Diagnostic Methods of Metabolic Syndrome in Children

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Abstract- We aimed to define Metabolic Syndrome (METs) from different viewpoints to determine the most appropriate method that could be used for early METs' diagnosis in general population and treat them immediately. This study was an analytic cross-sectional study which was conducted on 725, twelve year-old-girls and boys from Rasht city in Iran. METs was defined based on 7 different methods. Data were reported by descriptive statistics (number, percent, mean, and standard deviation) and analyzed by Cohen's kappa coefficient correlation and chi-square in SPSS version 19. The highest and lowest percentages of METs were obtained by DE Ferranti (17.5%) and viner *et al.,* (0.8%) methods, respectively. Results showed that viner *et al.,* had the highest degree of agreement with NCEP ATPIII and the lowest with DE Ferranti. Furthermore, De Ferranti showed the highest degree of agreement with NHANESIII and the lowest with Viner *et al*., According to results, the identification of the cut off points of obesity could help to promote public health care.

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Introduction

Metabolic syndrome (METs) has different complications such as cardiovascular diseases and diabetes type 2 (1,2). These complications commonly occur by the insulin resistance caused by increasing central obesity or general obesity and overweight (3). So, early diagnosis of metabolic syndrome in children is important.

Recently, the prevalence of obesity has an increasing trend in childhood and adolescent and this issue is one of the most harbinger of health in the world (4).

There are different physical characteristics in children and adults. For example, the United States national cholesterol education designed a method for METs in adults. This method defined METs based on waist circumference(WC) >102 centimeter in males and >88 cm in females (5). These numbers could not be used for children because of their different growth speed in different ages, and this leads to introduce many different methods for diagnosis of METs in pediatrics.

Cook *et al*., used WC ≥90th percentile for children and did not categorize HDL based on age (6). NCEP used cook method and selected WC >90th percentile instead of ≥90th percentile (7).

Moreover, modified NCEP ATP3 has been proposed new guideline based on abdominal obesity in boys and girls which indicated abdominal obesity ≥90 cm in men and ≥80 cm in females and triglyceride ≥150 mg/dl, HDL ≤40 and 50 in males and females respectively, and Systolic BP ≥130 mmHg or diastolic BP ≥85 mmHg (8).

Subsequently, De Ferranti (9), IDF (10), NHANES (11), and Viner (12) determined METs based on WC, TG, FBS, blood pressure, and HDL.

As it was informed, there is no uniform definition for METs. In this study, we aimed to define METs from different viewpoints to determine the most appropriate method that could be used for early METs diagnosis in general population and treat them immediately.

Materials and Methods

This study was an analytic cross-sectional study which was conducted on 725, twelve year-old-girls and boys from Rasht city in Iran. Data were collected by a checklist consisting of demographic characteristics, past

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medical history in students, clinical examination including the measurement of height (based on centimeter), weight (based on kilogram), body mass index (BMI, based on percentile), WC and laboratory tests (FBS, BS, Cholesterol, TG, LDL, and HDL) by venous sampling in fasting state of 10 hours.

Investigators used similar calibrated tools in all centers. Height and weight were measured by Seca stadiometer and scale, respectively. BMI was calculated by dividing weight (kg) to height (m^2). According to BMI, participants were divided into normal (5-85th percentile), overweight (85-95th percentile) and obese groups (≥ 95th percentile).

Ethical approval was obtained from Ethics committee of Guilan University of Medical Sciences and informed consent letters were obtained from parents. All participants were referred to the referral lab in Rasht. The lab had quality accreditation of laboratory department of Ministry of health.

METs was defined based on different methods as shown in table 1.

