REVIEW ARTICLE

A systematic review on the prevalence of metabolic syndrome in Iranian children and adolescents

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Background: Metabolic syndrome (MetS), a cluster of cardiovascular risk factors, is one of the most common metabolic disorders, which lead to many chronic diseases. The link between childhood MetS and occurrence of atherosclerosis and its sequels in adulthood is well documented. This study aims to systematically review the prevalence of MetS among Iranian children and adolescents. **Materials and Methods:** An electronic search was conducted on studies published from January 1990 to January 2015. The main international electronic data sources were PubMed and the NLM Gateway (for MEDLINE), Institute of Scientific Information (ISI), and SCOPUS. For Persian databases, we used domestic databases. We included all available population-based studies and national surveys conducted in the pediatric age group aged 3–21-year-old. **Results:** In this review, 2138 articles were identified (PubMed: 265; SCOPUS: 368; ISI: 465; Scientific Information Database: 189; IranMedex: 851; Irandoc: 46). After quality assessment, 13 qualified articles were evaluated. The number of total population and points of data were 24,772 and 125, respectively. Regarding the geographical distribution, we found 2 national, 6 provincial, and 5 district level points of data. The prevalence range of MetS among children was 1–22% using different definitions. Reported range of pediatric MetS defined by different criteria was as follows: National Cholesterol Education Program-Adult Treatment Panel III; 3–16%, International Diabetes Federation; 0–8%, American Heart Association; 4–9.5%, The National Health and Nutrition Examination Survey III; 1–18%, de Ferranti; 0–22%. **Conclusion:** MetS is a common metabolic disorder among Iranian children and adolescents, with increasing trends during the last decades. This finding provides baseline useful information for health policy makers to implement evidence based-health promotion for appropriate controlling of this growing health problem for the pediatric population.

Key words: Iran, metabolic syndrome, pediatrics, prevalence, systematic review

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INTRODUCTION

Noncommunicable diseases (NCDs) are considered as a global health problem with more considerable increasing trend in low- and middle-income countries (LMIC).[1,2] NCDs are the main causes of morbidity and mortality, especially in LMICs. The Global Burden of Disease Studies in 1990, 2000, and 2013 have reported that metabolic risk factors are the most important determinants of emerging NCDs all over the world.[3-7] The most common causes of NCDs-related morbidity and mortality are cardiovascular disease (CVD).[8]

Metabolic syndrome (MetS), a cluster of cardiovascular risk factors, is one of the most common metabolic disorders, which leads to many chronic diseases as CVDs, diabetes mellitus, cancer, kidney disease, and mental illness.[9-12] The concept of MetS in children and adolescents gain great concern during last decades due to the factors such as epidemiologic transition, double burden of nutritional disorders, lifestyle changes, and considerably high prevalence of obesity.

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Mentioned clustering may be associated with specific morbidity in childhood and different cardiometabolic disorders in adulthood.[13] In addition, there is growing body of evidence regarding the embryonic origin of the disorder.[14]

Though the prevalence of MetS among children and adolescents have been investigated in different populations worldwide, estimating the prevalence of MetS in children is a challenging issue due to the fact that different definitions used for MetS in children. The reported prevalence rates of MetS among children and adolescents ranged between 0 and 19.2%.[15]

Iran is facing a double burden of the diseases and is in a rapid epidemiological transition state. According to the findings of a nationwide survey, the prevalence of MetS in children have been reported to be 2.5%.[16] Moreover, some regional studies investigated the prevalence of pediatric MetS by using different diagnostic criteria.[17-28]

Given that MetS could be one of the most proper indexes for detecting people at high risk for NCDs and by considering that MetS and its components track from childhood to adulthood, it seems that determining the prevalence of Mets among Iranian children and adolescents would help us to assess the most effective preventive measures and interventional policies and consequently reduce the burden of NCDs and its related risk factors.

Therefore, this study aims to systematically review the prevalence of pediatric MetS among Iranian children and adolescents.

MATERIALS AND METHODS

This systematic review determined the prevalence of MetS among Iranian pediatric population; it is conducted as part of the National and Sub-national Burden of Diseases (NASBOD) study, from 1990 to 2014.[29,30] Methodology of the study (NASBOD) has been described in details, previously. The study protocol was approved by the Regional Ethics Committee of Isfahan University of Medical Sciences. Herein, we present the methods of current study in brief.

