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High frequency of metabolic syndrome in adult Zoroastrians in Yazd, Iran: a cross-sectional study

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Abstract

Background: Metabolic syndrome (MS) is a cluster of metabolic disturbances, and its prevalence is increasing worldwide. MS exhibits variations among ethnic groups. Zoroastrianism is an ethnic minority which has maintained its isolation and endogamy up to now. So, we evaluated the frequency of MS in Zoroastrians of Yazd, Iran.

Methods: In this cross-sectional study, participants aged ≥30 years were selected using a systematic random sampling. Weight, height, body mass index (BMI), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR) and blood pressure (BP) were measured using standard methods. Also, blood levels of glucose, triglycerides (TG), total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), urea, creatinine and uric acid (UA) were measured. Both revised National Cholesterol Education Program Adult Treatment Panel III (ATPIII) and Joint Interim Statement (JIS) criteria were used to diagnose the MS.

Results: The mean±SD age of the participants (n=403) was 56.9±12.8 years. The frequency of MS was 69.7% and 74.9% based on JIS and ATPIII criteria, respectively; this was significantly different by age, marital status, job, educational level, and menopausal status ($p<0.05$). The most prevalent abnormal parameters of MS according to ATPIII and JIS criteria were high WC (95%) and low HDL (87.9%), respectively. Mean LDL, systolic BP, WHR, UA, urea, and creatinine were different between men and women. The difference between the age groups was statistically significant for BMI, systolic BP, diastolic BP, TG, WHR and urea ($p<0.05$).

Conclusion: This study showed a high frequency of MS in Zoroastrians of Yazd, Iran.

Keywords: Metabolic syndrome, Minority, Frequency, Zoroastrian.

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Introduction

Metabolic syndrome (MS) is a cluster of metabolic disturbances that include abdominal obesity, atherogenic dyslipidemia (hypertriglyceridemia and low high-density lipoprotein (HDL)), elevated blood pressure, and glucose metabolism disorders, and is a determinant of cardiovascular disease and Type 2 diabetes mellitus (DM) (1). The prevalence of MS is increasing worldwide, and it exhibits variations among ethnic groups (2). It has been reported that prevalence of MS in Iran is one of the highest worldwide. In the adult population of the Tehran Lipid and Glucose Study, MS was found in 42% of women and 24% of men with a total age-standardized prevalence of 33.7% (3). Although Iranian people are mostly Muslims, the ethno-religious minority Zoroastrianism is present in Iran, representing approximately 0.02-0.05% of the population. Zoroastrianism originated

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between the ninth and sixth centuries BC and was introduced by Sassanid as the official religion during the last pre-Islamic Persian Empire (4). In the last millennium, Zoroastrians have lived in a high level of isolation as well as endogamy, and this condition has vigorously been maintained up to now. This enabled the survival of most of the indigenous Iranian ancestors' mtDNAs to foreign contributions to their gene pool in the recent past (5), thus providing an outstanding opportunity to study risk factors associated with MS in a limited genetic-variability setting. Most of this population is distributed throughout the Tehran, Kerman, and Yazd provinces. We evaluated the frequency of MS and its components for the first time in this ethnic population in Yazd, Iran.

Methods

Study population and design

In a community-based, cross-sectional study of inhabitant Zoroastrians of Yazd (Central Iran), 512 participants aged≥30 years were selected, using a systematic random sampling. Patients with a history of chronic conditions such as cardiac, pulmonary, renal, and thyroid diseases, or those patients using medications influencing either glucose and lipid metabolism (such as non-steroidal anti-inflammatory drugs and thyroid hormones) or blood pressure as well as those who had been hospitalized or had surgery in the past three months were excluded. After applying the inclusion and exclusion criteria, 403 subjects were eligible and enrolled in the study. The Medical Ethics Committee of Yazd Islamic Azad University of Medical Sciences approved the study protocol. Written informed consents were taken from all the participants. The subjects were invited to Yazd Diabetes Research Center.

