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Metabolic Syndrome and its Risk Factors among Overweight and Obese Palestinian Schoolchildren using IDF and NCEP-ATP/III Definitions

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Abstract

Background: Warning signs of metabolic syndrome (MetS) can appear during childhood. Early detection and treatment of MetS is likely to reduce morbidity and mortality in adulthood and help to keep to minimum the global burden of cardiovascular diseases and type II diabetes. This study aimed to establish the prevalence and to characterize metabolic syndrome and its individual components among overweight and obese Palestinian schoolchildren aged 6-<18 years in the West Bank.

Methods: A cross sectional study was conducted in the West Bank-Palestine in the year 2014. Out of the 840 schoolchildren, 216 (30.7%) were overweight and obese; 146 of them were evaluated for MetS using the International Diabetes Federation and modified National Cholesterol Education Program-Third Adult Treatment Panel definitions.

Results: Using NCEP criteria, MetS was significantly more prevalent in overweight and obese children (23.3%) than IDF (15.8%) and among boys (22.2% for NCEP vs 12.3% for IDF) and girls (23.3% for NCEP vs 20.0% for IDF). No sex-specific differences in the prevalence of MetS between age groups were determined using both criteria. The prevalence of individual MetS components according the IDF and NCEP criteria were respectively; (32% and 25.3%) for increased waist circumference, (15.8% and 37.0%) for increased blood pressure, (9.7% and 24.8%) for increased triglyceride, (57.2% and 55.9%) for low HDL, and (39.7% and 15.8%) for increased fast blood sugar. Clustering of metabolic abnormalities had significantly increased by increasing body mass index and waist circumferences, and with decreased HDL and elevated triglyceride.

Conclusions: The prevalence of MetS among overweight and obese Palestinian schoolchildren is high with dyslipidemia being the most common MetS abnormality. Regardless the definition used to diagnose MetS among children; the findings of this study present a serious threat to current and future health of Palestinian children.

Keywords: Dyslipidemia; Metabolic syndrome; Obesity; Cardiovascular disease; Palestine

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Introduction

Metabolic syndrome (MetS) is characterized by a cluster of several metabolic and cardiovascular risk factors such as abdominal obesity, insulin resistance, atherogenic dyslipidemia,

and hypertension [1-3]. It was first considered to be a condition of adulthood and linked to cardiovascular morbidity and mortality [4]. More recently, it has been identified as a condition of childhood [4,5]. The risk of having metabolic syndrome increases with age, affecting less than 10% of people in their 20's and 40%

of people in their 60's. However, warning signs of metabolic syndrome can appear during childhood [3]. Early detection and treatment of MetS is likely to reduce morbidity and mortality in adulthood and help to keep to minimum the global burden of CVD and type II diabetes.

Childhood obesity is a significant health problem and associated with several metabolic and cardiovascular complications [6-8]. Overweight and obesity had reached alarming rate among Palestinians [9-11]. Importantly, overweight and obesity, as well as their related diseases, are largely preventable. Prevention of childhood obesity, therefore, needs high priority. A comprehensive understanding of MetS in overweight and obese children and adolescent population may be important for the specific direction of prevention strategies. To the author's best knowledge, no studies had been conducted in Palestine to establish the prevalence of MetS among children while few studies have indicated high prevalence of MetS among adults [12-14] and among obese and overweight adults [11,15].

To date, no uniform definition has been established to diagnose MetS among children and more studies are recommended for each ethnicity. Currently, the two most widely used definitions are those of the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP/III) and the International Diabetes Federation (IDF) [16-21]. Since a formal definition has not been developed for Palestinians, this study aimed to characterize and establish prevalence of MetS and its components using IDF and NCEP-ATP/III definitions among overweight and obese schoolchildren in Nablus-Palestine and to explore its possible risk factors.