Table 1. METs diagnostic methods

1) Cook et al **3 or more criteria**	1. FBS≥110 2. WC≥90th percentile 3. TG≥110 mg/dl 4. HDL≤40 5. BP≥90th percentile
2) De Ferranti **3 or more criteria**	1. FBS≥110 2. WC>75th percentile 3. TG≥100 4. HDL<50 5. BP>90th percentile
3) IDF **Central obesity** **+** **2 other criteria**	1. WC≥90th percentile 2. TG≥150 3. HDL<40 4. SBP≥130 or DBP≥85 5. FBS≥100
4) NHANES III **3 or more criteria**	1. WC≥75th percentile 2. SBP or DBP>90thpercentile 3. TG≥100 4. FBS≥110 5. HDL<45
5) Modified NCEPATP III **3 from 5 criteria**	1. Abdominal obesity(abdominal obesity≥ 90 cm in men and ≥ 80 cm in females) 2. TG≥150 mg/dl 3. HDL≤40 in male HDL≤50 in female 4. SBP≥130 mmHg or DBP≥85 mmHg 5. FBS≥110
6) NCEP APPIII **More than 3 criteria**	1. WC>90th percentile 2. SBP or DBP>90th percentile 3. TG≥110 4. HDL<40 5. FBS≥110 mg/dL
7) viner etal **3 or more criteria**	1. BMI≥95th percentile 2. SBP≥95th percentile 3. TG>150mg/dL or HDL<35mg/dL Or Total cholesterol ≥95th percentile 4. Impaired Fasting Glucose FBS≥110 mg/dL

Data were reported by descriptive statistics (number, percent, mean, and standard deviation) and analyzed by Cohen’s kappa coefficient correlation and chi-square in SPSS version 19)

Results

In this study, 725 students included 247 (34.1 %) female and 478 (65%) male. Results showed that 85.1% were normal weight, 4.83% overweight, and 10.7% obese.

The highest and lowest percentages of METs were obtained by DE Ferranti (17.5%) and viner et al (0.8%) methods, respectively (Table 2).

Result showed that viner *et al.*, had the highest degree of *agreement* with NCEP ATPIII and the lowest with DE Ferranti. Furthermore, De Ferranti showed the highest degree of *agreement* with NHANESIII and the lowest with Viner *et al*., (Table 3).

There was a significant relation between the prevalence of METs and obesity by all methods (*P*<0.0001). Although, NHANES III and De Ferranti methods mentioned higher prevalence of METsin obese and overweight adolescents (Table 4).

Table 2. Prevalence of metabolic syndrome by different methods

		Count	Percent	95% lower confidence interval	95% upper confidence interval
Viner *et al*.	**Without metabolic syndrome**	719	99.2%	98.3%	99.7%
	With metabolic syndrome	6	0.8%	0.3%	1.7%
	Total	725	100.0%	-	-
IDF	**Without metabolic syndrome**	694	95.7%	94.1%	97.0%
	With metabolic syndrome	31	4.3%	3.0%	5.9%
	Total	725	100.0%	-	-
Cook *et al*.	**Without metabolic syndrome**	675	93.1%	91.1%	94.8%
	With metabolic syndrome	50	6.9%	5.2%	8.9%
	Total	725	100.0%	-	-
de Ferranti	**Without metabolic syndrome**	598	82.5%	79.6%	85.1%
	With metabolic syndrome	127	17.5%	14.9%	20.4%
	Total	725	100.0%	-	-
NHANESIII	**Without metabolic syndrome**	618	85.2%	82.5%	87.7%
	With metabolic syndrome	107	14.8%	12.3%	17.5%
	Total	725	100.0%	-	-
Modified NCEP ATPIII	**Without metabolic syndrome**	667	92.0%	89.9%	93.8%
	With metabolic syndrome	58	8.0%	6.2%	10.1%
	Total	725	100.0%	-	-
NCEP ATPIII	**Without metabolic syndrome**	710	97.9%	96.7%	98.8%
	With metabolic syndrome	15	2.1%	1.2%	3.3%
	Total	725	100.0%	-	-

