Comparison of the accuracy of three diagnostic criteria and estimating the prevalence of metabolic syndrome: A latent class analysis

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Background: Metabolic syndrome (MetS) is a growing public health problem with a worldwide distribution, and its prevalence is rapidly increasing worldwide. Hence, this study aimed to compare the prevalence of MetS based on the International Diabetes Federation (IDF), the National Cholesterol Education Program Expert Panel Adult Treatment Panel III (NCEP ATP III), and the American Association of Clinical Endocrinologists (AACE) diagnostic criteria. **Materials and Methods:** In this cross-sectional study, a total of 4737 people aged 45–69 years were enrolled in the 2nd phase of Shahroud Eye Cohort Study. We evaluated the prevalence of MetS with 95% confidence intervals by age and sex groups and according to MetS components. The accuracy (sensitivity and specificity) of these three methods was compared using latent class analysis. Finally, kappa statistic was used to determine the agreement between the diagnostic methods. **Results:** The prevalence of MetS varied from a minimum of 47.2% (as defined by the AACE) to a maximum of 60.0% (as defined by the IDF). The sensitivity of the three diagnostic methods of IDF, NCEP ATP III, and AACE was 98.9%, 94.4%, and 91.1%, respectively, and the specificity of these three methods was 94.6%, 97.0%, and 98.4%, respectively. Moreover, the highest agreement was found between the definition of the IDF and the NCEP ATP III. **Conclusion:** The IDF diagnostic method has a higher sensitivity for the diagnosis of MetS in Iranian middle-aged people. It is recommended to use this method for identifying more people at risk of MetS.

Key words: Latent class analysis, metabolic syndrome, sensitivity, specificity

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INTRODUCTION

Metabolic syndrome (MetS) is a group of interrelated risk factors with a metabolic origin (including abdominal obesity, hypertriglyceridemia, high-density lipoprotein-cholesterol [HDL-Chol] reduction, hypertension, and glucose intolerance).[1] This syndrome is a growing public health problem with a worldwide distribution, and its prevalence is rapidly increasing worldwide.[2] Although each of the components of MetS is known as an "independent contributor" to cardiovascular diseases, all of these factors together are independently associated with an increased risk of cardiovascular events.[3] MetS is one of the main causes of death in modern communities and is associated with an increase in the incidence of health-care services and related costs.[4]

The estimated prevalence of MetS varies due to differences in the criteria used to define it. The prevalence of this syndrome in different countries ranges from 21.3% to 39%[5,6] and in various studies in Iran, its prevalence is reported from 21.9% to 32%.[7,8] Moreover in a systematic review, the prevalence of MetS in Iranian children and adolescents was 1%–22%.[9]

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The incidence of MetS is reported differently in various countries; for instance, it was 49.8% in the USA (3.2-year follow-up),[10] 42.4% in Spain (6-year follow-up),[1] and 39.8% in Iran (9.3-year follow-up).[11] However, it is difficult to compare the prevalence of MetS in different communities, which differs in terms of genetic context, diet, activity rate, age, sex, and physical habits; in addition, because of the lack of consensus in the proposed definitions, the comparison has become more difficult in practice.[12] The pathophysiology of MetS has not yet been clearly defined, and it does not have a universal definition. Many scholars have come up with the idea that MetS is a surrogate of a combined syndrome, rather than a specific syndrome, which poses people at specific risks. As a consequence, several definitions of MetS are suggested by international institutions.[13] This study investigates and compares the three most commonly used definitions including the definitions proposed by the International Diabetes Federation (IDF),[14] the National Chol esterol Education Program-Adult Treatment Panel III (NCEP-ATP III),[4] and the American Association of Clinical Endocrinologists (AACE).[15]

Given the lack of a golden standard to determine the accuracy of these three diagnostic methods, latent class analysis (LCA) was used for this purpose. In this type of analysis, the actual condition of the disease, as a latent variable, was estimated based on the status of the disease (its presence or absence) evaluated via each of the three diagnostic methods, as manifest variables. Without a golden standard test, this analysis provides an estimate of the sensitivity and specificity of the diagnostic methods.[16]