Materials and Methods

Study population and sampling technique

A school-based cross-sectional study was conducted in 2014 in Nablus Districts in Palestine. A multi-stage stratified proportional sampling method was used to select the subjects from 39231 students. To diagnose MetS according to the new IDF definition, age is divided into three groups: 6 years to <10 years; age 10 years to <16 years; and 16 years to <18 years old. In the first stage, 840 participants (420 boys and 420 girls) were randomly selected from 12 schools. The number of participants had been selected then proportionally from each age group: 6-<10 years (320; 160 boys and 160 girls), 10-<16years (440; 220 boys and 220 girls), 16-<18years (160; 80 boys and 80 girls). In the second stage, children who presented with overweight and obesity and had met the inclusion criteria were invited to have blood samples taken (no.=216). The child was excluded from the study if he/she had hypo- or hyper-thyroidism, Cushing syndrome, epileptic, or taking regular medications other than anti-diabetic or lipidemic medication as indicated by his parents, and who had participated in the pilot study or his parents refused to sign informed consent.

Diagnostic criteria

The MetS prevalence was determined by the IDF new criteria for children and the NCEP-ATP III criteria adapted for youth [19,22,23]. For children aged between 6 and <10 years: Abdominal obesity is required as essential criteria. It is defined as waist circumference

(WC) \geq 90th percentile for age and gender; using the cut-off points established for American children and adolescents [24] but the MetS can't be diagnosed as stated in the IDF definition [19,25]. European data for WC was used as recommended by IDF criteria as no specific ethnicity cut-off points are available for Palestinian [19,25]. For children aged between 10 and <16 years, a diagnosis of the metabolic syndrome made as the presence of abdominal obesity (WC \geq 90th percentile or adult cut-off if lower) and the presence of two or more of the other components: Elevated TG (\geq 1.7 mmol/L (\geq 150 mg/dL)), low HDL cholesterol ($<$ 1.03 mmol/L ($<$ 40 mg/dL)), high blood pressure (Systolic \geq 130 mmHg or diastolic \geq 85 mmHg), and elevated blood glucose (\geq 5.6 mmol/L (\geq 100 mg/dL) [19,25]. For children aged 16 years or more, the IDF criteria for adults is used to define it; central obesity (defined as WC \geq 94 cm for men and \geq 80 cm for women) plus any two of the following four factors: Raised triglycerides: \geq 1.7mmol/L, reduced HDL-cholesterol: $<$ 1.03 mmol/L ($<$ 40 mg/dL) in males and $<$ 1.29 mmol/L ($<$ 50 mg/dL) in females, or specific treatment for these lipid abnormalities, raised blood pressure: systolic BP \geq 130 or diastolic BP \geq 85mm Hg, or treatment of previously diagnosed hypertension, impaired fasting glycaemia (IFG): Fasting plasma glucose (FPG) \geq 5.6 mmol/L (\geq 100 mg/dL), or previously diagnosed type II diabetes. To diagnose MetS using modified NCEP-ATP III criteria, the definition based on Cook et al., (2003) work [17] and was altered by Wan et al., (2007) [23]. This definition is based on criteria analogous to that of the National Cholesterol Education Program Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adult Treatment Panel III [26]. It defines MetS as three or more of the following: fasting TG \geq 110 mg/dL; HDL cholesterol $<$ 40 mg/dL; WC \geq 90th percentile for age and sex, according to national reference curves [27]; systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) \geq 90th percentile for sex, age and height, from national reference cut-off points [17]; FBG \geq 100 mg/dL [23]. Obesity was determined based on BMI and the classification scheme introduced by the Centers for Disease Control and prevention (CDC). CDC charts were used for defining respondents who were at risk of overweight (BMI $>$ 85th percentile) and obesity (BMI $>$ 95th percentile) [28,29]. Abdominal obesity was defined using WC percentiles by sex and age. Percentiles \geq 90 were defined as abdominal obesity. Hypertension was detected using seventh Joint National Committee on Evaluation, Diagnosis, Treatment, and Prevention of Blood Pressure (JNC7) classification criteria. If blood pressure (systolic and diastolic) reading was at $>$ 90th percentile based on sex and height, it was defined as pre-hypertension and readings $>$ 95 and $>$ 99 were defined as type I and II hypertension, respectively [30,31]. The health status of children was established from the self-administrated questionnaire that was answered by the parents. The parents were also asked about the type of medication that is given to their children to treat diabetes if found. Anthropometrics, blood pressure measurements, and biochemical analysis were done as described previously [11,15].