Table 3. Degree of agreement between different methods

	Viner Et al	IDF	Cook *et al.*	DE Ferranti	NHANESIII	Modified NCEP ATPII	NCEP ATPII
Viner *et al.*	agreement =100 kappa=1	agreement =96/3 Kappa=0/260 P<0/0001	agreement =93/9 Kappa=0/203 P<0/0001	agreement =83/3 Kappa=0/076 P<0/0001	agreement 86= Kappa=0/092 P<0/0001	agreement =92/8 Kappa=0/195 P<0/0001	agreement =98/3 Kappa=0/374 P<0/0001
IDF	agreement =96/3 Kappa=0/260 P<0/0001	agreement =100 kappa=1	agreement =96/8 Kappa=0/700 P<0/0001	agreement =86/4 Kappa=0/334 P<0/0001	agreement =89 Kappa=0/379 P<0/0001	agreement =95/7 Kappa=0/733 P<0/0001	agreement =97/2 Kappa=0/553 P<0/0001
Cook *et al.*	agreement =93/9 Kappa=0/203 P<0/0001	agreement =96/8 Kappa=0/700 P<0/0001	agreement =100 kappa=1	agreement =89/4 Kappa=0/517 P<0/0001	agreement =91/9 Kappa=0/585 P<0/0001	agreement =93/9 Kappa=0/599 P<0/0001	agreement =95/2 Kappa=0/444 P<0/0001
De Ferranti	agreement =83/3 Kappa=0/076 P<0/0001	agreement =86/4 Kappa=0/334 P<0/0001	agreement =89/4 Kappa=0/517 P<0/0001	agreement =100 kappa=1	agreement =97/3 Kappa=0/898 P<0/0001	agreement =88/3 Kappa=0/434 P<0/0001	agreement =84/6 Kappa=0/181 P<0/0001
NHANESIII	agreement =86 Kappa=0/092 P<0/0001	agreement =89 Kappa=0/379 P<0/0001	agreement =91/9 Kappa=0/585 P<0/0001	agreement =97/3 Kappa=0/898 P<0/0001	agreement =100 kappa=1	agreement =90/5 Kappa=0/492 P<0/0001	agreement =87/3 Kappa=0/218 P<0/0001
Modified NCEP ATPII	agreement =92/8 Kappa=0/195 P<0/0001	agreement =95/7 Kappa=0/733 P<0/0001	agreement =93/9 Kappa=0/599 P<0/0001	agreement =88/4 Kappa=0/434 P<0/0001	agreement =90/5 Kappa=0/492 P<0/0001	agreement =100 kappa=1	agreement =94/5 Kappa=0/368 P<0/0001
NCEP ATPIII	agreement =98/3 Kappa=0/374 P<0/0001	agreement =97/2 Kappa=0/553 P<0/0001	agreement =95/2 Kappa=0/444 P<0/0001	agreement =84/6 Kappa=0/181 P<0/0001	agreement =87/3 Kappa=0/218 P<0/0001	agreement =93/5 Kappa=0/368 P<0/0001	agreement =100 kappa=1

Table 4. Comparing Body mass index in different methods for metabolic syndrome diagnosis

method		Body mass index						
		Normal weight (5th-85th percentile)		Over Weight (85th≤ ≥ 95th percentile)		Obesity (≥ 95th percentile)		***P***
		Count	Column N %	Count	Column N %	Count	Column N %	
Viner *et al.*	**Without metabolic syndrome**	617	100.0%	73	100.0%	29	82.9%	0.0001
	With metabolic syndrome	0	0.0%	0	0.0%	6	17.1%	
	Total	617	100.0%	73	100.0%	35	100.0%	
IDF	**Without metabolic syndrome**	613	99.4%	58	79.5%	23	65.7%	0.0001
	With metabolic syndrome	4	0.6%	15	20.5%	12	34.3%	
	Total	617	100.0%	73	100.0%	35	100.0%	
Cook *et al.*	**Without metabolic syndrome**	609	98.7%	47	64.4%	19	54.3%	0.0001
	With metabolic syndrome	8	1.3%	26	35.6%	16	45.7%	
	Total	617	100.0%	73	100.0%	35	100.0%	
de Ferranti	**Without metabolic syndrome**	558	90.4%	25	34.2%	15	42.9%	0.0001