Outcomes definition

All included definitions of MetS in children and adolescents are presented in Appendix 1.[31-39]

Search strategy

To assess the English and Persian papers on pediatric MetS in Iranian children and adolescents, published papers were searched from January 1990 to January 2015. The main international electronic data sources were PubMed and the NLM Gateway (for MEDLINE), Institute of Scientific Information (ISI), and SCOPUS. Domestic databases with systematic search capability and the most coverage of national indexed Iranian scientific journals including IranMedex, Irandoc, and Scientific Information Database (SID) were used for Persian document [Table 1].

To have a more comprehensive search, the Emtree of SCOPUS and the medical subject headings (mesh) including entry terms of PubMed were used. The Persian keywords equivalent to their English search terms were used for national search.

The systematic search of electronic databases followed by the comprehensive hand searching process to obtain the highest level of access to the published, available unpublished and gray literature.

The new cases were added through register system of international database, for more data availability.

All the Iranian scientific journals not indexed in electronic databases, governmental reports, projects' reports, conferences, and reference lists were reviewed by hand searching [Table 1].

Study selection and eligibility criteria

We limited the search results to national, provincial, district, community population-based studies in child and adolescence, to Iran, to human subject (age 6–18 years) and to time period of January 1990–January 2014. There was no restriction on language. All research papers, abstracts, conference proceeding, titles of thesis, dissertations, and

Table 1: Search strategy for the prevalence of metabolic syndrome in Iranian pediatric population

PubMed	(((((metabolic[All Fields]) OR (dysmetabolic[All Fields])) OR ("insulin resistance"[MeSH Terms] OR ("insulin"[All Fields] AND "resistance"[All Fields])) OR "insulin resistance"[All Fields]))) OR reaven[All Fields])) AND ("syndrome"[MeSH Terms] OR "syndrome"[All Fields])) AND ("Iran"[Mesh] OR "iran"[All Fields]) OR Iranian[All Fields] OR I.R.Iran[All Fields] OR "I.R Iran"[All Fields] OR ("persia"[MeSH Terms] OR "persia"[All Fields]))
ISI Web of Science	("metabolic " OR "insulin resistance" OR "dysmetabolic" OR " reaven" OR "cardiovascular") AND "syndrome*" AND (Iran* OR "I.R. Iran" OR persia*)
Scopus	((AFFIL (iran* OR "I.R. Iran" OR persia*) AND PUBYEAR >1984) OR (TITLE-ABS-KEY (iran* OR "I.R. Iran" OR persia*) AND PUBYEAR>1984)) AND ((TITLE-ABS-KEY(("metabolic" OR "insulin resistance" OR "dysmetabolic" OR "reaven" OR "cardiovascular") AND "syndrome*") AND PUBYEAR >1984)
IranMedex, SID and Irandoc	"Metabolic syndrome", "Dysmetabolic syndrome"," Cardiovascular syndrome", "Insulin resistance syndrome"

reports included to our inclusion criteria as document types.

We excluded papers of nonpopulation-based studies. The studies that focused on special populations such as school-based studies were excluded. When there were multiple publications from the same population, only the largest study or the main source of data was included.

Data management

The results of each of databases' search import to separate endnote library. Duplicated papers were deleted. Remained papers were assessed in three phases for relevancy: Title; title abstract and full text review.

Quality assessment and data extraction

Quality of each selected paper was determined using quality assessment form which contains three parts as follows; general information, sampling quality, and measurement quality. Using the forms each paper was ranked as excellent,[13-19] good,[6-12] or poor (≤5) based on total score. Data were extracted from papers with good and excellent quality score. The quality assessment has been followed independently by two research experts (Kappa statistic for agreement for quality assessment; 0.92) and probable discrepancy between them resolved based on third expert opinion.

Data from selected eligible papers were extracted using standardized data extraction sheet.[40] This process was conducted by two researchers. In the cases of discrepancy, a third expert consulted for resolving it.

Details of each study including its general information, characteristics of studied population, methodology of each study, total sample size, age and sex groups, urban/rural areas, different definitions of MetS, which was used and reported prevalence and study outcomes indicators (age specific prevalence of MetS) were recorded in the predefined standard electronic data extraction sheets.

RESULTS

In this review, 2138 articles were identified (PubMed: 265; SCOPUS: 368; ISI: 465; SID: 189; IranMedex: 851; Irandoc: 46). During three refine steps and after removing of duplicates, 179 articles related to the study domain were selected. After quality assessment, 197 studies were selected for text appraisal, of which 13 qualified articles were evaluated at the final step. Overall, 2 of 13 articles were from the CASPIAN I and III studies [Figure 1].

