Screening for Metabolic Syndrome in School Children and Adolescents at Benha City, Egypt

ABSTRACT

Background: The prevalence of Metabolic syndrome in childhood has been raised in the last few years with serious medical and public health problem. However, very few previous studies have described its status in Egyptian children and adolescents. This study aimed at assessment of the prevalence and risk factors of Metabolic syndrome among children and adolescents in Benha city. **Methods:** This cross-sectional study included 910 participants from Benha city aged from 6 to 18 years. Anthropometric measurements; height, weight, BMI and WC and blood tests were conducted to assess components of metabolic syndrome defined according to the International Diabetes Federation criteria. Suitable statistical tests were adopted to define possible associations between Metabolic syndrome and other factors. **Results:** the mean age was 11.6 ± 3.4 years, 53% of subjects were males. 60% of subjects came from urban regions. The prevalence of metabolic syndrome was 5% (49 out of 910 subjects). There was insignificant difference in MetS prevalence between males and females p= 0.55. Low HDL-C (24%) and central obesity (17.7%), were the most prevalent components. while 10% had high BP, 10% had high TG and 9% had elevated FG. Females had higher frequency of central obesity than males (57%) vs. (43%), while males had significant higher frequency of Low HDL-C (65%) vs. (35%). Urban dwellers had higher rates of central obesity, high TG and elevated FG. **Conclusion:** The prevalence of metabolic syndrome (according to the definition of International Diabetes Federation) among children and adolescents living in Benha city, Egypt was 5%.

Keywords: *Metabolic syndrome*, *prevalence, children, adolescents*

INTRODUCTION

Metabolic syndrome (MetS) is an aberrant metabolic alterations cluster, involving hypertension, hyperinsulinemia, dyslipidemia and central obesity, which increases cardiovascular disease (CVDs) risk (1). MetS in children raises type 2 diabetes and CVDs risk such as coronary artery disease in adulthood (2).

Rapid increasing in obesity prevalence and type 2 diabetes incidence in paediatric population over the past two decades have made MetS early identification and preventative measures something crucial for avoiding CVDs and developing health outcomes during adolescence and older age (3).

MetS components in childhood are similar to adults, however the cut-off values in children are different putting into consideration hormonal changes effect during maturation and growth and the impact of familial heredity, and ethnicity making it hard to compare pediatric MetS prevalence among different countries and regions (4–6).

IDF has established diagnostic criteria for MetS in adolescents and children, which comprise central adiposity (waist circumference (WC) ≥ 90th percentile) and the presence of at least two of the following conditions: triglycerides (TG) ≥ 150 mg/dl, HDL-C < 40 mg/dl, systolic blood pressure (BP) ≥ 130 mmHg or diastolic BP ≥ 85 mmHg, fasting plasma glucose (FG) ≥ 100 mg/dl, or a previously diagnosed case of type 2 diabetes (7).

previous reviews reported that MetS prevalence extended between 0.2 and 38.9%, with 3.3% as median in the general population and was significantly greater among children who were overweight or obese (11.9%, and 29.2% respectively) (8–10).

This cross-sectional study was conducted to evaluate MetS occurence among children and adolescents in Benha city in Egypt, and to describe MetS components in this specific population.

SUBJECTS AND METHODS

Subjects

Nine hundred and ten adolescents and school going children from both sexes were involved in this cross-sectional study, they all live in Benha city, Egypt and aged from 6 to 18 years. They were recruited from schools during the period between first of October 2022 to the 28th of February 2023. The calculated sample size of the study were 910 participants at 5% level of significance. The expected proportion of children and adolescents who have metabolic syndrome (21%) and a confidence level of 95%. All participants' parents or guardians have provided written informed permission with explanation of the study purpose, steps, possible hazards. Subjects with history of significant systemic disease, acute or chronic inflammatory diseases, thyroid dysfunction or participants using androgens, anabolic steroids or insulin, that may potentially change metabolic profile, were excluded from our research.