Data Collection

Inventory, including age, sex, job, education, history of hypertension, hyperlipidemia, gestational diabetes mellitus, and alcohol consumption as well as family history of DM, was completed for all the subjects by a trained examiner. Weight was measured using a calibrated scale (Seca 220, Seca GmbH & Co. KG., Hamburg, Germany) with patients wearing light clothing standing in an upright position and to the nearest 0.1kg. Height measurement was taken to the nearest 0.5cm using a standard stadiometer (Seca 220, Seca GmbH & Co. KG., Hamburg, Germany) while patients were not wearing shoes. BMI was calculated by dividing weight (kg) by height squared (m^2). A flexible measuring tape was used to measure waist circumference (WC) to the nearest 0.1 cm at the end of normal expiration from the least point between the iliac crest and the inferior costal margin. Hip circumference (HC) was also measured as WC at the maximal circumference over the great trochanters. Waist-to-hip ratio (WHR) was then calculated by dividing WC to HC. Blood pressure (BP) was measured to the nearest two mmHg, twice (on a single occasion) in a seated position by a standard mercury sphygmomanometer after a 10-minute rest. After 12-14 hours of overnight fasting, venous blood samples were taken from the subjects and were analyzed at Yazd Diabetes Research Center laboratory. An oral glucose tolerance test (OGTT) was conducted using 75-gr oral glucose powder. Blood levels of glucose, triglycerides (TG), total cholesterol (TC), HDL, low-density lipoprotein (LDL), urea, Cr and uric acid were measured by an autoanalyzer (AMS Autolab, Italy) using pertinent Pars Azmun kits (Pars Azmun Co, Tehran, Iran); e.g. GOD-PAP for glucose, CHOD-PAP for TC, GPO-PAP for TG, ENZYMATIC for LDL, PERCIPITANT for HDL). Both revised National Cholesterol Education Program Adult Treatment Panel III (ATPIII, 2005) (6) and Joint Interim Statement (JIS, 2009) (7) criteria were used to identify metabolic syndrome (MS). Based on ATPIII, MS is diagnosed when at least three of the following traits are present: BP≥130/85mmHg or drug treatment for elevated BP, FPG≥100mg/dl or drug treatment for elevated blood glucose, serum

TG≥150mg/dl or drug treatment for elevated TG, serum HDL<40mg/dl in men and <50mg/dl in women or drug treatment for low HDL, and abdominal obesity, defined as a WC in men≥90cm and in women≥80cm. The JIS criteria for MS is similar to ATPIII, except for increased WC, which was defined as WC>89 for men and >91 cm for women based on the study done by Azizi et al. in Iran (7). The latest American Diabetes Association (ADA) criteria were used for diagnosis of DM in the participants (8).

Statistical Analysis

Data were analyzed using SPSS 17 (SPSS Inc., Chicago, IL). Descriptive quantitative methods (measures of central tendency and dispersion) as well as t-test, ANOVA, $\chi 2$ test and Fisher's exact test were used. P value≤ 0.05 was considered statistically significant.

Results

One hundred and fifty-three (38%) were men and 250 (62%) women. The mean±SD age of the participants was 56.9 ± 12.8 years (range: 30-88 years). The marital status of the subjects was as follows: 349 (86.6%) married, 40 (9.9%) widowed and 14 (3.5%) single. Among the married and widowed subjects, 152 (37.5%) had endogamy and 239 (59.3%) exogamy. The participants were mainly homemakers (44.2%). Seventy percent had an educational level of a high-school diploma or higher while only 5.5% were illiterate. Also, 35.7% of the subjects consumed alcohol. Personal and family history of DM was found in 18.6% and 43.2% of the participants, respectively. After biochemical evaluation, 30 additional Type 2 DM, 104 impaired glucose tolerance (IGT), and 140 impaired fasting glucose (IFG) cases were discovered. History of hypertension and/or taking antihypertensive drugs was found in 125 (31%) sub-

