore, there was a significant difference regarding smoking (P = 0.036), socioeconomic status (P = 0.001), and education (P = 0.008) between the 2 groups.

Table 2 shows that during the 9.8-year follow-up, 55.1% of males, 57.3% of females, and 56.1% of total subjects had been newly diagnosed with MetS. As a result, annual incidence rate of MetS was 5.62% in males and 5.84% in females. The incidence of MetS in females (58.7/1000 person-years) was greater than males (56.1/1000 person-years), yet there was no significant difference between the 2 groups. The incidence of MetS was 57 /1000 person-year for all subjects (Table 3). The weighted incidence (age adjustment) of MetS in the survey, according to the age distribution of Yazd urban population (2011), was 53.4/1000 person-year and 52.4/1000 person-years for males and females, respectively and for all participants (53.08/1000 person-years). The weighted incidence of MetS in the survey, according to the age distribution of WHO (18) in 2001, was 56.05/1000 person-years.

Older participants had a greater risk for developing MetS when compared to 20- to 30-year-old attendants, yet, the increased risk was not significant for 65- to 74-year-olds. High level of economic status increased the incidence of MetS, significantly (hazard ratio (HR) = 1.57 and 95% confidence interval (CI):1.11 - 2.25). High level of education decreased the incidence of MetS, significantly (HR = 0.66, 95% CI: 0.49 - 0.9). Although the level of moderate (HR = 0.96, 95%CI: 0.75 - 1.08) and vigorous physical activity (HR = 0.86, 95%CI: 0.52 - 1.41) decreased incidence of MetS, there was no significant difference between the levels of physical activity and the risk of MetS. There was no significant difference between variables of gender and smoking with the risk of MetS. The gender stratified association between general characteristics and hazard ratio for MetS is reported in Table 4. The analysis revealed that compared to 20- to 30-year-old attendants, the risk of MetS significantly increased in the age group of 40 to 49 years (HR = 1.84, 95%CI: 1.23 - 2.76) and age group of 50 to 64 years (HR = 2.06, 95%CI: 1.41 - 3.02) in males. In females, compared to 20- to 30-year-old attendants, risk of MetS significantly increased in the age group of 30 to 39 years (HR = 2.06, 95%CI: 1.26 - 3.32), the age group of 40 to 49 years (HR = 2.87, 95%CI: 1.77 - 4.65), and the age group of 50 to 64 years (HR = 2.79, 95%CI: 1.71 - 4.55). In males, there was no significant difference in the increased risk of Mets and levels of socioeconomic status, yet in females high level of socioeconomic status increased the risk of MetS (HR = 1.88, 95%CI: 1.05 to 3.34). There was no significant difference between levels of physical activity and education to increase or decrease risk of MetS in males and females.

The relationship between MetS components is reported in Table 5. In participants, high fasting blood glucose, abdominal obesity, and hypertriglyceridemia were significantly associated with increased risk of MetS in crude and age and gender adjusted model (model I). The result was replicated only for fasting blood glucose (HR = 1.96, 95%CI: 1.11 - 3.45) and hypertriglyceridemia (HR = 1.75, 95%CI: 1.18 - 2.58) when other variables such as age, gender, other 4 components of MetS, smoking, economic status, physical activity, and education (model II) were taken into account. The relationship between MetS components according to gender is summarized in Table 6. In males, abdominal obesity was associated with increasing incidence of MetS (the most powerful risk factor), significantly in crude (HR = 1.5, 95%CI: 1.16 - 1.93) and age-adjusted model (HR = 1.45, 95%CI: 1.11 - 1.9). Also, hypertriglyceridemia was associated with increasing incidence of MetS in crude and model I in males. Nevertheless, after adjustment for age, other 4 components of MetS, smoking, economic status, physical activity, and education (Model II), only hypertriglyceridemia was significantly associated with increas-

Table 1. Baseline Characteristics of the Follow-Up Group and Those Lost to Follow-Up

