Prevalence of metabolic syndrome using international diabetes federation, National Cholesterol Education Panel- Adult Treatment Panel III and Iranian criteria: results of Tabari cohort study

Adeleh Bahar¹ · Zahra Kashi¹ · Motahareh Kheradmand² · Akbar Hedayatizadeh-Omran³ · Mahdi Moradinazar⁴ · Fatemeh Ramezani¹ · Mahdi Afshari⁵ · Mahmood Moosazadeh²

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Abstract

Background Metabolic syndrome is defined by co-incidence of multiple metabolic disorders such as central obesity, high triglycerides, low HDL, hyperglycemia and high blood pressure, which increases the risk of cardiovascular disease and diabetes. The aim of this study was to estimate the prevalence of metabolic syndrome using Adult Treatment Panel III (ATP-III), International Diabetes Federation (IDF) and Iranian criteria in large-scaled population based cohort study and to determine the concordance between these criteria.

Methods In the present study all information collected in Tabari cohort study(TCS) were utilized. These information were collected using a structural questionnaire and taking blood samples from all the participants. Blood pressure and anthropometric indices were measured for all participants by trained practitioners. Categorical variables were compared using chi-square test. In addition, the quantitative variables were compared between the two the groups using independent t-test. Kappa coefficient was estimated to show the agreement between the results of the three criteria.

Results The prevalences of Metabolic syndrome were 41.10%(CI 95%:40.10–42.02), 44.60%(CI 95%:43.61–45.54), and 30.80% (CI 95%:29.89–31.69) based on ATPIII, international IDF and IDF Iranian criteria respectively. The Kappa agreement coefficients between Iranian IDF with ATPIII definition and international IDF were estimated as 61.80% and 71.20% in the total population respectively.

Conclusion Kappa coefficient showed that the Iranian IDF had a good agreement with International IDF and an intermediate agreement with the ATP-III. Considering more emphasis of international and Iranian IDF on waist circumference (WC), a better agreement between these two criteria is plausible. Regarding the high prevalence of abdominal obesity among Iranian population, applying these criteria to identify high risk persons might be helpful.

Keywords Metabolic syndrome; international IDF · ATP-III · Tabari cohort study

✉ Mahmood Moosazadeh
mmoosazadeh1351@gmail.com

¹ Diabetes research center, Mazandaran University of medical sciences, Sari, Iran

² Health Sciences Research center, Addiction Institute, Mazandaran University of Medical Sciences, Sari, Iran

³ Gastrointestinal Cancer Research Center, Mazandaran University of Medical Sciences, Sari, Iran

⁴ Research Center for Environmental Determinants of Health, Kermanshah University of Medical Sciences, Kermanshah, Iran

⁵ Department of Community Medicine, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran

Introduction

Metabolic syndrome is a major risk factor of stroke, cardiovascular disease and type 2 diabetes mellitus [1, 2]. The risk of stroke is 2–3 folds higher in patients with metabolic syndrome compared to those without. Additionally, metabolic syndrome causes four and two folds higher risk of myocardial infarction (MI) and death respectively [3]. It is now one of the greatest public health challenges worldwide in both developed and developing countries [4]. There are several criteria and definitions for the metabolic syndrome. Organizations such as International Federation for Diabetes (IDF) and National Cholesterol Education Panel –Adult Treatment Panel III (NCEP-ATP III) set different definitions for components of

metabolic syndrome [5–7]. According to Iranian Metabolic syndrome criteria, the normal waist circumference is considered less than 95 cm in both men and women [8, 9]. According to the IDF definition, 25% of the world's population are suffered from metabolic syndrome [10], although this estimate varies greatly according to age, race, and sex [3]. There is notable difference in the prevalence of metabolic syndrome, especially in the Asian population due to differences in lifestyle and ethnic groups [5]. In Iran, according to the recent studies, the overall prevalence of metabolic syndrome is 25% and 39% based on NCEP-ATP III and IDF criteria respectively [11]. Considering the high prevalence of obesity in northern of Iran [4], estimating the prevalence of Metabolic syndrome and its components as well as identifying persons at risk can reduce the risk of diabetes, cardiovascular disease and mortality [12]. The aim of this study was to estimate the prevalence of metabolic syndrome using ATP III, IDF international and IDF Iranian criteria in a large-scaled population based cohort study and to determine the degree of agreement between these criteria.