Considering the whole data of systematic review results and national data sources; the number of total population and points of data were 24,772 and 125, respectively. From reported points of data, 51 of them were for total population and 37 and 37 of them were not for girls and boys, respectively. Regarding the geographically distribution, we found 2 national, 6 provincial, and 5 district level points of data.

In one of the articles (1 out of 13), preschool children (aged <6 years) were included. In other papers, the age range of studied population was 6–21-year-old.

Table 2 represents the prevalence of MetS in Iranian children and adolescences during 1990–2013 using different definition for MetS.

The prevalence range of MetS among children was 1–22% according to different definition. Reported range of pediatric MetS by different definition criteria were as follows: National Cholesterol Education Program-Adult Treatment Panel III (ATP III); 3–16%, International Diabetes Federation (IDF); 0–8%, American Heart Association (AHA); 4–9.5%, The National Health and Nutrition Examination Survey (NHANES III); 1–18%, de Ferranti: 0–22%.

DISCUSSION

In this study, for the 1st time in Iran, we systematically reviewed studies reporting the prevalence of MetS among Iranian pediatric population. Reviewing data of 24,772 total population with 125 point of data, indicated that as a result of nutritional transition, MetS is a common metabolic disorder among Iranian children. The summarized epidemiologic data of MetS provide us baseline information and identifies fields that should be investigated in future research.

A review study in 2004 reported an estimated prevalence rate of 3–4% for pediatrics MetS.[39] The corresponding figure in another review on 36 articles published between 2007 and 2009 was 1.2–22.6%.[41] A recent review on published reports worldwide in 2012 and showed that the prevalence of MetS ranged from 0 to 19.2% with a median of 3.3%.[15]

In this study, based on various definitions, the reported range for the prevalence of MetS was 1–22%. Reported range of pediatric MetS using different criteria was as follows: ATP III: 3–16%, IDF: 0–8%, AHA: 4–9.5%, NHANES III: 1–18%, de Ferranti : 0–22%. The results of the current review were similar to that reported for its worldwide prevalence.

As there is no consensus regarding the definition of pediatrics MetS, various prevalence rates of this disorder have been reported in different studies. Ford and Li have

Table 2: The prevalence of metabolic syndrome in population-based studies in Iranian children and adolescences 1990-2013

Reference	Location and name of study	Year of study	Year of publication	Age-group (years)	Sex	Urban/ rural	Definition	Sample size (*n*)	Prevalence (%)	CI 95% prevalence
Mehrdad *et al.*[17]	Tehran	1999-2001	2006	3-9	Both	Urban	ATP III	T: 1067 M: 506 F: 561	0.9 0.5 1.4	0.4-1.7 0.1-1.7 0.6-2.7
Esmaillzadeh *et al.*[18]	Tehran-TLGS	1998-2001 (Phase I)	2006	10-19	Both	Urban	ATP III	T: 3265 M: 1413 F: 1623	10.1 10.3 9.9	9-11.1 8.6-11.8 8.4-11.3
Kelishadi *et al.*[19]	National-CASPIAN I	2003-2004	2006	6-18	Both	Both	ATP III NHANES III	T: 4811 M: 2248 F: 2563	ATP III 14 14 13 NHANES III 2 2 2	 13.0-15.00 12.6-15.5 11.7-14.3 1.6-2.4 1.4-2.6 1.4-2.6
				6-10					ATP III 13 14 12 NHANES III 2 2 2	 12.0-13.9 12.6-15.5 10.7-13.3 1.6-2.4 1.4-2.6 1.4-2.6
				10-14					ATP III 15 14 16 NHANES III 3 2 3	 14.0-16.0 12.6-15.5 14.5-17.4 2.5-3.5 1.4-2.6 2.3-3.7
				14-18					ATP III 13 15 11 NHANES III 1 3 1	 12.0-13.9 13.5-16.5 9.8-12.2 0.7-1.32 2.31-3.76 0.6-1.4
Kazemi *et al.*[20]	Zanjan	2003	2008	17-21	Both	Urban	ATP III-IDF	T: 507 M: 277 F: 230	ATP III 15.6 9 7.8 IDF 4.1 3.6 4.8	ATP III 4-8.2 5.9-13.0 4.7-12.1 IDF 2.4-5.8 1.7-6.5 2.4-8.4
Salem and Vazirinejad[21]	Rafsanjan	2006-2007	2009	11-18	Female	Urban	ATP III	T: 1221	3.9	2.8-5
Mirhosseini *et al.*[22]	Mashhad	2007	2009	15-17	Female	Urban	ATP III	T: 622	6.5	4.6-8.6
Afkhami-Ardekani *et al.*[23]	Tehran-TLGS	1999-2001 (Phase I)	2010	10-19	Both	Urban	ATP III AHA NHANES III IDF	T: 932 M: 402 F: 530	ATP III 7.4 AHA 4.1 NHANES III 13.6 IDF 3.5	 5.7-9 2.8-5 11-15 2.3-4.7
		2003-2005 (Phase II)	2010						ATP III 6.7 AHA 9.4 NHANES III 13.4 IDF 8	 5-8 7-11 11-15 6-9