Data analysis

The Statistical Product and Service Solutions (SPSS) (version 21, IBM Corporation) was used for data analysis. Means, standard deviations, and percentages wherever appropriate were used to

describe variables and the Pearson Chi-square and Fisher Exact test were used to compare the categorical variables. A p-value of less than or equal 0.05 was considered statistically significant.

Result

Stage 1: Out of the 840 children, 216 (30.7%) were overweight and obese (14.2% overweight and 16.5% obese) with significant increase in the prevalence of obesity and overweight among age group 10-<18 compared to age group 6-<10 years (p value <0.01) (**Additional File 1**). Sex-specific anthropometric measurements were established for boys and girls and are shown in **Additional File 2**.

Stage 2: Out of 216 overweight and obese children, 146 participants (81 boys and 65 girls) underwent the second stage of this study and 70 participants refused to be tested for blood. Of the 146 agreed to participate in stage 2, 71.2% were obese (41% girls, 59% boys) and 28.8% were overweight (51% girls, 49% boys).

Prevalence of MetS based on the criteria used, gender, and age group

Based on the criteria used, the prevalence of MetS was high and significantly more prevalent using NCEP (23.3%) than IDF criteria (15.8%) (p value 0.000) (**Table 1**). Based on gender, no sex-specific differences in the prevalence of MetS between boys and girls were determined using IDF (p value 0.21) or NCEP criteria (p value 0.734) (**Table 1**). Based on age groups, no significant difference in the prevalence of MetS was determined between the age group 6-<10 years and the age group 10-<18 years using IDF (p value 0.332) and NCEP criteria (p value 0.995) (**Table 2**).

Differences in the prevalence of MetS abnormalities based on the diagnostic criteria used

The most prevalent component of MetS was reduced HDL according to both criteria (**Table 3**). The prevalence of individual

MetS components according the IDF and NCEP criteria were respectively; (32.2% and 25.3%) for increased WC, (15.8% and 37.0%) for elevated blood pressure, (9.7% and 24.8%) for elevated triglyceride, (57.2% and 55.9%) for reduced HDL and (39.7% and 15.8%) for elevated FBS (**Table 3**). Increased WC, reduced HDL, and elevated FBS were significantly more prevalent according to IDF (32.2 and 57.2%, 39.7%; respectively) than NCEP (25.3% and 55.9%, 15.8%; respectively) (p value 0.000). On the other hand, elevated triglyceride and elevated blood pressure were significantly more prevalent according to NCEP (24.8% and 37.0%; respectively) than IDF (9.7% and 15.8%; respectively) (p value 0.000).

Risk factors and culturing of metabolic abnormalities

Age: The prevalence of the following abnormalities had significantly increased with increasing age: overweight and obesity (p value 0.001), increased central obesity using NCEP definition (p value 0.038), elevated BP using IDF definition (p value 0.031), and elevated triglyceride using IDF definition (p value 0.041) (**Table 4**).

Gender: Sex-specific clustering of MetS abnormalities had shown no significant differences between boys and girls using both IDF (p value 0.453) and NCEP criteria (p value 0.489) (**Additional File 3**). Sex-specific frequency of individual components of the MetS among overweight and obese children is shown in **Table 5**. According to IDF criteria, central obesity (WC) and FBS were significantly more prevalent in girls (43.1% and 49.2%; respectively) than boys (23.5% and 32.1%; respectively) (p value 0.012 and 0.036; respectively) (**Table 5**).