Methods

In the present study we used data collected in TCS. The aim and design of Tabari cohort has been explained in detail previously [13]. TCS is part of a nationwide cohort named as Prospective Epidemiological Research Studies in IrAN (PERSIAN) cohort. Detailed explanation of PERSIAN cohort study has been published elsewhere [14, 15]. The enrollment phase of TCS started in June 2015 and ended in November 2017. The sampling was performed using census method. Two health care volunteers in the urban areas and Behvarz workers in the mountainous areas recruited all eligible subjects to the cohort center. The health volunteers began the household selection from the right side of the cohort center. These selections in mountainous areas was carried out according to the household numbers from the registries in the rural health houses. Of 12,191 eligible urban residents, 7012 subjects were enrolled in the TABARI cohort. In mountainous areas, 4417 individuals were eligible for the study, 3243 of whom were admitted in the cohort. Therefore, In the first phase of TCS, 10,255 participants aged 35–70 years were enrolled from urban and mountainous area in Sari, Mazandaran, Iran (7012 urban and 3243 mountainous populations).

The information collection tool in this cohort was a structural questionnaire standardized by PERSIAN cohort team as well as taking blood samples from all the participants. Blood pressure and anthropometric indices were measured for all participants by trained practitioners. Blood pressure was measured twice for each participant from each hand with 10 min interval using mercuric pressure-gauge. Anthropometric

parameters including height, weight and waist circumference were measured according to a standard protocol. The SECA 226 (SECA, Hamburg, Germany) was used to measure the height. The weight measurements were performed using the SECA 755 (SECA, Hamburg, Germany) counter balance with minimal indoor clothing without shoes. All participants were requested to stand in the center of the platform of the scale and remain motionless until the measurement can be obtained. Waist measurement was also performed according to the definition of NIH, measuring in the horizontal plane of the superior border of the iliac crest (WC-IC) [16].

Blood samples were collected after 12 h fasting from all participants. Fasting blood sugar (FBS), triglyceride (TG), and high density lipoprotein cholesterol (HDL-C) levels were measured using AutoAnalyzer (BT 1500, Biotechnica, Italy). The CBC assay was also performed using alpha cell counter (Nihon Kohden, Tokyo, Japan). All experiments were performed in Tabari cohort laboratory. The metabolic syndrome prevalence was evaluated in participants according to three definitions (NCEP-ATP III, IDF and IDF ethnic specific cut-off for Iranian population). Based on NCEP-ATP III, having at least three criteria from the following criteria is considered as metabolic syndrome:

- 1- Waist circumference equal to or more than 102 cm in men and more than 88 cm in women,
- 2- triglyceride equal or more than 150 mg/dl or receiving medication,
- 3- HDL less than 40 mg/dl in men or 50 mg/dl in women or receiving medication,
- 4- Hypertension (systolic blood pressure equal to or more than 130 mmHg or diastolic pressure equal to or more than 85 mmHg) or receiving medication,
- 5- Hyperglycemia (fasting blood sugar equal to or more than 100 mg/dl or receiving medication).

Based on IDF international, waist circumference equal to or more than 94 cm in men and 80 cm in women plus at least two of the following criteria is considered as metabolic syndrome:

- 1- Triglyceride equal to or more than 150 mg/dl,
- 2- HDL less than 40 mg/dl in men or 50 mg/dl in women or receiving medication,
- 3- Hypertension (systolic blood pressure equal to or more than 130 mmHg or diastolic pressure equal to or more than 85 mmHg) or receiving medication,
- 4- Hyperglycemia (fasting blood sugar equal to or more than 100 mg/dl or receiving medication).