Contd...

Table 2: Contd...

Reference	Location and name of study	Year of study	Year of publication	Age-group (years)	Sex	Urban/ rural	Definition	Sample size (*n*)	Prevalence (%)	CI 95% prevalence
Chiti *et al*.[24]	Tehran-TLGS	2005-2008 (Phase III)	2010	10-19	Both	Urban	ATP III AHA NHANES III IDF	T: 1523	ATP III 9.5 AHA 5.1 NHANES III 17.8 IDF 5.8	 8-11 4-6.2 15.9-19.7 4.6-7
Mirmiran *et al*.[25]	Tehran-TLGS	1999-2001 (Phase I)	2010	10-19	Both	Urban	Cook Duncan Boney Cruz De Ferranti	T: 2645	6.7 7.7 0.7 1.8 15.1	5.7-7.7 6.7-8.7 0.4-1.1 1.3-2.3 13.7-16.5
Mehrkash *et al*.[26]	Gorgan	2009	2011	15-17	Both	Urban	NHANES III	T: 450 M: 225 F: 225	3.3 4.9 1.8	1.8-5.4 2.46-8.57 0.48-4.48
Khashayar *et al*.[16]	National-CASPIAN III	2009-2010	2012	10-18	Both	Both R: 30.6% U: 69.3%	IDF	T: 5738	2.5	2.1-2.9
Sarrafzadegan *et al*.[27]	Isfahan	2000-2007	2013	Isfahan	Both	Both	IDF, De Ferranti	T: 1992 M: 1039 F: 975	IDF 4.8 6.6 2.8	 3.9-5.8 5.2-8.3 1.8-4.0
				Junior high school				T: 1039 M: 539 F: 500	5.3 7.2 3.1	4.0-6.8 5.1-9.7 1.6-4.8
				High school				T: 953 M: 475 F: 478	4.2 5.9 2.4	3.0-5.6 3.9-8.4 1.1-4.0
								T: 1992 M: 1039 F: 975	De Ferranti 12.7 14.4 10.9	 11.2-14.2 12.3-16.7 8.9-12.9
				Junior high school				T: 1039 M: 539 F: 500	13.2 15.8 10.2	11.1-15.3 12.7-19.1 7.6-13.1
				High school				T: 953 M: 475 F: 478	12.3 13.0 11.5	10.2-14.5 10.1-16.4 8.7-14.7
Ahmadi *et al*.[28]	Isfahan	2000-2007	2013	11-14 Arak	Both	Both	IDF De Ferranti	T: 515	IDF	
								Urban T: 338 M: 166 F: 172	 6.21 10.84 1.74	 3.8-9.3 6.5-16.5 0.3-5.0
								Rural T177 M: 93 F: 84	 2.82 2.15 3.57	 0.9-6.4 0.2-7.5 0.7-10.0
									De Ferranti	
								Urban T: 338 M: 166 F: 172	 16.86 22.89 11.04	 13.0-21.2 16.7-30.0 6.7-16.7
								Rural T: 177 M: 93 F: 84	 5.64 4.30 7.14	 2.7-10.1 1.1-10.6 2.6-14.9
				11-14 Isfahan				T: 524	IDF	
								Urban T: 459 M: 247	 4.79 6.07	 3.0-7.16 3.4-9.8

Contd...

Table 2: Contd...