Considering the abovementioned facts, as the prevalence of MetS has increased in recent years, and because of the importance of determining the prevalence of MetS in Iran for screening and planning to prevent mortality and morbidity of this syndrome, this study was conducted to (1) determine and compare the prevalence of MetS among the Iranian middle-aged population based on the NCEP ATP III, IDF, and AACE diagnostic criteria; (2) compare the accuracy (sensitivity and specificity) of each of these three methods using the LCA; and, finally (3) determine the best criteria for the diagnosis of MetS in Iranian adult population.

MATERIALS AND METHODS

Study design and participants

The present study is part of the Shahroud Eye Cohort Study (ShECS) and is based on the results of the second phase of this study that was conducted in 2014. The details on the methodology of ShECS have already been presented.[17] This section provides a summary of the methodology of the study. In the ShECS, using stratified cluster random sampling, a total of 300 clusters were randomly selected from Shahroud city and within nine strata. The health centers were set as the strata. From each cluster, at least twenty individuals aged 40–64 years were selected to participate in the first phase of the study. After explaining the objectives of the study, they were invited to undergo a full ophthalmic examination. After obtaining a written informed consent, the participants were interviewed and examined. In the interview, the researchers collected data on demographic factors, employment status, and medical and ophthalmology history. The study protocol was reviewed and approved by the Ethics Committee of Shahroud University of Medical Sciences (930/09). The second phase of the study began in 2014 by inviting people who participated in the first phase. In the first phase, 5190 individuals aged 40–64 years were enrolled in the study; in the second phase, 4737 participants from among those who participated in the first phase (91.3%) were studied. In the second phase, in addition to ophthalmic and optometric examinations and collecting data on demographic characteristics, blood glucose, glycated hemoglobin, triglyceride, Chol, and HDL-Chol tests were examined after 12 h of fasting.

Procedures and assessment of variables

In both phases, every participant's weight was measured using a portable digital scale with an accuracy of 0.1 kg, and their height was measured using a nonstretchable tape measure in a standing position without shoes. Body mass index (BMI) was calculated by dividing the weight (in kilograms) by height (in meters squared). Overweight was defined as BMI ≥25, and obesity was defined as BMI >30. Moreover, following the World Health Organization's (WHO) protocol, in the second phase, waist circumference was measured using a nonstretchable tape measure at the midpoint of the lower edge of the last tangible rib above the iliac crest.[18]

In both phases, using an electronic sphygmomanometer device, blood pressure was measured by a trained nurse at the right hand in sitting position after 5 min of rest. On the day of admission, blood pressure was measured twice with a 3-min time interval. After two measurements, if the difference between the obtained numbers was >10 mmHg in systolic blood pressure and/or 5 mmHg in diastolic blood pressure, the measurement was performed for the third time, and the two measurements that were more closely aligned were recorded. The mean systolic and diastolic blood pressures obtained in these two measurements were considered as systolic and diastolic blood pressures.

The prevalence of MetS was estimated on the basis of the three diagnostic criteria including IDF,[14] NCEP ATP III,[4] and AACE [Table 1].[15]

Table 1: Diagnostic criteria for metabolic syndrome (adapted from UpToDate's definition of metabolic syndrome)