Based on IDF Iranian: waist circumference equal to or more than 95 cm in both genders plus at least two of the following criteria is considered as metabolic syndrome:

- 1- Triglyceride equal to or more than 150 mg/dl,
- 2- HDL less than 40 mg/dl in men or 50 mg/dl in women or receiving medication,
- 3- Hypertension (systolic blood pressure equal to or more than 130 mmHg or diastolic pressure equal to or more than 85 mmHg) or receiving medication,
- 4- Hyperglycemia (fasting blood sugar equal to or more than 100 mg/dl or receiving medication) (Table 1). It should be noted that three samples (0.03%) had no blood specimens and FBS, TG and HDL variables had not been measured for these three samples. Due to the completely random and very low incidence of this missing, we were estimated them with Expectation-Maximization (EM) algorithm method.

Statistical analysis was performed by SPSS software (ver.24). Data were described as percentage, mean and standard deviation. Categorical variables were compared using chi-square test and comparing quantitative variables between two groups was performed using independent t-test. Logistic regression analysis was used to investigate the factors associated with the outcome. Possible confounding variables including gender, age group, residency, socioeconomic status (Socioeconomic status was categorized into five level as level 1 for the lowest socioeconomic status and level 5 for the highest socioeconomic status) and current smoking were included to multiple logistic regression model by enter method. To determine the degree of agreement between the

various definitions of the metabolic syndrome, the Kappa coefficient was calculated.

Results

In present study, 10,255 people (4149 male and 6106 female) were enrolled. Among all participants, 7012 people were urban area residents and the rest of them were from the Mountainous areas. The participants were in the age group 35–70 years with mean $\pm$ SD age 50.23 ± 9.37 . Table 2 shows the mean level of fasting blood glucose (FBS) and other metabolic syndrome components in all study population.

The prevalence of metabolic syndrome was 41.10% (CI 95%:40.10–42.02), 44.60% (CI 95%:43.61–45.54), and 30.80% (CI 95%:29.89–31.69) based on ATP III, international IDF and IDF Iranian criteria respectively. The prevalence of the metabolic syndrome was higher in female population than men according to all criteria (Table 3). Also Table 3 shows the Kappa agreement coefficients between the ATP III criteria with two other definitions in the whole population and separately by gender. The Kappa agreement coefficients between Iranian IDF with ATP III definition and international IDF were 61.80% and 71.20% in the total population respectively. These agreement coefficients between the ATP III criteria with international IDF and Iranian standard were 58.60% and 57.40% in males and 88.10% and 64.20% in females respectively.

The role of each metabolic syndrome component (based on the definition of ATP III) as risk factor of metabolic syndrome

Table 1 Diagnostic Criteria for the of Metabolic syndrome according ATP III and IDF

Variable	NCEP-ATP III	IDF international	*IDF Ethnic specific cut-off for Iranian Population
Waist circumference	Male ≥ 102 cm, ≥ 88 cm Female	Male ≥ 94 cm, Female ≥ 80 cm	Male and Female ≥ 95 cm
Triglycerides	≥ 150 mg/dl or pharmacologic treatment	≥ 150 mg/dl or pharmacologic treatment	≥ 150 mg/dl or pharmacologic treatment
HDL cholesterol	Male < 40 mg/dl, Female < 50 mg/dl or pharmacologic treatment	Male < 40 mg/dl, Female < 50 mg/dl or pharmacologic treatment	Male < 40 mg/dl, Female < 50 mg/dl or pharmacologic treatment
Hypertension	≥ 130 mmHg systolic / ≥ 85 mmHg diastolic or current use of antihypertensive drugs	≥ 130 mmHg systolic / ≥ 85 mmHg diastolic or current use of antihypertensive drugs	≥ 130 mmHg systolic / ≥ 85 mmHg diastolic or current use of antihypertensive drugs
Hyperglycemia	FBS ≥ 100 mg/dl or current use of anti-diabetes drugs	FBS ≥ 100 mg/dl or current use of anti-diabetes drugs	FBS ≥ 100 mg/dl or current use of anti-diabetes drugs
Criteria for Metabolic syndrome determine	Any three of the five criteria above	Waist circumference plus two of the four criteria	Waist circumference plus two of the four criteria