BMI: With increasing BMI, clustering of metabolic abnormalities had significantly increased according to IDF and NCEP criteria (**Additional File 3**). This includes central obesity according to both criteria (p value 0.000), BP according to NCEP criteria (p value 0.013), and reduced HDL according to both criteria (p value ≤ 0.001) (**Additional File**

Table 1 Sex-specific prevalence of MetS according to IDF and NCEP criteria (N=146).

MetS	Boys (no.= 81)	Girls (no. 65)	Total (no. 146)	p-value	OR (95%CI)
	no. (%)	no. (%)	no. (%)		
IDF overweight and obese	10(12.3)	13(20.0)	23(15.8)	0.21	1.77(0.23-4.36)
IDF overweight	0(0)	1(4.8)	1(2.4)	0.19	1.05(0.954-1.115)
IDF obese	10(16.7)	12(27.3)	22(21.2)		
NCEP overweight and obese	18(22.2)	16(24.6)	34(23.3)	0.734	1.143(0.529-2.468)
NCEP overweight	0(0)	0(0)	0(0)	0.494	1.33(0.584-3.045)
NCEP obese	18(30.0)	16(36.4)	34(32.7)		

Table 2 Age-specific prevalence of MetS and metabolic abnormalities according to IDF and NCEP criteria.

Age-specific prevalence	6-<10 (no. =30)	10-<18 (no. =116)	p value	OR (95%CI)
	no. (%)	no. (%)		
Met NCEP	7(23.3)	27(23.3)	0.995	0.997(0.39-2.57)
Met IDF	3(10)	20(17.2)	0.332	1.875(0.52-6.79)
Met NCEP vs IDF (10-<18)		--	0.000*	48.73(12.12-195.9)
Met IDF obese vs overweight (10-<18)		--	0.001*	14.16(1.82-110.15)
Met NCEP obese vs overweight (10-<18)		--	0.000*	1.57(1.33-1.87)

Table 3 Prevalence of MetS abnormalities according to IDF and NCEP criteria.

Variable	IDF	NCEP	p value
	no. (%)	no. (%)	
WC	47(32.2)	37(25.3)	0.000*
BP	23(15.8)	54(37.0)	0.000*
Triglyceride	14(9.7)	36(24.8)	0.000*
HDL	83(57.2)	81(55.9)	0.000*
FBS	58(39.7)	23(15.8)	0.000*

Table 4 Age-specific prevalence of metabolic abnormalities according to IDF and NCEP criteria.

Variable	6-<10 (no. =30)	10-<18 (no. =116)	p value	OR (95%CI)
	no. (%)	no. (%)		
BMI (Overweight)	0(0)	42(36.2)	--	--
BMI(Obese)	30(100)	74(63.8)	--	--
BMI (Total overweight and obese)	30(100)	116(100)	0.000*	1.568(1.37-1.80)
WC IDF	12(40)	35(30.2)	0.304	0.648(0.28-1.49)
WC NCEP	12(40)	25(21.6)	0.038*	0.412(0.175-0.986)
BP IDF	1(3.3)	22(19)	0.031*	6.787(0.88-52.55)
BP NCEP	15(50)	39(33.6)	0.098	0.506(0.23-1.14)
Triglyceride IDF	0(0)	15(21.9)	0.041*	1.149(1.071-1.232)
Triglyceride NCEP	4(13.3)	33(28.4)	0.09	2.584(0.84-7.98)
HDL IDF	15(50)	69(59.6)	0.349	1.468(0.656-3.287)
HDL NCEP	15(50)	67(57.8)	0.445	1.367(0.61-3.06)
FBS IDF	10(33.3)	48(41.4)	0.422	1.412(0.61-3.28)
FBS NCEP	3(10)	20(17.2)	0.332	1.875(0.518-6.787)

Table 5 Sex-specific frequency of individual components of the MetS among overweight and obese children.