Continuance of Table 4

	With metabolic syndrome	59	9.6%	48	65.8%	20	57.1%	
	Total	617	100.0%	73	100.0%	35	100.0%	
NHANESIII	**Without metabolic syndrome**	571	92.5%	31	42.5%	16	45.7%	0.0001
	With metabolic syndrome	46	7.5%	42	57.5%	19	54.3%	
	Total	617	100.0%	73	100.0%	35	100.0%	
Modified NCEP ATPIII	**Without metabolic syndrome**	595	96.4%	50	68.5%	22	62.9%	0.0001
	With metabolic syndrome	22	3.6%	23	31.5%	13	37.1%	
	Total	617	100.0%	73	100.0%	35	100.0%	
NCEP ATPIII	**Without metabolic syndrome**	617	100.0%	65	89.0%	28	80.0%	0.0001
	With metabolic syndrome	0	0.0%	8	11.0%	7	20.0%	
	Total	617	100.0%	73	100.0%	35	100.0%	

Discussion

Atherosclerosis and coronary heart diseases in adulthood are common and lethal. This process begins early in childhood (13). The presence of identifiable risk factors such as obesity, hypertension, and diabetes mellitus can accelerate this process (14,15). So, trying to detect risk factors of Atherosclerosis in primary school children is important (16). In this study, the prevalence of obesity and overweight was almost 15%. In our country such as other countries, prevalence of obesity in children was increased and more effort should be done on the reduction of BMI and obesity (17-19). BMI does not measure body fat directly, but can be considered as an alternative way to show obesity (20).

Waist circumference is used as a common parameter for diagnosing METsand this shows its importance. It is believed that WC and not BMI could relate with obesity induced complications. Furthermore, Dysrated *et al*., mentioned a high negative correlation between WC and cardiorespiratory 95 fitness in men (r=-0.68) and a moderate correlation in women (21).

American diabetes association (ADA) recently suggested that control and screening of possible risk factors that starts in childhood can help to identify and decrease risks of heart diseases. So, it seems that not only measuring BMI, but also WC can help clinicians for early detection of diseases (22).

The prevalence of METs in adolescents is very different which differs between 0.2-9.5 percent in USA and 1.4- 4.1 in Europe (based on IDF, WHO, and NCEP ATPIII) (23).

However, Ghaemi *et al*., reported METs prevalence 20% in Iran. In their study, participants had 2 criteria such as high TG, low HDL, hypertension or abnormal glucose tolerance test in addition to obesity (24). These results showed an increased prevalence of METs in comparison to other previous Iranian researches (25-26).

Although, in this study De Ferranti method determined the highest frequency of METs (17.5%), 9.4% of them had normal weight and this might be related to the increased WC.

To the best of our knowledge, there was a significant prevalence of METs based on BMI by all methods. According to these results, although, increased METs prevalence can be expected consequent to increased BMI, this study showed that METs in none-obese children may also be occurred and recommended that all none-obese children with high blood sugar or increased waist circumference without other components should be checked for METs.

So, for early diagnosis of METs, it seems that regular checkups for blood pressure, blood glucose and lipids in pediatric field could be helpful.

According to results, the identification of the cut off points of obesity could help to promote public health care.