Parameters	NCEP ATP III 2005	IDF 2005	AACE 2003
Required		Waist ≥94 cm (men) or ≥80 cm (women)	High risk of insulin resistance or BMI ≥25 kg/m^2 or waist≥102 cm (men) or ≥88 cm (women)
Number of abnormalities	≥3 of below items	And ≥2 of below items	And ≥2 of below items
Glucose	≥5.6 mmol/L (100 mg/dL) or drug treatment for elevated blood glucose	≥5.6 mmol/L (100 mg/dL) or diagnosed diabetes	≥6.1 mmol/L (110 mg/dL) or ≥2 h glucose 7.8 mmol/L (140 mg/dL)
HDL cholesterol	<1.0 mmol/L (40 mg/dL) (men); <1.3 mmol/L (50 mg/dL) (women) or drug treatment for low HDL-C	<1.0 mmol/L (40 mg/dL) (men); <1.3 mmol/L (50 mg/dL) (women) or drug treatment for low HDL-C	<1.0 mmol/L (40 mg/dL) (men); <1.3 mmol/L (50 mg/dL) (women)
TGs	≥1.7 mmol/L (150 mg/dL) or drug treatment for elevated TGs	≥1.7 mmol/L (150 mg/dL) or drug treatment for high TGs	≥1.7 mmol/L (150 mg/dL)
Obesity	Waist ≥102 cm (men) or ≥88 cm (women)		
HTN	≥130/85 mmHg or drug treatment for HTN	≥130/85 mmHg or drug treatment for HTN	≥130/85 mmHg

NCEP ATP III=The National Cholesterol Education Program-Adult Treatment Panel III; IDF=International Diabetes Federation; AACE=American Association of Clinical Endocrinologist; HDL-C=High-density lipoprotein-cholesterol; BMI=Body mass index; TGs=Triglycerides; HTN=Hypertension

LCA combines the results of three diagnostic tests through a sophisticated statistical model to obtain accurate estimates of disease prevalence where there is no single standard test.[16] We used a LCA method to cluster the participants with and without MetS. In addition, the LCA was used to calculate the sensitivity and specificity of each of these three methods and to compare them with each other. LCA is one of the statistical methods that, in the absence of a gold standard, can be used to check the sensitivity and specificity of diagnostic tests. Using the LCA, we can calculate the conditional probabilities of each of the diagnostic criteria (IDF, NCEP ATPIII, and AACE) used for the diagnosis of MetS in the presence or absence of two latent classes; it indicates the sensitivity and specificity of that diagnostic criterion.[19] In LCA, we seek to find the minimum number of latent classes to show the relationships between the observed variables. Comparison between the extracted models is performed using the Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC). Lower values of AIC and BIC represent the best model.[20] In this analysis, the status of the disease is treated as a latent variable with two levels, i.e., MetS/healthy. The outcomes of the three diagnostic methods including the IDF, NCEP ATP III, and AACE, as the manifest variables, are considered imperfect classifier of the disease status. When using LCA model with two latent classes (patient/healthy) (two-class LCA), the estimated parameters indicate the sensitivity (the probability of a positive test in the presence of the target disease) and specificity (the probability of a negative test in the absence of the target disease). As one of the primary assumptions of this analysis method, called "identifiability," the number of parameters estimated in the model should not exceed the number of diagnostic tests. Conditional independence is the second assumption for the implementation of the LCA model. For example, in order to establish this condition in cases where there are two independent latent classes, we need to have at least three binary diagnostic tests.[16] All of the abovementioned assumptions were valid in this study.

Statistical analysis

In this study, the estimated prevalence of MetS in different age and sex groups based on the three abovementioned definitions was compared with each other and presented at a 95% confidence interval. The sensitivity and specificity of the diagnostic criteria of MetS were calculated using LCA package in R.3.5.0 software (R is a free software environment. it is supported by R foundation. It is seated in Vienna, Austria, and is active worldwide). For comparison between different diagnostic methods in terms of sensitivity and specificity, we used Youden index (J). The J can be formally defined as J = max (Se + Sp − 1). The Youden index[21] was used to determine the optimal threshold and the most appropriate diagnostic criterion. According to the formula (sensitivity + specificity − 1), a criterion with the highest value is the most appropriate diagnostic criterion.[21] Kappa statistic was used to determine the agreement between the diagnostic methods. The level of agreement above 0.8 is appropriate for judging the extent of the agreement (almost perfect if $\kappa > 0.80$).[22] For all the tests, the effect of cluster sampling was taken into account when calculating the confidence interval.