Sex-specific frequency	Boys	Girls	Total	p value*	OR, 95% (CI)
	no. (%)	no. (%)	no. (%)		
BMI (Overweight)	21(25.9)	21(32.3)	42(28.8)	0.397	0.802(0.482-1.335)
BMI(Obese)	60(74.1)	44(67.6)	104(71.2)	0.405	1.094(0.886-1.352)
BMI Total	81(55.5)	65(44.5)	146(100)	0.397	0.733(.037-1.505)
WC IDF	19(23.5)	28(43.1)	47(32.2)	0.012*	2.469(1.213-5.027)
WC NCEP	17(21.0)	20(30.8)	37(25.3)	0.177	1.673(0.790-3.544)
BP IDF	14(17.3)	9(13.8)	23(15.8)	0.571	0.769(0.310-1.910)
BP NCEP	26(32.1)	28(43.1)	54(37.0)	0.172	1.601(0.813-3.151)
Triglyceride IDF	6(7.4)	8(12.5)	14(9.7)	0.303	1.786(0.586-5.438)
Triglyceride NCEP	19(23.5)	17(26.6)	36(24.8)	0.667	1.18(.0554-2.514)
HDL IDF	48(59.3)	35(54.7)	83(57.2)	0.581	0.831(0.428-1.609)
HDL NCEP	48(59.3)	33(51.6)	81(55.9)	0.732	0.732(0.378-1.417)
FBS IDF	26(32.1)	32(49.2)	58(39.7)	0.036*	2.05(1.046-4.024)
FBS NCEP	11(13.6)	12(18.5)	23(15.8)	0.647	1.44(0.59-3.52)

4). MetS was significantly more prevalent in obese children than overweight children using IDF (p value 0.005) and NCEP criteria (p value 0.000) criteria (**Additional File 4**).

Elevated FBS: Children with elevated FBS were at higher risk of having MetS according to NCEP criteria (p value 0.000) but not the IDF (p value 0.24) (**Table 6**).

Central obesity: Children with increased central obesity had shown significant increase in clustering of metabolic abnormalities (3 or more) (**Additional File 3**) according to NCEP (67.6%) (p value 0.000) and IDF criteria (48.9%) (p value 0.04). They have shown also higher risk of having MetS according to both criteria (**Table 6**).

Discussion

Metabolic syndrome (MetS) is one of the major causes of morbidity and mortality in the world [32]. The clustering of cardio vascular disease (CVD) risk factors that typifies the metabolic syndrome is now considered the driving force for a CVD epidemic. It is estimated that around a quarter of the world's adult population has metabolic syndrome [33]. The importance of identifying the risk factors of MetS in children is because its presence in this phase of life remains many years in silence and therefore, its identification can contribute to the prevention of chronic diseases and premature death [16,34]. The

Table 6 Risk factors associated with MetS (increased waist circumferences, elevated fast blood sugar, decreased high density lipoprotein, elevated blood pressure, and elevated triglyceride).

Variable	MetS IDF			MetS NCEP		
	no.(%)	p value	OR, 95% (CI)	no.(%)	p value	OR, 95%(CI)
WC	23(48.9)	0.000***	1.96 (1.48-2.54)	23(67.6)	0.000***	14.64 (5.89-36.40)
FBS	23(15.8)	0.24	2.79 (1.12-6.98)	14(60.9)	0.000***	8.01 (3.053-21.021)
HDL	22(95.7)	0.000***	21.65 (2.829-165.625)	38(88.4)	0.000***	10.19 (3.709-28.004)
BP	12(52.2)	0.000***	11.1 (3.98-30.991)	35(81.4)	0.000***	19.34 (7.74-48.31)
Trig	8(34.8)	0.000***	8.83 (2.804-27.860)	26(60.5)	0.000***	12.79 (5.34-30.67)

prevalence of metabolic syndrome in children and adolescents has been reported in various populations using a variety of age and gender specific cut-off points for the different components (waist circumference, fast blood sugar, blood pressure, and lipid levels). To the authors' best knowledge, this is the first study that had established the prevalence of MetS among children and had explored its risk factors.