Variable	Follow-Up	Loss to Follow-Up	Total	P Value
Age, y	43.03 ± 14.41	45.87 ± 17.8	43.8 ± 15.4	0.016
Weight, kg	68.6 ± 12.2	66.2 ± 13.4	67.96 ± 12.5	0.006
BMI, Kg/m^2	24.9 ± 4.1	24.4 ± 4.8	24.8 ± 4.3	0.115
Systolic blood pressure, mmHg	121.9 ± 12.7	123.4 ± 14.6	122.3 ± 13.3	0.121
Diastolic blood pressure, mmHg	79.8 ± 7.5	79.8 ± 7.8	79.81 ± 7.6	0.949
Fasting blood glucose, mg/dL	87.2 ± 23.1	85.2 ± 18.9	86.7 ± 22.1	0.178
Triglyceride, mg/dL	129.2 ± 69.7	126.4 ± 77.7	128.4 ± 71.9	0.573
HDL-cholesterol, mg/dL	56.8 ± 13.3	56.5 ± 12.9	56.7 ± 13.2	0.703
Waist circumference, cm	88.7 ± 11.2	87.4 ± 12.3	88.3 ± 11.5	0.099
Gender				0.209
Male	441 (54.5)	142 (50.2)	583	
Female	368 (45.5)	141 (49.8)	509	
Current smokers, %	140 (68.3)	140 (17.3)	65 (23)	0.036
Socioeconomic Status, %				0.001
Low	94 (25.2)	41 (32.8)	135	
Moderate	149 (39.9)	62 (49.6)	211	
High	130 (34.9)	22 (17.6)	152	
Physical activity, %				0.090
Low	326 (60.5)	132 (69.1)	458	
Moderate	181 (33.6)	52 (27.2)	233	
Vigorous	32 (5.9)	7 (3.7)	39	
Education, %				0.008
Low	363 (46.7)	156 (56.5)	519	
Moderate	313 (40.2)	98 (35.5)	411	
High	102 (13.1)	22 (8)	124	

[a]Values are expressed as mean ± standard deviation or No. (%).

Table 2. Cumulative and Annual MetS Risk Between Males and Females in Central Iran, 2005-6 to 2015-16

Gender	At Risk (n)	Loss to Follow-Up (n)	Cases (n)	9.8-yr Cumulative Incidence Rate, %	Annual Incidence Rate, %
Males	441	142	243	55.1	5.62
Females	368	141	211	57.3	5.84
Total population	809	283	454	56.1	5.7

ing risk of MetS (the most powerful component) (HR = 1.64, 95%CI: 1.02 - 2.65). Although abdominal obesity was significantly associated with increased risk of MetS in crude analysis and age adjusted model, this result was not replicated when other variables were taken into account. In female adults, high fasting blood glucose, abdominal obesity, and hypertriglyceridemia were significantly associated with increased risk of MetS both in crude and age adjusted models. However, only high blood glucose remained significant when other covariates, like age, other 4 components of MetS, smoking, economic status, physical activity, and education, were taken into account (HR = 6.6, 95%CI: 1.91 to 22.8).

Table 3. Hazard Ratio of MetS Risk in Central Iran, 2005-6 to 2015-16

Variable		At Risk (n)	Person Year	Cases (n)	Incidence/1000 Person-Year	Hazard Ratio HR (95%CI)
Age groups	20 - 30	174	1743.27	64	36.71	1
	30 - 39	193	1916.19	106	55.32	1.53 (1.12 - 2.09)
	40 - 49	179	1742.11	116	66.59	2.23 (1.64 - 3.03)
	50 - 64	184	1780.85	128	71.87	2.37 (1.76 - 3.21)
	$\geq$ 65	79	783.01	40	51.08	1.42 (0.96 - 2.11)
Gender	Male	441	4331.82	243	56.1	1
	Female	368	3633.61	211	58.07	1.06 (0.88 - 1.27)
Smoking	Smoker	140	1383.31	69	49.88	1
	Non-smoker	669	6582.12	385	58.49	1.26 (0.98 - 1.63)
Socioeconomic Status	Low	94	949.53	51	53.71	1
	Moderate	149	1476.05	77	52.17	1.35 (0.94 - 1.94)
	High	130	1286.21	82	63.75	1.57 (1.11 - 2.25)
Physical activity	Low	326	3214.09	183	56.93	1
	Moderate	181	1791.58	97	54.14	0.96 (0.75 - 1.23)
	Vigorous	32	321.86	17	52.82	0.86 (0.52 - 1.41)
Education	Low	363	3562.90	226	63.43	1
	Moderate	313	3070.04	168	54.72	0.88 (0.72 - 1.08)
	High	102	1021.85	51	49.91	0.66 (0.49 - 0.90)
Total		809	7965.43	454	57	