NCEP-ATP III = National Cholesterol Education Panel –Adult Treatment Panel III

IDF = International Diabetes Federation

*IDF. Waist circumference based on Iranian National Committee of Obesity INCO criteria: men and women ≥ 95 cm

Table 2 Comparison of clinical data group Metabolic Syndrome

Variable	Female(<i>n</i> = 6106)	Male (<i>n</i> = 4149)	<i>P</i> value
	Mean ± Standard Deviation	Mean ± Standard Deviation	
FBS(mg/dl)	109.83 ± 32.75	110.34 ± 33.89	0.441
Diastole(mmHg)	73.02 ± 7.72	73.87 ± 7.77	<0.001
Systole (mmHg)	114.24 ± 13.74	115.70 ± 13.60	<0.001
TG(mg/dl)	149.70 ± 91.21	172.46 ± 127.65	<0.001
HDL-C(mg/dl)	52.85 ± 10.69	46.59 ± 9.50	<0.001
WC(cm)	93.85 ± 11.60	92.94 ± 10.96	<0.001

evaluated by the univariate and multiple logistic regression models. WC was the most important risk factor (Adjusted OR = 1.08, CI 95%:1.08–1.09) (Table 4).

Table 5 shows the results of chi-square test and the univariate and multiple logistic regression analysis of the factors associated with metabolic syndrome based on the definition of ATPIII. The metabolic syndrome prevalence was 49.20% in female and 29.10% in male. The odds of having metabolic syndrome in female was 2.69 times higher than male (Adjusted OR = 2.69, 95% CI:2.45–2.96). Overall, 23.30% of people aged under 40 and 53.10% of people aged ≥ 60 years had metabolic syndrome. Considering the 35–39 year- age group as reference, the odds ratios of having metabolic syndrome for 40–49, 50–59 and 60–70 year- age groups were 1.94(Adjusted OR = 1.94 95% CI:1.69–2.23), 3.79 (Adjusted OR = 3.79, 95% CI:3.29–4.36) and 5.35(Adjusted OR = 5.35, 95% CI:4.58–6.26) respectively. In total population, 240.5% of smokers and 42.70% of non-smokers were suffering from metabolic syndrome. On the other hand, Out of 43.90% of residents in urban areas, and 34.90% of mountainous area residents suffered from metabolic syndrome. The odds of developing a metabolic syndrome in the urban population of Tabari cohort was 1.99 times higher than the mountainous population (Adjusted OR = 1.99, 95% CI: 1.78–

2.24). The role of socioeconomic level in predicting metabolic syndrome was not significant.

Discussion

Given the increasing prevalence of obesity in Iran and especially in Mazandaran province, the present study aimed to evaluate the prevalence of metabolic syndrome in Mazandaran province by Iranian and other international criteria. Results of present study showed that the prevalence of metabolic syndrome in Tabari cohort population, varied between 30.80% and 44.60% according to different criteria. The highest prevalence was related to International IDF criteria and the lowest one was estimated by Iranian IDF. Prevalence of metabolic syndrome according to ATP III was 41.10%. Kappa coefficient showed that the Iranian IDF had the good agreement with International IDF and an intermediate agreement with the ATP-III. According to our knowledge this is the first study reporting the prevalence of metabolic syndrome in large scale population based cohort according to three different criteria.