Table 1. Frequency distribution of MS based on the ATPIII and JIS criteria and by some demographic factors

MS criteria / Demographic factors		Total	ATPIII n (%)	p*	JIS n (%)	p*
Age groups	30-39	32	16(50)		15(46.9)	
	40-49	99	52(52.5)		42(42.4)	
	50-59	98	85(86.7)	<0.001	81(82.7)	<0.001
	60-69	92	81(88)		80(87)	
	70-89	82	68(82.9)		63(76.8)	
Marital status	Single	14	7 (50)		60 (42.9)	
	Married	349	257 (73.6)	0.001	240 (68.8)	0.004
	Widow	40	38 (95)		35 (87.5)	
Job	Office worker	40	20 (50)		19 (47.5)	
	Worker	16	10 (62.5)		10 (62.5)	
	Homemaker	178	141 (79.2)	0.004	125 (70.2)	0.023
	Farmer	10	7 (70)		7 (70)	
	Retired	113	89 (78.8)		83 (73.5)	
	Self-employed	46	35 (76.1)		37 (80.4)	
Education	Illiterate	22	21 (95.5)		19 (86.4)	
	Primary school	86	75 (87.2)		72 (83.7)	
	Guidance school and High school	21	15 (71.4)	<0.001	15 (71.4)	<0.001
	Diploma	207	156 (75.4)		142 (68.6)	
	Associates degree or higher	67	35 (52.2)		33 (49.3)	

* χ^2 test

Table 2. Frequency distribution of abnormal parameters of MS according to ATPIII and JIS criteria

MS criteria / Abnormal parameter	ATPIII (N=302)	JIS (N=281)
WC (cm)	287 (95)	233 (82.9)
FBS (mg/dl)	216 (71.5)	207 (73.7)
TG (mg/dl)	241 (79.8)	231 (82.2)
HDL (mg/dl)	263 (87.1)	247 (87.9)
BP (mmHg)	176 (58.3)	169 (60.1)

Data are presented as number (%)

Table 3. Comparison of MS parameters in the groups with and without MS based on JIS and ATPIII criteria

Criteria	JIS						ATPIII					
Parameter	MS		MD	95% CI		p*	MS		MD	95% CI		p*
	Yes	No		Lower	Upper		Yes	No		Lower	Upper	
Systolic BP	129.8 ± 17.0	116.6 ± 15.3	-13.2	-16.7	-9.6	<0.001	112.6 ± 14.2	115.0 ± 5.8	-12.4	-16.2	-8.6	<0.001
Diastolic BP	80.8 ± 10.9	73.6 ± 8.5	-7.3	-9.4	-5.1	<0.001	71.8 ± 7.8	71.2 ± 2.5	-7.2	-9.5	-4.9	<0.001
WHR	0.92 ± 0.06	0.85 ± 0.08	-0.05	-0.07	-0.04	<0.001	0.82 ± 0.08	.079 ± 0.10	-0.06	-0.08	-0.05	<0.001
FBS	116.1 ± 38.6	94.2 ± 19.9	-21.9	-29.1	-14.6	<0.001	88.9 ± 8.6	91.5 ± 9.3	-23.7	-31.4	-16.0	<0.001
TG	193.9 ± 75.9	141.7 ± 61.4	-52.2	-67.5	-36.9	<0.001	113.3 ± 32.0	118.0 ± 27.6	-51.5	-67.9	-35.2	<0.001
TC	202.7 ± 38.4	194.1 ± 33.7	-8.7	-16.6	-0.8	0.032	191.4 ± 25.9	219.7 ± 34.6	-7.3	-15.7	1.1	0.088
HDL-C	39.3 ± 9.0	42.3 ± 9.0	2.9	1.0	4.9	0.003	42.1 ± 8.9	50.5 ± 7.1	2.7	0.7	4.7	0.01
LDL-C	122.7 ± 25.6	126.0 ± 22.4	2.1	-3.5	7.7	0.461	127.0 ± 18.9	145 ± 27.4	3.3	-1.7	8.3	0.221
Uric acid	5.4 ± 1.2	4.8 ± 1.2	-0.6	-0.8	-0.3	<0.001	4.9 ± 1.5	5.2 ± 1.1	-0.4	-0.6	-0.1	0.011
Urea	35.4 ± 10.6	32.3 ± 9.1	-3.1	-5.1	-1.0	0.006	35.1 ± 11.9	30.7 ± 5.9	-3.1	-3.8	0.8	0.193
Cr	0.99 ± 0.27	0.96 ± 0.19	-0.04	-0.09	0.01	0.121	1.05 ± 0.24	0.89 ± 0.18	-0.01	-0.07	0.04	0.627