4. Discussion

In this study, after 9.8-year of follow-up, the incidence of MetS was 57/1000 person-years. In males and females, the incidence of MetS was 56.1 and 58.7/1000 person-years, respectively. The incidence of MetS in females was higher than males, which was similar to some studies (2, 10, 19-21) yet different from other studies (9, 22); there was no significant difference in incidence of MetS between males and females. A similar result was reported in other studies (23, 24). It should be noted that after age adjustment based on age distribution of Yazd urban population (2011), the incidence of MetS was 53.4/1000 persons-year and 52.4/1000 persons-years for males and females. As a result, after age adjustment, the incidence of MetS in males was slightly more than females. In a cohort study, after 9.3-year follow-up, the incidence rate of MetS was reported as 55/1000 person-years in Tehran, the capital of Iran (2011), that was similar to the current study. Also, the study showed that the incidence of MetS in males and females was 74.9 and 43.4/1000 person-years, respectively (12) that was more than our study on males and lower than that of females. It should be noted that the criteria for definition of MetS in the 2 studies were similar.

In a study by Hwang et al. in Korea during a 5-year follow-up, the incidence density of MetS was 30 and 46.4/1000 person-years in males and females, respectively (5). As a result, the incidence of MetS in the current study was higher than Hwang's study, yet the duration of follow-up was approximately twice. In Santos's cohort study, during a 5-year follow- up done in an urban South European population, incidence density of MetS was reported as 47.2/1000 person-years (similar in males and females) that was lower than the current study (21). It should be noted that the time of their follow-up was approximately half of the current study. The difference in incidence of MetS in the current study and other studies (5, 21, 25) might be the duration of follow-up, age distribution of the population, life style, urban or rural area, definition of MetS, cut-off points for waist circumference, circadian clock genes, and other factors.

In a study in China (in a newly-urbanized community, aged 18 to 80 years), the incidence of MetS increased from 2005 to 2014 (females, 31.6% vs. 48.3%; males, 26.3% vs. 41.1%) (10) that was lower than the current study (57.3% and 55.1% in females and males, respectively). In the current study, the incidence of MetS in males with the age group of 30 to

Table 4. Hazard Ratio of MetS Between Males and Females According to Age, Smoking, Economic Status, Physical Activity and Education

Gender			At Risk (n)	Person Year	Cases (n)	Incidence/1000 Person-Year	Hazard Ratio HR (95%CI)
Men	Age groups	20 - 30	96	960.81	41	42.67	1
		30 - 39	90	897.62	48	53.47	1.17 (0.77 - 1.79)
		40 - 49	99	960.61	57	59.34	1.84 (1.23 - 2.76)
		50 - 64	110	1058.66	75	70.84	2.06 (1.41 - 3.02)
		65 - 74	46	454.12	22	48.44	1.20 (0.71 - 2.02)
	Smoking	Smokers	140	1383.31	69	49.88	1
		Non-smokers	301	2948.51	174	59.01	1.28 (0.97 - 1.7)
	Socioeconomic Status	Low	57	570.26	31	54.36	1
		Moderate	102	1007.63	54	53.59	1.35 (0.86 - 2.14)
		High	79	778.04	51	65.55	1.47 (0.93 - 2.34)
	Physical activity	Low	222	2178.29	129	59.22	1
		Moderate	108	1064.96	56	52.58	0.89 (0.65 - 1.21)
		Vigorous	23	227.92	11	48.26	0.82 (0.44 - 1.52)
	Education	Low	162	1582.39	91	57.51	1
		Moderate	179	1748.35	103	58.91	1.01 (0.76 - 1.34)
		High	75	752.50	40	53.16	0.71 (0.49 - 1.04)
	Total	441	4331.82	243	56.1		
Women	Age groups	20 - 30	78	782.46	23	29.39	1
		30 - 39	103	1018.56	58	56.94	2.06 (1.26 - 3.32)
		40 - 49	80	781.50	59	75.49	2.87 (1.77 - 4.65)
		50 - 64	74	722.19	53	73.39	2.79 (1.71 - 4.55)
		65 - 74	33	328.89	18	54.73	1.83 (0.99 - 3.40)
	Smoking	Smokers	-	-	-	-	-
		Non-smokers	-	-	-	-	-
	Economic Status	Low	37	379.28	20	52.73	1
		Moderate	47	468.42	23	49.10	1.38 (0.75 - 2.54)
		High	51	508.16	31	61	1.88 (1.05 - 3.34)
	Physical activity	Low	104	1035.79	54	52.13	1
		Moderate	73	726.62	41	56.42	1.10 (0.73 - 1.66)
		Vigorous	9	93.94	6	63.87	1.02 (0.43 - 2.36)
	Education	Low	201	1980.50	135	68.16	1
		Moderate	134	1321.69	65	49.18	0.75 (0.56 - 1.01)
		High	27	269.35	11	40.84	0.61 (0.33 - 1.13)
	Total	368	3633.61	211	58.7		