RESULTS

The participants in this study included 1946 males (41.1%) and 2791 females (58.9%), and their mean (standard deviation) age was 56.5 (6.2) and 55.4 (6.2) years for males and females, respectively.

The results of the LCA showed that 58.4% of the participants (standard error [SE]: 0.73) were in the class with MetS and 41.6% of the participants (SE: 0.73) were in the class without MetS. The sensitivity of the three diagnostic methods including IDF, NCEP ATP III, and AACE was 98.9%, 94.4%, and 91.1%, respectively, and the specificity of these three methods was 94.6%, 97.9%, and 98.4%, respectively [Table 2].

The agreements and differences between the definitions of IDF, NCEP ATP III, and AACE in terms of the diagnosis of MetS are presented in Table 3. The agreement between these three definitions was statistically significant, but the highest agreement was observed between the definitions of IDF and NCEP ATP III ($\kappa = 0.92$, $P < 0.001$). As compared with the definition of the IDF, the definition of the AACE had the highest sensitivity (97.7%) and the highest negative predictive value (97.2%). However, as compared with the definition of the ACCE, the definition of the IDF had the highest specificity (97.2%) and the highest positive predictive value (97.7%) [Table 3].

The prevalence of MetS varied from a minimum of 47.2% (44.9% in males and 48.8% in females) based on AACE definition to a maximum of 60% (53.6% in males and 65.6% in females) based on IDF definition [Table 4]. Moreover, the prevalence of MetS based on all the three definitions in all the age groups was higher in females than that in males. In addition, the prevalence of MetS increased with age in females and in total, which was statistically significant, but this difference was not significant in males [Table 4].

Table 2: Sensitivity and specificity estimates from the latent class analysis of the third report of the National Cholesterol Education Program Expert Panel, International Diabetes Federation, and American Association of Clinical Endocrinologists definitions in identifying the cases of metabolic syndrome in Iranian middle-aged population

	Sensitivity (95% CI)	Specificity (95% CI)
IDF	98.9 (98.5-99.4)	94.6 (93.6-95.8)
NCEP ATP III	94.4 (93.5-95.3)	97.0 (96.2-97.8)
AACE	91.1 (90.0-92.2)	98.4 (98.8-99.0)

CI=Confidence interval; NCEP ATP III=The third report of the National Cholesterol Education Program Expert Panel; IDF=International Diabetes Federation; AACE=American Association of Clinical Endocrinologists

The results showed that the mean BMI in all age groups and in both sexes was more than 25, and 79.19% of the participants in the study (68.4% of males and 86.7% of females) had BMI ≥ 25. Based on AACE definition, 69.8% of the participants (36.8% of males and 92.8% of females) and based on IDF definition 88.8% of the participants (72.7% of males and 98.8% of females) had abdominal obesity. Table 5 presents the prevalence of MetS components by gender based on the three definitions.

DISCUSSION

Observing the previously stated assumptions of the LCA (identifiability and conditional independency) which were used for the three primary diagnostic tests, we identified two latent classes, including the presence of MetS and the absence of MetS, with a prevalence of 58.4% and 41.6%, respectively. Considering the high level of agreement between the definitions of IDF, NCEP ATP III, and AACE in this study [Table 2], the combination of these three diagnostic methods could be used to diagnose the target patients. The comparison of the sensitivity and specificity values estimated from the two-way comparisons of diagnostic methods as well as the sensitivity and specificity estimated by the LCA model [Tables 2 and 3] and the Youden index values indicated that the IDF-based MetS diagnostic method had a higher accuracy in the Iranian population aged over 40 years. In the study of Onesi and Ignatius[23] which used five criteria for the definition of MetS, and have used WHO criteria as a gold standard, the highest agreement was found between the WHO criteria and IDF criteria. In a study by Pokharel *et al*.[24] which aimed at determining the prevalence of MetS in patients with Type 2 diabetes based on four criteria (WHO, IDF, NCEP ATP III, and Harmonized), Harmonized was reported as the most sensitive method for the diagnosis of MetS in patients with diabetes mellitus, whereas IDF and NCEP ATP III were