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References

1. Kakudi HA, Loo CK, Pasupa K, editors. Risk Quantification of Metabolic Syndrome with Quantum Particle Swarm Optimisation. Proceedings of the 26th International Conference on World Wide Web Companion; 2017: International World Wide Web Conferences Steering Committee.
2. Castro AVB, Kolka CM, Kim SP, Bergman RN. Obesity, insulin resistance and comorbidities? Mechanisms of association. Arq Bras Endocrinol Metabol 2014;58:600-9.
3. Roberts CK, Hevener AL, Barnard RJ. Metabolic syndrome and insulin resistance: underlying causes and modification by exercise training. Compr Physiol 2013;3:1-58.
4. Golshekan K, Badeli H, Rezaieian S, Mohammadpour H, Hassanzadehrad A. Effect of oral ondansetron on decreasing the vomiting associated with acute gastroenteritis in Iranian children. Iranian J Pediatr 2013;23:557.
5. Williams L. Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report. Circulation 2002;106:3143-421.
6. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. Arch Pediatr Adolesc Med 2003;157:821-7.
7. Corona G, Mannucci E, Petrone L, Schulman C, Balercia G, Fisher AD, et al. A comparison of NCEP-ATPIII and IDF metabolic syndrome definitions with relation to metabolic syndrome-associated sexual dysfunction. J Sex Med 2007;4:789-96.
8. Chackrewarthy S, Gunasekera D, Pathmeswaren A, Wijekoon C, Ranawaka U, Kato N, et al. A comparison between revised NCEP ATP III and IDF definitions in diagnosing metabolic syndrome in an urban Sri Lankan population: the Ragama health study. ISRN Endocrinol 2013;2013:320176.
9. De Ferranti S, Gauvreau K, Ludwig D, Neufeld E, Newburger J, Nader R. Prevalence of the metabolic syndrome in American adolescents: Findings from the Third National Health and Nutrition Examination Survey. ACC Curr J Rev 2005;14:95.
10. Zimmet P, Alberti KGM, Kaufman F, Tajima N, Silink M, Arslanian S, et al. The metabolic syndrome in children and adolescents–an IDF consensus report. Pediatr Diabet 2007;8:299-306.
11. Grundy S. American Heart Association, National Heart, Lung, and Blood Institute. Definition of metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 2004;109:433-8.
12. Viner R, Segal T, Lichtarowicz-Krynska E, Hindmarsh 156 P. Prevalence of the insulin resistance syndrome in obesity. Arch Dis Childhood 2005;90:10-4.
13. Badeli H, Dalili H, Rad AH, Medghalchi A, Dalili S, Koohmanaee S. Birth weight as a cardio metabolic risk factor in Iranian adolescents. Int J Prevent Med 2017;8:72.
14. Jacobson MS, Kohn MR. Cardiovascular Risk Factors and Atherosclerosis. A Clinical Handbook in Adolescent Medicine: A Guide for Health Professionals Who Work with Adolescents and Young Adults. New Jersey: World Scientific, 2013:685-96.
15. Badeli H, Hashemian H, Nazari N, Rad AH. The percentage of error of different weight estimation methods toward actual weight in children admitted to 17 Shahrivar Hospital. Int J Prev Med 2015;6:13.
16. Nedog V, Lobnik E, Lobnik A, Bevc S. Early Detection of Atherosclerosis in Primary School Children. Cardiol Angiol 2014;2:154-62.
17. Dalili S, Mohammadi H, Rezvany SM, Dadashi A, Novin MH, Gholaminejad H, et al. The relationship between blood pressure, anthropometric indices and metabolic profile in adolescents: a cross sectional study. Indian J Pediatr 2014;25:445-9.
18. Dalili S, Rezvani SM, Dalili H, Amiri ZM, Mohammadi H, Medghalchi A, et al. Cardio-metabolic risk factors in Iranian children: where we are and the others? Acta Med Iran 2014;52:831-6.
19. Koohmanaee S, Tabrizi M, Naderi N, Rad AH, Moghaddam KB, Dalili S. Parental Anthropometric Indices and Obesity in Children. Acta Med Iran 2016;54:270-5.
20. Higgins V, Adeli K. Pediatric Metabolic Syndrome: pathophysiology and laboratory assessment. EJIFCC 2017;28:25.
21. Dyrstad SM, Edvardsen E, Hansen BH, Anderssen SA. Waist circumference thresholds and cardiorespiratory fitness. J Sport Health Sci 2019;8:17-22.
22. Association AD. Standards of Medical Care in Diabetes—2017: 178 Summary of Revisions. Diabet Care 2017;40:S4-5.

23. Tailor AM, Peeters PH, Norat T, Vineis P, Romaguera D. An update on the prevalence of the metabolic syndrome in children and adolescents. Int J Pediatr Obes 2010;5:202-13.
24. Ghaemi N, Aghaei Monavar A. Prevalence of Metabolic Syndrome In Children With Overweight. Med J Mashhad Univ Med Sci 2011;53:98-103.
25. Esmaillzadeh A , Mirmiran P, AzadbakhtC, Etemadi A, Azizi F. High prevalence of the metabolic syndrome in Iranian adolescents. Obesity 2006;14:377-82 .
26. Salem Z, Vazirinegad R. Prevalence of obesity and metabolic syndrome in adolescent girls in South East of Iran. Pak J Med Sci 2009;25:196-200.