The findings of this study had demonstrated that the overall prevalence of MetS was high among overweight and obese children aged 6-<18 and significantly higher according NCEP criteria (23.3%) than IDF (15.8%) without significant differences between age groups and genders. Similar frequencies of MetS were reported among overweight and obese children world widely [17,35-37]. Higher frequencies were reported in different populations [38,39] and when IDF definition was implemented [40-44].

In order to help policy makers in establishing policies and strategies for preventing MetS among children, we had explored the MetS risk factors among children. The pathogenesis of the MetS and each of its components is complex and not well understood and continues to challenge the experts but both insulin resistance and central obesity are considered significant factors [24,27]. Obesity is associated with metabolic disorders starting early in life. Obesity, particularly in the central (abdominal) region, is associated with an increase in risk of cardiovascular disease and has been determined as a key precipitating factor for type II diabetes [45]. The finding of this study indicate that the prevalence of overweight and obesity was high (30.7%) among Palestinian schoolchildren and the clustering of metabolic abnormalities had increased with increasing body mass index with no gender-specific differences. Obesity was associated with increased central obesity and decreased HDL according to IDF and NCEP definitions and elevated BP according to NCEP definition. The IDF groups suggest that the MetS should not be diagnosed in children younger than 10, but that a strong message for weight reduction should be delivered for those with abdominal obesity [20]. They assume that the IDF criteria for MetS in children and adolescent may change in future as more outcome data become available. Therefore, we had established the prevalence of MetS in children aged 10-<18 years which was significantly more pronounced when modified NCEP definition was implemented than IDF definition and had increased with increasing obesity according to both criteria. None of the overweight children aged 10-<18 years had been diagnosed with MetS according to NCEP definition and only one had been diagnosed with MetS according

to IDF definition. These results indicate that obesity but not gender or age could be significant risk factors for increased MetS among Palestinian schoolchildren. Overweight and obesity, as well as their related diseases, are largely preventable. Prevention of childhood obesity among Palestinian children, therefore, needs high priority. Depending on these results, we assume also that both definitions with their cutoffs used may be not realistic for diagnosing MetS in normal weight Palestinian school children.

Most research focus on investigation of how obesity in children should be better defined (e.g. WC, BMI, weight, etc.) and develops ethnic specific age and sex normal ranges for WC, ideally based on healthy values [25]. Central obesity is a prerequisite risk factor for the diagnosis of the syndrome in the new IDF definition [45]. Therefore, we had investigated the association between central obesity and FBS with other risk factors. Children in this study had shown significant increase in the prevalence of central obesity according to IDF (32.2%) compared to NCEP (25.3%) definitions and the prevalence had increased with increasing BMI. Children with increased central obesity had shown significant increase in clustering of metabolic abnormalities (3 or more) according to NCEP (67.6%) compared to IDF definition (48.9%). Therefore, central obesity had significantly increased the risk of having Mets according to NCEP definition. Surprisingly, central obesity was not associated with increased FBS according to both definitions. Although elevated FBS was the second prominent component using IDF definition, it was not associated with any MetS abnormalities.

Gender is another risk factor. Different studies have been undertaken to characterize the major components of the metabolic syndrome in females and males in different populations [19,28,46-49]. In agreement with other studies among Palestinians, MetS and its other risk factors were more clustered in girls than boys with no significant differences using both definitions [11,13-15,50] and increased with increasing obesity [11,15]. Elevated FBS and central obesity were significantly more prevalent in girls than boys using IDF definition. Moreover, these risk factors seem to cluster at early age in girls as 28.6% of girls have ≥ 3 components in age group 6-<10 years compared to 18.8% in boys using NCEP definition. None of the boys at this age has three of more components or had met the IDF definition. In addition to that, although no statistical differences in BMI between boys and girls in all age groups was determined, central obesity was more prevalent among girls using both definitions

and significantly higher using IDF definition. These results agree with previous studies [11,14,51,52]. Therefore, more attention should be paid to obese girls especially those with central obesity and elevated levels of fast blood sugar as they are at higher risk for early mortality.