Table 3 Kappa agreement coefficient and Prevalence of Metabolic syndrome by gender according to ATP III, IDF Iranian and IDF international criteria

Variable	Total(<i>n</i> = 10,255)		Male(<i>n</i> = 4149)		Female(<i>n</i> = 6106)	
	Metabolic syndrome		Metabolic syndrome		Metabolic syndrome	
	Yes n(%)	No n(%)	Yes n(%)	No n(%)	Yes n(%)	No n(%)
IDF-Iranian	3157(30.80)	7098(69.20)	1239(29.90)	2910(70.10)	1918(31.40)	4188(68.60)
IDF	4571(44.60)	5684(55.40)	1325(31.90)	2824(68.10)	3246(53.20)	2860(46.80)
ATPIII	4211(41.10)	6044(58.90)	1206(29.10)	2943(70.90)	3005(49.20)	3101(50.80)
Kappa	Between NCEP-ATPIII and Iranian criteria		57.40%		64.20%	
agreement	Between NCEP-ATPIII and IDF-international criteria		58.60%		88.10%	
coefficient	Agreement between IDF-Iranian and IDF-international Criteria		95.10%		57.50%	

Table 4 Ffactors related to prevalence of metabolic syndrome in patients (according to ATPIII Criteria logistic regression)

Variable	Univariate model			Multivariate (Adjusted) model		
	OR	CI 95% OR	P value	OR	CI 95% OR	P value
FBS(mg/dl)	1.03	1.02–1.03	<0.001	1.02	1.01–1.02	<0.001
DBP (mmHg)	1.07	1.06–1.08	<0.001	0.99	0.98–1.00	0.242
SBP (mmHg)	1.05	1.05–1.06	<0.001	1.05	1.04–1.05	<0.001
TG(mg/dl)	1.01	1.00–1.01	<0.001	1.01	1.00–1.01	<0.001
HDL-C(mg/dl)	0.96	0.96–0.97	<0.001	0.97	0.96–0.97	<0.001
WC(cm)	1.10	1.09–1.11	<0.001	1.08	1.08–1.09	<0.001

Prevalence of metabolic syndrome in Iranian adult population in a systematic review and meta-analysis study was reported as 36.9% (95% CI: 32.7–41.2%) and 34.6% (95% CI: 31.7–37.6%) according to ATP-III and International IDF respectively [17]. In a more recent systematic review in Iranian population, the total prevalences of metabolic syndrome based on NCEP/ATP III and IDF criteria were 29% (95% CI: 24–35) and 38% (95% CI: 32–43) respectively [18]. Although the overall prevalence of metabolic syndrome according to international IDF in these Iranian studies and also in other countries [19, 20] was lower than that in the present study, the different age groups of the populations recruited in these studies should be mentioned. In our study, the participants' age range was lower but the metabolic syndrome was more than the other studies suggesting early onset of metabolic syndrome among Iranian young adults. This can be a warning

to our society. Similar to the results of the present study, in several other studies the prevalence of metabolic syndrome according to international IDF was higher than that based on the ATP III criteria [11, 19–23]. It seems that stricter cut-off for waist circumference in International IDF criteria and high prevalence of abdominal obesity in Iranian population causes the higher prevalence of metabolic syndrome compared to ATP-III. The most commonly used indicator for abdominal obesity is waist circumference [24], on the other hand, it is a prominent feature of metabolic syndrome which should be specific for gender and ethnicity [25]. Esteghamati et al. reported that IDF recommended waist circumference is not appropriate for Iranian population [25].

In the present study, results of the logistic regression models showed that the odds of having metabolic syndrome were 2.69 times more in women than in men. Greater

Table 5 Risk of Metabolic syndrome according to demographic and lifestyle factors according to ATP III criteria –Logistic regression