Reference	Location and name of study	Year of study	Year of publication	Age-group (years)	Sex	Urban/ rural	Definition	Sample size (*n*)	Prevalence (%)	CI 95% prevalence
								F: 212	3.30	1.3-6.6
								Rural		
								T: 65	4.61	0.9-12.9
								M: 33	6.06	0.7-20.2
								F: 32	3.30	0.7-16.2
								T: 524	De Ferranti	
								Urban		
								T: 459	11.98	9.1-15.3
				14-18				M: 247	14.57	10.4-19.6
								F: 212	8.96	5.4-13.6
								Rural		
								T: 65	7.69	2.5-17.0
								M: 33	9.09	1.9-24.3
								F: 32	6.25	0.7-20.8
								T: 505	IDF	
								Urban		
								T: 337	2.07	0.8-4.2
								M: 171	2.40	0.6-5.8
								F: 166	1.75	0.3-5.1
								Rural		
								T: 168	2.92	0.9-6.8
								M: 84	4.79	1.3-11.7
								F: 84	1.19	0.3-6.4
								T: 505	De Ferranti	
				14-18				Urban		
				Isfahan				T: 337	9.79	6.8-13.4
								M: 171	8.43	4.5-13.3
								F: 166	11.11	6.5-16.59
								Rural		
								T: 168	10.11	6.0-15.7
								M: 84	10.71	5.0-19.3
								F: 84	9.52	4.2-17.9
								T: 448	IDF	
								Urban		
								T: 398	6.73	4.5-9.7
								M: 202	9.90	6.1-14.8
								F: 196	3.57	1.4-7.2
								Rural		
								T: 50	0	0-7.0
								M: 23	0	0-14.8
								F: 27	0	0-12.0
								Urban	De Ferranti	
								T: 398	15.7	12.15-19.5
								M: 202	18.81	13.6-24.8
								F: 196	11.23	7.1-16.4
								Rural		
								T: 50	6	1.2-16.5
								M: 23	0	0-14.8
								F: 27	11.11	2.3-29.1

CI = Confi dence interval; T = Total; M = Male; F = Female; U = Urban; R = Rural; CASPIAN = Childhood and Adolescence Surveillance and Prevention of Adult Non-Communicable Disease; TLGS = Tehran Lipid and Glucose Study; ATP III = National Cholesterol Education Program-Adult Treatment Panel III; NHANES III = The National Health and Nutrition Examination Survey; AHA = American Heart Association; IDF = International Diabetes Federation

indicated that forty definitions of MetS in children have been used in 27 publications.[42] It seems that for determining how different definitions or cutoff values influence the prevalence rate of Mets, we should compare the rate reported by different criteria in the same population. Though some studies in Iran had reported the rate of MetS in children according to different criteria, but considering the range of reported rate of Mets, we could not reach accurate conclusion in this field. It is suggested that among different definitions, IDF definition for the pediatric age group is more appropriate.[43]

It seems that comparing the results of two CASPIAN survey could help us to suggest the changes in the prevalence of this disorder among Iranian pediatric population. Reevaluation and determining the prevalence of MetS in two surveys of the CASPIAN study according to the same criteria (IDF), showed that the prevalence of MetS had increased, i.e., in

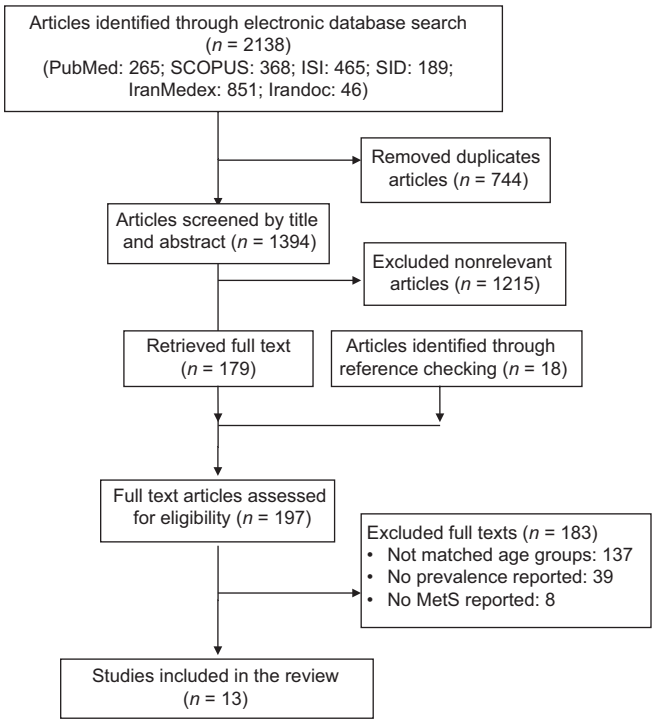

Figure 1: Flowchart of study selection

similar age groups of children and adolescents in CASPIAN I and III, it was 2.7% and 4%, respectively. It may be due to the effect of epidemiologic transition of our region.