The prevalence of suggested risk factors that contribute to the MetS in children varies significantly with the cut off used [53]. Insufficient data about waist circumferences cut-off points have prevented region-specific definitions to be established for the Arabian population. The presence of central obesity is an absolute requirement for the IDF criteria but the European threshold to define central obesity in our population may be under-inclusive for our population (ethnicity). More data is needed in this subject to establish Palestinian waist circumferences thresholds. This could be one of the reasons for having higher prevalence of MetS in this study according to NCEP definition than the IDF definition. In fact, the prevalence of MetS for Palestinians from the same district was more using IDF definition than NCEP definition for overweight and obese adults [11,15]. Moreover, different studies had indicated that MetS is significantly more prevalent among adult Palestinians when IDF definition is implemented than NCEP definition [14,51,52]. Therefore, similar to other studies [54,55], the results of this study indicate that modified NCEP-ATP/III definition with modified cut-off points for youth should be considered for the diagnosis of the MetS among Palestinian children unless waist circumference with ethnicity specific values for Palestinians are established. In this study, the prevalence of MetS abnormalities varied between IDF and NCEP definitions. The most prevalent component of MetS among study subjects was reduced HDL-cholesterol using both definitions. Reduced HDL and elevated BP were significantly associated with increased central obesity and elevated triglyceride using NCEP definition. Similar results were observed among overweight and obese adult Palestinians in both sexes [11,15]. Moreover, elevated triglyceride was associated significantly with all abnormalities except central obesity according to NCEP definition. Screening for dyslipidemia among children and adults is necessary especially among children at risk. We are now investigating the risk factors for reduced HDL among Palestinians in both genders and in different age groups. Overall, obesity, central obesity, and dyslipidemia could be the most significant risk factors for MetS among children in Palestine according to NCEP definition.

Conclusion

The findings of this study provide evidence-based data on the considerable prevalence of childhood MetS among Palestinian children. Obesity and central obesity as well as dyslipidemia were the most significant risk factors for MetS among children. Because the number of overweight and obese children is increasing and because it is evident that MetS starts at early life, we recommend that more attention should be paid on the young population at risk to reduce childhood obesity and subsequent cardiovascular diseases. Prevention of childhood obesity among Palestinian

children needs high priority. Attention should be made through health care providers, social media, and educational campaigns about the benefits of losing weight in reducing MetS and its components. Depending on the results, we assume that both definitions, IDF and NCEP-ATP III, with their cutoffs used may be not realistic for diagnosing MetS in normal weight Palestinian children. Therefore, we recommend developing ethnic specific age and sex normal ranges for waist circumferences, ideally based on healthy values. More research is needed in order to identify optimal criteria for defining and establishing cut off for different MetS components for Palestinian at different age groups. However, modified NCEP-ATP/III definition with modified cut-off points for youth should be considered for the diagnosis of the MetS among obese Palestinian children unless waist circumferences with ethnicity specific values for Palestinians are established.

Declarations

Competing of interests

"The authors declare that they have no competing interests" in this section.

Ethical considerations

The study was carried out in accordance with the ethical standards, Declarations of Helsinki. Approval was obtained from Institutional Review Board "IRB" at An-Najah National University in Palestine prior to the research conduction. Permission from the Ministry of Education and the principal of the school was granted. All study participants were freely accepted to join the study and they provided a signed consent form from their parents. All were assured that all data collected would be confidential and available for the researcher only. It was explained to the participants that they had the right to withdraw from the research anytime. Blood tests were free and the participants did not pay for it.

Consent for publication

"Not applicable" in this section.

Author's contributors

BD wrote the initial draft of the manuscript. BD, AAH, LN, and SA contributed to the study design and literature the search, AAH, LN, and SA carried out the data collection. BD, AAH analyzed the data and prepared data tables. All authors were involved in interrupting the data and had full approval of the submitted and published version and all authors approved the final manuscript.

Availability of data and materials

Most data generated or analysed during this study are included in this manuscript. Other data that support the findings of this study and/or analysed during the current study are available from the corresponding author on reasonable request.

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