Table 3: The concordance and diagnostic accuracy of the National Cholesterol Education Program-Adult Treatment Panel III, International Diabetes Federation, and American Association of Clinical Endocrinologists definitions in identifying the cases of metabolic syndrome in Iranian middle-aged population

Definitions	Concordance			Diagnostic accuracy (%)			
	κ (95% CI)	*P**	Agreement	Sensitivity	Specificity	PPV	NPV
IDF versus NCEP ATP III	0.92 (0.91-0.92)	<0.001	Almost perfect	88.07	95.46	96.77	83.83
NCEP ATP III versus IDF	0.90 (0.89-0.91)	<0.001	Almost perfect	96.77	83.83	88.07	95.46
IDF versus AACE	0.86 (0.85-0.87)	<0.001	Almost perfect	75.99	97.22	97.68	72.42
AACE versus IDF	0.85 (0.84-0.86)	<0.001	Almost perfect	97.68	72.42	75.99	97.22
NCEP ATP III versus AACE	0.84 (0.83-0.85)	<0.001	Almost perfect	77.91	90.64	91.13	76.88
AACE versus NCEP ATP III	0.84 (0.83-0.85)	<0.001	Almost perfect	91.13	76.88	77.91	90.64

*Chi-square test was used to compare the level of agreement between two different definitions of MetS. Level of agreement and diagnostic accuracy are presented as κ value (95% CI) and %, respectively. MetS=Metabolic syndrome; CI=Confidence interval; NCEP ATP III=The National Cholesterol Education Program-Adult Treatment Panel III; IDF=International Diabetes Federation; AACE=American Association of Clinical Endocrinologists; PPV=Positive predictive value; NPV=Negative predictive value

Table 4: Age-specific prevalence of metabolic syndrome in middle-aged population, Shahroud, Iran, 2014

Age groups by sex	IDF Proportion (95% CI)	*P**	ATP III Proportion (95% CI)	*P*	AACE Proportion (95% CI)	*P**
Male						
45-49	49.65 (43.82-55.48)	0.858	41.99 (36.04-47.95)	0.268	48.07 (41.97-54.17)	0.606
50-54	51.19 (46.89-55.50)		44.18 (40.02-48.33)		47.62 (43.52-51.72)	
55-59	50.40 (46.11-54.86)		43.20 (38.89-47.51)		45.24 (41.02-49.45)	
60-64	53.57 (48.53-58.61)		49.61 (44.65-54.58)		45.54 (40.72-50.38)	
65-69	50.62 (44.07-57.16)		45.64 (38.78-52.50)		42.04 (35.36-48.72)	
Total	51.17 (48.88-53.46)		44.89 (42.60-47.18)		45.93 (43.75-48.12)	
Female						
45-49	54.65 (50.85-58.46)	<0.001	53.28 (49.46-57.09)	<0.001	49.74 (45.74-53.75)	<0.001
50-54	65.75 (62.65-68.85)		63.73 (60.49-66.97)		57.61 (54.39-60.83)	
55-59	68.67 (64.96-72.37)		67.77 (64.12-71.41)		63.17 (59.36-66.99)	
60-64	71.27 (67.06-75.49)		69.76 (65.56-73.97)		62.93 (58.44-67.42)	
65-69	76.87 (71.90-81.83)		74.73 (69.66-79.80)		67.73 (62.15-73.31)	
Total	66.18 (64.45-67.91)		64.64 (62.88-66.41)		59.23 (57.40-61.06)	
Total population						
45-49	53.01 (44.94-56.08)	<0.001	49.59 (46.41-52.77)	<0.001	49.19 (45.79-52.59)	0.040
50-54	59.97 (57.40-62.53)		56.00 (53.36-58.64)		53.63 (51.11-56.16)	
55-59	60.82 (57.90-63.75)		57.24 (54.28-60.20)		55.46 (52.51-58.41)	
60-64	63.16 (59.67-66.65)		60.56 (57.15-63.97)		54.96 (51.41-58.51)	
65-69	64.69 (60.42-68.97)		61.30 (56.98-65.63)		55.79 (51.32-60.25)	
Total	60.00 (58.53-61.49)		56.55 (55.07-58.04)		53.75 (52.31-55.20)	