39 years was 53.47/1000 person-years that was lower than a Korean study carried out by Ryu et al. In a Korean study, the unadjusted and the age-adjusted incidence density of MetS was 70.5 and 76.9/1000 person-years, respectively, which was higher than the current study on the same age group (26). The annual cumulative incidence rate in the current study was 5.6% in males and 5.8% in females that was higher than a Korean study (males, 2.8%; females, 4.2%) and also higher than a French study (males, 3.5%; females, 2.7%) (5, 22).

Table 5. Hazard Ratio of Components of MetS in Central Iran During Years 2005-6 to 2015-16[a]

Risk Factors	Crude	Model I1	Model II2
High fasting blood sugar	1.64 (1.26 - 2.22)	1.67 (1.23 - 2.27)	1.96 (1.11 - 3.45)
Hypertension	1.01 (0.82 - 1.23)	0.95 (0.75 - 1.19)	1.06 (0.69 - 1.60)
Abdominal obesity	1.49 (1.24 - 1.79)	1.52 (1.25 - 1.85)	1.39 (0.96 - 2.03)
Hypertriglyceridem	1.57 (1.29 - 1.91)	1.65 (1.35 - 2.02)	1.75 (1.18 - 2.58)
Low HDL-cholesterol	0.82 (0.62 - 1.10)	0.95 (0.71 - 1.28)	0.90 (0.53 - 1.53)

[a]Model I: adjusted for age and sex and five components of MetS; model II: adjusted for age, other four components of MetS, smoking, economic status, physical activity and education.

The current study revealed that high level of socioeconomic status increased the incidence of MetS, significantly. Also, low physical activity decreased the incidence of MetS. In developing countries, decreasing physical activity and as a result, increasing obesity due to western diet and fast food and diseases related to lifestyle changes enhanced the incidence of MetS in comparison with developed countries (5, 27). According to the 3 definitions of MetS (NCEP III, IDF, and the joint interim statement) in the Tehran lipid and glucose study, there was a significant difference in incidence of MetS and low level of physical activity (2). Also, in the current study, low level of physical activity enhanced the incidence of MetS. In the current study, the incidence of MetS had an increase with age in all subjects except in the age group of 65 to 74 years. After the age of 30 years and especially the age of 40 years, the incidence of MetS in females exceeded that of males that is similar to Hwang's study (5). One reason for this increase might be the start of menopausal period in females (28, 29). The current study showed that the most powerful component for incidence of MetS in males was obesity while for females this was high fasting blood glucose after adjustment for covariant and in crude hazard ratio (Model I). The result was similar to Hwang's study for males and different for females (5). In the current study high fasting blood glucose was the most effective component (in Model II) for females whereas for males, it was hypertriglyceridemia that was different from other studies (4, 5). However, components of MetS interact with each other and the mechanism has not been well-recognized. Thus, we cannot say clearly which component is the most effective risk factor to create MetS (5). According to Palaniappan et al. study (20), the most effective predictors for MetS in males and females were obesity and diabetes that was different to the current study for males and similar for females. However, obesity and insulin resistance are directly correlated and obesity increases insulin resistance (5, 20). Insulin resistance enhances hypertriglyceridemia, diabetes, hypertension, and low HDL-cholesterol (30). According to the definition of MetS, people, who have 3 of 5 components have been affected by MetS. Therefore, changing lifestyle is highly essential for the higher risk group (who have two components) rather than the lower risk group (who have none or one component) (4, 5, 21, 26).