MD=Mean difference
95% CI= 95% Confidence Interval
* t-test

jects. A history of hyperlipidemia and/or taking antihyperlipidemic agents was found in 111 (27.5%) subjects. Based on the both criteria, the frequency of MS was significantly different by age group, marital status, job, educational level, and menopausal status, but this was not significant for gender, alcohol consumption, and family history of DM. Table 1 shows the frequency distribution of MS based on the two definitions by some demographic factors. As represented in Table 2, the most prevalent abnormal parameters of MS according to ATPIII and JIS criteria were high WC (95%) and low HDL (87.9%), respectively. Mean values of known risk factors of MS were significantly different when compared between the subjects with and without MS based on the both criteria applied, except for mean serum levels of LDL and Cr based on JIS criteria, and TC, LDL, urea, and Cr based on the ATPIII criteria (Table 3). Mean values of systolic BP, WHR, LDL, uric acid, urea, and Cr were different between men and women (Table 4). These parameters also were evaluated in different age groups. The difference between the age groups was statistically significant for BMI, systolic BP, diastolic BP, TG, WHR, and urea (Table 5). Table 6 represents the frequency of MS by glucose metabolism condition and according to the two definitions used.

Discussion

Results of this study showed a high frequency of MS (i.e. 74.9% and 69.7% on the basis of ATPIII and JIS criteria, respectively) in Yazd Zoroastrian population aged 30 years and older. This study showed a higher frequency of MS in women based on ATPIII criteria, but MS was more prevalent in men based on JIS criteria, albeit the difference was not statistically significant. In a study conducted in the Fars province (south Iran), the frequency of MS in an adult population according to ATPIII and International Diabetes Federation (IDF) criteria

Table 4. Comparison of MS parameters according to the gender of the participants

Parameter	Gender		MD	95% CI		p*
	Male	Female		Lower	Upper	
LDL	119.3 ± 23.8	126.4 ± 24.8	-7.2	-12.1	-2.2	0.005
Systolic BP	129.6 ± 16.3	123.5 ± 17.9	5.9	2.5	9.3	0.001
WHR	0.93 ± 0.06	0.88 ± 0.07	0.05	0.04	0.06	<0.001
Uric acid	5.7 ± 1.1	4.9 ± 1.2	0.8	0.6	1.1	<0.001
Urea	36.3 ± 10.4	33.3 ± 10.0	3.0	1.0	5.1	0.004
Cr	1.09 ± 0.31	0.92 ± 0.18	0.2	0.1	0.2	<0.001