*Pearson χ^2. CI=Confidence interval; ATP III=Adult Treatment Panel III; IDF=International Diabetes Federation; AACE=American Association of Clinical Endocrinologists

Table 5: Sex-specific prevalence of metabolic syndrome components by three different definitions in middle-aged population, Shahroud, Iran, 2014

Metabolic syndrome components	IDF Proportion (95% CI)	ATP III Proportion (95% CI)	AACE Proportion (95% CI)
In males			
IFG	38.62 (36.49-40.76)	38.62 (36.49-40.76	21.98 (20.10-23.87)
Low HDL-C	54.42 (52.25-56.59)	54.42 (52.25-56.59)	54.00 (51.83-56.17)
High TG	53.26 (51.03-55.50)	53.26 (51.03-55.50)	53.26 (51.03-55.50)
HTN	47.81 (45.25-50.37)	47.81 (45.25-50.37)	47.81 (45.25-50.37)
Obesity	72.68 (70.54-74.83)	36.83 (34.55-39.11)	-
High risk of insulin resistance or BMI ≥25 kg/m² or waist circumference ≥102 cm (men) or ≥88 cm (women)	-	-	68.93 (66.84-71.02)
In females			
IFG	44.01 (42.00-46.03)	44.01 (42.00-46.03)	25.13 (23.50-26.76)
Low HDL	66.69 (64.90-68.48)	66.69 (64.90-68.48)	66.10 (64.32-67.88)
High TG	52.70 (50.95-54.44)	52.70 (50.95-54.44)	52.26 (50.50-54.03)
HTN	44.69 (42.84-46.52)	44.69 (42.84-46.52)	44.69 (42.84-46.52)
Obesity	98.78 (98.38-99.18)	92.81 (91.76-93.87)	-
High risk of insulin resistance or BMI ≥25 kg/m² or waist circumference ≥102 cm (men) or ≥88 cm (women)	-	-	94.76 (93.90-95.61)
Total			
IFG	41.81 (40.32-43.29)	41.81 (40.32-43.29)	23.84 (22.63-25.05)
Low HDL	61.67 (60.22-63.11)	61.67 (60.22-63.11)	61.14 (59.71-62.57)
High TG	52.93 (51.52-54.34)	52.93 (51.52-54.34)	52.67 (51.25-54.10)
HTN	45.97 (44.38-47.56)	45.97 (44.38-47.56)	45.97 (44.38-47.56)
Obesity	92.81 (87.07-89.03)	69.80 (68.43-71.16)	-
High risk of insulin resistance or BMI ≥25 kg/m² or waist circumference ≥102 cm (men) or ≥88 cm (women)	-	-	84.14 (83.09-85.18)

CI=Confidence interval; IFG=Impaired fasting glucose; HDL-C=High-density lipoprotein-cholesterol; BMI=Body mass index; ATP III=Adult Treatment Panel III; IDF=International Diabetes Federation; AACE=American Association of Clinical Endocrinologists; TG=Triglyceride; HTN=Hypertension

reported as the most specific methods for detecting the syndrome. It should be noted that the abovementioned study did not report Youden index. A study conducted in Shantou in China evaluated the prevalence of MetS using a new model for diagnosing MetS, so called multivariate medical reference range (MMRR) and compared it with the two methods of the Chinese Joint Committee for Developing Chinese Guidelines (JCDCG) and IDF; the results indicated a significant agreement between MMRR criteria and the other two criteria, i.e., JCDCG and IDF. However, the comparison of the estimated sensitivity and specificity using the two-way comparison of diagnostic criteria showed that the two criteria of MMRR and JCDCG were more appropriate than the IDF for the diagnosis of MetS in the Chinese community.[25]