The current study was the first cohort study in Yazd (central part of Iran) to find incidence of MetS and the most powerful components as predictors of MetS. Thus, this is the strong point of the current study for the management and decrease of MetS in central Iran. There are a number of limitations that should be considered while interpreting the current results. In the present study, 25.9% of subjects, who did not have MetS in the baseline of survey, were lost to follow-up. Researchers in a cohort study in Korea also reported that they had 30.4% subject attrition to follow-up (5). Consequently, it could be said that the event is common in cohort studies. In the current study, there were significant differences in age, weight, smoking, economic status, and education, which was similar to Tehran lipid and glucose follow-up study (12). As another study reported, they had significant differences in age between follow-up and loss to follow-up groups. Their follow-up group was older than the loss to follow-up group (5). The researchers of the current tried very hard to find and invite all subjects. However, some of them could not be accessed.

In conclusion, the current study showed the incidence of MetS in males and females and its component in an urban area of central Iran. The incidence of MetS was 56.1 and 58.7/1000 person-years in males and females, respectively, and the difference in incidence was related to age, gender, smoking, economic status, physical activity, and education. The most effective component as a predictor of MetS in females was high fasting blood glucose. However, in males, the most powerful risk factor for MetS was hypertriglyceridemia. Subjects with two components of MetS were at a higher risk for MetS. Therefore, modification in lifestyle is recommended.

Acknowledgments

We would like to thank all the staff of Yazd cardiovascular research center, who helped and supported this study and especially thank all participants for their patience during the 10-year follow-up of the study.

Table 6. Hazard Ratio of Components of MetS According to Gender in Central Iran During Years During Years 2005-6 to 2015-16[a]

Risk Factors	Males			Females		
	Crude	Model I1	Model II2	Crude	Model I1	Model II2
High fasting blood glucose	1.36 (0.93 - 1.99)	1.31 (0.88 - 1.95)	1.66 (0.87 - 3.15)	2.41 (1.56 - 3.72)	2.49 (1.54 - 4.04)	6.60 (1.91 - 22.82)
Hypertension	0.99 (0.76 - 1.30)	0.94 (0.70 - 1.26)	0.84 (0.52 - 1.35)	1.04 (0.76 - 1.42)	0.95 (0.65 - 1.37)	1.99 (0.80 - 4.95)
Abdominal obesity	1.50 (1.16 - 1.93)	1.45 (1.11 - 1.90)	1.36 (0.87 - 2.12)	1.49 (1.12 - 1.98)	1.73 (1.29 - 2.34)	1.58 (0.61 - 4.10)
Hypertriglyceridemia	1.35 (1.04 - 1.77)	1.37 (1.04 - 1.80)	1.64 (1.02 - 2.65)	1.88 (1.40 - 2.54)	2.03 (1.49 - 2.77)	1.50 (0.58 - 3.90)
Low HDL-cholesterol	0.89 (0.56 - 1.43)	1.08 (0.66 - 1.76)	1.07 (0.52 - 2.21)	0.77 (0.53 - 1.11)	0.95 (0.64 - 1.40)	0.79 (0.30 - 2.11)

[a]Model I: adjusted for age and five components of MetS; model II: Adjusted for age, other four components of MetS, smoking, economic status, physical activity and education.

Footnotes

Conflicts of Interests: All of the authors reported that there were no conflicts of interest during the follow-up and there were no financial support for this study.

Funding/Support: This article was extracted from a thesis that was supported by Yazd Cardiovascular Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran and Iran National Science Foundation (INSF).

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