Data are presented as Mean ± Standard Deviation
* t-test

Table 5. Comparison of MS parameters according to the age groups

Parameter	Age groups					Mean square	p*
	30-39	40-49	50-59	60-69	70-89		
BMI	25.8 ± 3.9	25.9 ± 3.5	26.8 ± 3.9	26.7 ± 3.8	25.1 ± 3.6	45.4	0.011
Systolic BP	114.5 ± 13.8	117.5 ± 14.4	128.5 ± 16.8	130.5 ± 14.1	131.8 ± 21.1	4149.3	<0.001
Diastolic BP	73.9 ± 1.0	76.1 ± 8.9	80.7 ± 8.9	80.3 ± 9.2	79.2 ± 14.9	510.8	0.001
TG	163.8 ± 77.7	159.2 ± 70.9	191.8 ± 84.9	184.0 ± 65.4	183.6 ± 75.7	16521.9	0.020
WHR	0.86 ± 0.08	0.87 ± 0.08	0.91 ± 0.6	0.91 ± 0.07	0.90 ± 0.07	0.04	<0.001
Urea	31.5 ± 10.4	31.5 ± 7.2	34.9 ± 9.2	35.4 ± 10.9	37.5 ± 12.5	490.6	0.001

Data are presented as Mean ± Standard Deviation
* ANOVA test

Table 6. Frequency distribution of MS based on the ATPIII and JIS criteria according to glucose metabolism conditions

MS criteria	Total		ATPIII	p*	JIS	p*
Glucose Metabolism Condition						
Personal history of DM	Yes	75	72 (96)	<0.001	71 (94.7)	<0.001
	No	328	230 (70.1)		210 (64)	
New case of DM	Yes	53	52 (98.1)	<0.001	48 (90.6)	<0.001
	No	350	250 (71.4)		233 (66.6)	
IFG	Yes	140	132 (43.7)	<0.001	128 (45.6)	<0.001
	No	263	170 (56.3)		153 (54.4)	
IGT	Yes	104	80 (26.5)	0.588	77 (27.4)	0.267
	No	299	222 (73.5)		204 (72.6)	

Data are presented as number (%)
* χ^2 test

was 26% and 30.5%, respectively. This was not statistically different between men and women (9). In a survey conducted by Ford et al., the prevalence of MS by ATPIII criteria in Americans aged 60-69 and ≥70 years was 43.5% and 42%, respectively (10). In a study done on the Turkish citizens (Istanbul, Turkey), aged ≥20 years, the prevalence of MS varied significantly between different ethnic groups (West Thracians, 24.9%; Armenians, 20.4%; Greeks, 19.3%; East Turkistanis, 15.3%), despite the similar environmental condition and geographical location of the participants. The prevalence also increased with age in all the four ethnic groups studied (11). In another study on Turkish inhabitants with a mean age of 72 years, MS was more prevalent in women than in men (25.1% vs. 20.2% by ATPIII criteria) (11). The prevalence of MS in Caucasian people aged ≥65 who participated in the Cardiovascular Health Study was 20.8% and 27.6% based on ATPIII and World Health Organization (WHO) criteria, respectively (12). In the Chinese elderly population, the prevalence of MS was higher by IDF definition compared to ATPIII and the former considered more suitable definition for screening MS risk (13). In another Iranian study, the prevalence of MS was 50.8% based on the ATPIII criteria and women were more affected than men (14), which is consistent with our study. Iranian women have less physical activity and higher prevalence of overweight and obesity than men (15). The frequency of MS based on JIS criteria was slightly lower than by the ATPIII criteria in our study, which seems to be due to the necessity of the central obesity trait in the JIS criteria. The CASPIAN study showed the prevalence of MS in 6-18 years old Iranian students according to ATPIII is seven times National Health And Nutrition Examination Survey III (NHANESIII). There was no significant difference between men and women. The most prevalent MS parameters were high TG and low HDL (16). In our study, the most frequent parameter of MS by the JIS criteria was low HDL. This may be attributed to low mean HDL in the Iranian population (17), which might be, in turn, due to industrialization, unhealthy diet, lifestyle changes, obesity, and smoking (18). On the other hand, some studies have