Variable		Univariate model					multiple (Adjusted) model		
		Metabolic syndrome		OR	CI 95% OR	P value	OR	CI 95% OR	P value
		Yes n (%)	No n (%)						
Gender	Male	1206(29.10)	2943(70.90)	ref	ref	ref	ref	ref	ref
	Female	3005(49.20)	3101(50.80)	2.36	2.17–2.57	<0.001	2.69	2.45–2.96	<0.001
Age groups (year)	35–39	376(23.30)	1236(76.70)	ref	ref	ref	ref	ref	ref
	40–49	1214(35.40)	2217(64.60)	1.80	1.57–2.06	<0.001	1.94	1.69–2.23	<0.001
	50–59	1568(48.50)	1662(51.50)	3.10	2.71–3.55	<0.001	3.79	3.29–4.36	<0.001
	60–70	1053(53.10)	929(46.90)	3.73	3.22–4.31	<0.001	5.35	4.58–6.26	<0.001
place	Urban	3079(43.90)	3933(56.10)	1.46	1.34–1.59	<0.001	1.99	1.78–2.24	<0.001
	Mountainous	1132(34.90)	2111(65.10)	ref	ref	ref	ref	ref	ref
level social economic	1(lowest)	805(39.20)	1246(60.80)	ref	ref	ref	ref	ref	ref
	2	882(43.00)	1170(57.00)	1.17	1.03–1.32	0.015	1.14	0.99–1.31	0.068
	3	889(43.40)	1161(56.60)	1.18	1.05–1.34	0.007	1.11	0.95–1.29	0.174
	4	790(38.50)	1261(61.50)	0.97	0.85–1.10	0.631	0.96	0.82–1.12	0.598
	5 (highest)	845(41.20)	1206(58.80)	1.08	0.96–1.23	0.203	0.97	0.83–1.14	0.714
Smoking	No	3983(42.70)	5343(57.30)	ref	ref	ref	ref	ref	ref
	Yes	228(24.50)	701(75.50)	0.44	0.37–0.51	<0.001	0.79	0.67–0.94	0.008

prevalence of metabolic syndrome in women has been reported in previous studies [17, 18]. On the other hand, the prevalence of metabolic syndrome increased by increasing age significantly ($P < 0.001$). Participants aged greater than 60 had 5.35 times more odds of having metabolic syndrome in compared with those in 39–35 year- age group. The major role of age in predicting of metabolic syndrome is consistent with previous studies [26].

Among other variables which has been assessed in this study, place of residency was another important factor. Participants who lived in urban area have 1.99 times more odds of having metabolic syndrome than who lived in mountainous region.

Results of present study consistent with previous studies showed a good agreement between International IDF criteria and ATP-III criteria [27, 28]. On the other hand concordance between Iranian IDF and ATP-III criteria was intermediate. The reason of the high agreement of Iranian IDF with IDF international and intermediate agreement with ATP-III is in determining of cut point the waist circumference and also the high prevalence of obesity in this region.

In the present study, the degree of the agreement between Iranian IDF and IDF international in determining the prevalence of metabolic syndrome among male was high (95.10%). But there was low agreement between ATP-III and these two criteria (less than 60%). Among female, the agreement between Iranian IDF and IDF international was less than 60% while the corresponding agreements between ATP-III and IDF international and also between ATP-III and Iranian IDF were 80% and 64% respectively. The main reason for such differences is the cut point for waist circumference in determination of the central obesity which is 95 and more (both genders) in Iranian IDF, 94 and more (for male) and 80 and more (for female) in IDF international and 102 or more (for male) and 88 or more (for female) in ATP-III criteria. In addition, the high prevalence of central obesity in both genders especially among women living in northern parts of Iran was another reason for the above differences.

According to our knowledge this is the first study estimating the concordance between Iranian IDF with other criteria. Considering more emphasis of international and Iranian IDF on waist circumference, a better agreement between these two is plausible. Regarding the high prevalence of abdominal obesity among Iranian population, applying this criteria to identify persons at risk might be helpful.

The main limitation of our study was the cross sectional design of the research. This study was from the first phase of Tabari cohort and follow up of the participants is going on. Considering that the population study were selected just from one urban and mountainous area and the participants age was limited to 35–70 years, we cannot perfectly generalize the results of the study to general population of Iran.

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Compliance with ethical standards

Conflict of interest None declared.

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