In a study among 1018 Emirati adolescents, aged 12–18 years, the prevalence of MetS according to the IDF definition was 13% (21% in boys and 4% in girls).[44] The corresponding figure was 7.6% among Chinese adolescents with higher proportion in boys using IDF criteria.[45]

The results of current study regarding gender difference in the prevalence of Mets were heterogeneous. In some studies, it was similar in both sexes and in others, it was higher in boys. In a study in India, the prevalence of MetS was higher in girls than in boys.[46]

The results of a review study proposed higher prevalence of MetS in boys than in girls.[15]

In the current study, the prevalence of MetS was higher in older children than in younger ones; this finding was in line with some other studies.[15] It may be due to that by increasing age and during prepubertal and pubertal periods, some changes including increasing in insulin resistance, body fat, and blood pressure and decreasing in insulin sensitivity will be occurred. In addition, some other changes in lifestyle such as decreasing physical activity, smoking, or changes in eating habits may explain the higher rate of MetS in older children and adolescents.[47]

Most studies included in this review have reported the prevalence of MetS in urban population, but the results of three studies conducted in both urban and rural areas have demonstrated that the prevalence of MetS was higher among urban than in rural children and adolescents.[16,19,28] Tandon *et al*. in India have reported higher rate of MetS in urban population.[46,48,49] The lower prevalence of MetS in rural children might be because of their healthier lifestyle in terms of higher physical activity and more natural dietary habits.

This study is the first systematic review study about the prevalence of pediatric MetS in a country located in the Middle East and North Africa. We used all available national and sub-national sources of data using advanced comprehensive search approaches. We considered all published, unpublished and gray literature, as well as the main national sources.

The limitations of this review were large variations of data for the range of prevalence rates of MetS reported among Iranian children and adolescents, this variation is mainly because of different criteria used for definition of Mets, differences in the geographical location of populations studied as well as their nutritional, social and cultural characteristics, quality of the data, methodology of the studies and studied population. Therefore, we had limitation for appropriate comparison of available data. In addition, most of the data were related to children aged 6 years and older and scarce data existed for preschool-age children.

CONCLUSION

Reviewing the reports of available epidemiological data regarding the prevalence rate of MetS indicated that MetS is one important disorder in Iranian pediatric population, with a rate comparable to that reported worldwide. We also found that the prevalence of pediatric MetS has increased in Iran. The current findings underscore the necessity of implementation of evidence-based policies and programs for health promotion and primordial prevention of NCD.

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Conflicts of interest

There are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

All authors had contribution in the general designing of paper, designing of systematic review, primary draft preparation, and revision. All authors have given approval

to the final version of the manuscript, and accepted the responsibility of its content.

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APPENDIX

Appendix 1: Different definitions of metabolic syndrome in the pediatric age group

	IDF[31]	De Ferranti and Osganian[32]	ATP III[33]	NHANES III[34]	AHA[35]	Cook *et al.*[36]	Duncan *et al.*[37]	Boney *et al.*[38]	Cruz and Goran[39]
Waist circumference		≥75th percentile	≥90th percentile	≥75th percentile	≥90th percentile	≥90th percentile	≥90th percentile	≥85th percentile	≥90th percentile
HDL-C (mg/dL)	≤40	<40	≤40	≤40	≤10th percentile	<40	<40	<5th percentile	<10th percentile
Triglyceride (mg/dL)	≥150	>100	≥110	>100	≥110	>100	>100	>90th percentile	>90th percentile
Systolic or diastolic BP	>90th percentile	≥90th percentile	≥90th percentile	≥90th percentile	≥90th percentile	≥90th percentile	≥90th percentile	≥90th percentile	≥95th percentile
FBS (mg/dL)	≥100	>100	≥100	≥100	≥10	>100	>100	>100	>100
Waist- to- height ratio	>0.5								

IDF = International Diabetes Federation; ATP III = National Cholesterol Education Program-Adult Treatment Panel III; NHANES III = The National Health and Nutrition Examination Survey; AHA = American Heart Association; FBS = Fasting blood sugar; HDL-C = High-density lipoprotein cholesterol; BP = Blood pressure