shown that gene polymorphism is responsible for a 40-60% variation in plasma levels of HDL in different individuals (19). Central obesity was the most prevalent parameter of MS based on the ATPIII criteria in the current study. This may be related to the high prevalence of obesity as well as high WHR in Iran (20). Obesity is considered a principal factor in MS because it causes insulin resistance, hypertension, and various metabolic disorders (21). Björntorp suggested that an abnormal response to stress might cause neuroendocrine changes related to lipid and glucose metabolism. So, abdominal obesity and MS may reflect changes in the subject's hormone function. MS was more common in subjects who consume alcohol than those who do not, but this was not statistically significant. Some studies have shown different results (22) that may be associated with age, sex, and amount of alcohol intake. Wakabayashi et al. showed that light drinking is associated with a lower risk of metabolic syndrome in Japanese men and women while very heavy drinking is thought to increase the risk of metabolic syndrome in Japanese men (23).

This study showed a higher frequency of MS in homemakers and self-employed subjects and the lowest frequency in office workers, which may be due to the younger age of people in the latter group. There was an increasing frequency of MS by age in the current study. This may be attributed to any of the parameters of MS. De Luis et al. showed steady decreasing prevalence of MS with decreasing age in age groups of 85-95 and >95 years (24). A survey conducted on 20-89 years old adults showed the prevalence of MS was 25.9% and 29.6%, respectively according to the ATPIII and IDF criteria. Also, the prevalence increased with age up to 80-89 years old (21). In our study, although the frequency was higher in subjects aged 70 and above compared to 30-39 years old group, it was lower than subjects aged 60-69 years. This may be related to malnutrition, insufficient care, higher mortality rate, and socioeconomic status of these subjects. These results agree with the Jalali et al. study (9). Although not statistically significant, there was a higher frequency of MS in subjects with a positive family history of DM in our study. Similarly, in a research conducted by Chiti et al. regarding the prevalence of MS in children and adolescents, no significant associations were found (25). The prevalence of MS in subjects with IFG was 43.7% and 45.6% according to the ATPIII and JIS criteria, respectively. For IGT, these values were 80% and 77%, respectively. The Xiang et al. study showed that based on ATPIII criteria, in men subjects, MS was found in 65.6% and 73.5% with IFG/IGT and Type 2 DM, respectively. Women subjects with IFG/IGT and Type 2 DM showed an MS prevalence of 51.0% and 75.4%, respectively (26). The parameters of MS are in association with increased risk of Type 2 DM complications, and IGT may also progress to overt diabetes (27). There are some limitations to this study. The first was its cross-sectional design, limiting the causality relationship between the variables. The second limitation was the fewer number of subjects aged 30-39 compared to other age groups. This may lead to overestimation of the frequency of MS due to healthier participants in this age group. Also, our data was collected from the central part of Iran, and the results cannot be generalized to the entire country. Finally, the daily amount of alcohol consumption was not determined in this study. As strength, to our best knowledge, this is the first population-based study in Zoroastrians used ATPIII and JIS criteria to estimate the frequency of MS. Another strength of this study was to assess MS according to the optimal cut-off points based on previous national studies.

Conclusion

This study found that there is a high frequency of MS in the adult Zoroastrian population of Yazd, Iran. This may be attributed to some factors including genetics, as well as the high occurrence of IGF/IGT which is associated with higher frequency

of MS, as demonstrated in other studies (27). Moreover, the majority of our study population were female. Considering the less physical activity, as well as higher rates of overweight and obesity of this group who are also mainly homemakers, increased rate of MS may be justifiable. Additionally, as mentioned earlier, the fewer number of participants in some age groups may have been lead to the overestimation of this frequency. The most concerning finding to emerge from this study was that higher frequency of MS in women based on ATPIII criteria while MS was more prevalent in men based on JIS criteria. We found that the most prevalent parameter of MS by the JIS and ATPIII criteria was low HDL and central obesity, respectively. Further studies on different ethnic groups around the world using the cohort methodology could be a good direction for future research on this issue.

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