In the present study, the highest prevalence of MetS estimated by the IDF, NCEP ATP III, and AACE criteria was 60%, 55.2%, and 47.1%, respectively. The prevalence of this syndrome in the first phase of the study in 2009 estimated based on AACE criteria was 12.14%.[26] Therefore, the present study results indicate a significant increase in the prevalence and incidence of this syndrome among middle-aged people who were studied within the 5-year period. It is worth noting that part of this significant difference was due to some limitations in the first phase of the study (not measuring plasma lipids and the use of nonglycemic blood glucose for the diagnosis of glucose intolerance) that resulted in underestimation of the prevalence of MetS.

The prevalence of MetS in this study (estimated based on all the three definitions), as well as the prevalence estimated via LCA, was higher than the prevalence reported in Japan (7.8%, ATP III),[27] China (18.2%, IDF),[28] low-income African countries (11%, IDF),[29] Kazakh Nomads of the northwest of China (13.8%, ATP III; 20.9%, IDF),[30] and Iran (36.9%, ATP III; 34.6%, IDF).[31] The difference between this study and the mentioned studies in terms of the prevalence of MetS may be due to differences in diagnostic criteria and also the diversity of the participants in terms of variables including age or underlying illnesses such as diabetes. In addition, the results of a previous study on the 5-year incidence of diabetes among the same population indicated a high 5-year incidence of diabetes in this population.[32]

Regardless of the criteria used to define MetS, the results of the study indicate a high prevalence of this syndrome among the Iranian middle-aged population, which is significantly higher than those reported for the general population of Iran[7,8] and other parts of the world.[5,6] This seemingly different prevalence appears to be due to the use of different cutoff points and the set of criteria used in these three definitions, especially for defining the cutoff point of abdominal obesity. As the cutoff point of abdominal obesity based on the IDF definition is lower than those defined by the other two definitions, based on this definition, more people are identified as patients with MetS.

The results of this study showed that with increasing age, the prevalence of MetS in both sexes increased. This result was predictable because the probability of developing MetS in both sexes is affected by age-related processes, such as decreased secretion of growth hormone, increased secretion of hypercortisolism, hypogonadism, gradual decrease in basal metabolism, abdominal fat deposits, and insulin resistance.[13]

The prevalence of MetS among the participants in this study based on all the three definitions was higher in females compared to males in all age groups. The higher values of mean BMI and waist circumference in females, as compared to males, which were observed in our study, justify the higher prevalence of MetS among women. In studies conducted in low-income countries in Africa, China, Iran, and Nepal, MetS was more prevalent among females than males.[24,29-31,33]

This study was one of the largest population-based studies in Iran. The other strengths of this study are the acceptable percentage of respondents (91.3%), accurate implementation, and daily monitoring of data collection process. The use of LCA method for comparing diagnostic criteria of MetS was one of the other strengths of the present report. However, this study has some limitations; for instance, it did not measure insulin resistance and did not compare the desired definitions with other ones. LCA has already been used for the study of various classes of risk factors associated with MetS,[34] but this study is the first study comparing different MetS diagnostic criteria using LCA. Taking into consideration the results of the present study, the use of IDF definition seems to help identifying more Iranian people at risk for cardiovascular diseases, cerebrovascular diseases, and insulin resistance.

The results of this study highlighted the high prevalence of MetS and increased risk of cardiovascular diseases and cerebrovascular diseases among the Iranian middle-aged population. Moreover, based on the results of the study, for the diagnosis of MetS among the Iranian middle-aged population, IDF definition is considered better than NCEP ATP III and AACE definitions. Using the results of this study, the authorities of the health system in the country are expected to take urgent measures to immediately formulate and implement strategies to prevent or delay the complications of the syndrome.

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Conflicts of interest

There are no conflicts of interest.

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