Methods

Anthropometric measurements: The subject's height was determined in a standing position, barefoot, utilizing the closest 0.1-centimeter stadiometer. Every subject was weighed using digital scales to the closest 0.01 kg while wearing little clothing and no shoes. WC was estimated at the midpoint between the iliac crest and the last rib utilzing non-stretchable plastic tape to the closest 0.1 cm with the participant standing and breathing normally. The 90^{th} percentile of WC for age and sex of Egyptian children and adolescents was calculated depending on values in previous Egyptian studies (11,12). The formula for calculating BMI was weight (in kilograms) divided by height (in metres) squared. It was independently input into the Egyptian growth charts, corrected for gender and age, and Z-scores were then computed. The students were categorized regarding their BMI as overweight and obese if their BMI was above the 85th percentile, and normal weight if their BMI was between the 15th and 85th percentiles (13).

Blood pressure measurement: BP was assessed by employing a properly sized cuff with a mercury sphygmomanometer, while individuals were seated comfortably. Prior to taking the measurements, subjects were given a minimum of 10 minutes to rest. To determine systolic and diastolic blood pressure, the first and fifth Korotkoff sounds were utilized. Each measurement was taken twice, with a 5-minute interval between them, and the resulting systolic and diastolic BP values were averaged and recorded. High BP was identified as a mean systolic BP of ≥ 130 mmHg or a mean diastolic BP of ≥ 85 mmHg. (14,15).

Blood tests: Participants fasted for 12 hours before blood samples were collected from the antecubital vein by trained nurses. These samples were centrifuged at 3000 rpm, aliquoted, and stored at -80°C. Biochemical analyses were performed using the Cobas 6000 machine. Glucose (FG), TC, LDL, and TG were measured utilizing glucose oxidase and enzymatic ways. HDL-C was assessed utilizing clearance method. (15).

Definitions: MetS in children was diagnosed based on IDF criteria, which required central obesity, identified as WC equal to or exceeding the 90th percentile with ethnicity-specific values, along with the presence of any two of the following four factors: triglyceride levels equal to or exceeding 1.7 mmol/L (150.4 mg/dL), HDL-C levels less than 1.03 mmol/L (39.8 mg/dL), SBP and DBP equal to or exceeding 130 mmHg and 85 mmHg, respectively and fasting glucose levels equal to or exceeding 5.6 mmol/L (100.9 mg/dL), or a confirmed diagnosis of type 2 diabetes mellitus (7). IDF recommended that MetS should not be diagnosed in individuals under the age of 10. However, in this study, the IDF criteria mentioned earlier were used to identify MetS and its associated factors in children under the age of 10. These factors could serve as predictors for MetS development in adolescence and adulthood (15).

STATISTICAL ANALYSIS

The data analysis was conducted using IBM's Statistical Package for Social Sciences software (SPSS), specifically, IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp, Armonk, NY). To evaluate the distribution's normality, the Kolmogorov-Smirnov test was employed. Continuous data were reported with descriptive statistics, including the mean ± standard deviation, median, and interquartile range (IQR). Categorical data, on the other hand, were presented as counts and percentages. When comparing two means, an independent-samples t-test was employed. For continuous data involving more than two dependent parametric variables across different time points, a one-way ANOVA (F test) was utilized to test for significant changes. Proportions between two qualitative parameters were compared using the Chi-square (X^2) test, and in cases of small sample sizes, the Fisher Exact test of significance was used in place of the Chi-square test. The significance level (p value) was set at <0.05 for results deemed significant and <0.001 for highly significant results.

RESULTS

Clinical data and demographic of all studied subjects showed that mean age was 11.6 ± 3.4 years, 53% of subjects were males. Mean weight, height, BMI and WC were 46.7 ± 18.9Kg, 1.47 ± 0.17 meter, 20.5 ± 4.7 and 73.2 ± 15.8 cm. 60% of subjects came from urban region. The incidence of metabolic syndrome was 5% (49 out of 910 subjects). the mean SBP and DBP were 103.9 ± 14.6 and 67.4 ± 7.9 mmHg respectively. Laboratory data among all studied subjects showed that the mean TC, TGs, LDL and HDL of all studied subjects were (mg/dL) 149.5 ± 19.9, 94.1 ± 29.6, 104.3 ± 22.2 and 48.2 ± 7 respectively. The mean FG was 89.1 ± 8.1 mg/dL **(Table.1).**

Comparing demographic, clinical and biochemical data between males and females showed that males had mean height significantly taller than females (1.5 ± 0.18 vs 1.45 ± 0.15 meter with p value <0.0001). However, males had significantly lower means of BMI (20 ± 4.19 vs. 21.07 ± 5.16 p = 0.001), waist circumference (71.6 ± 13.9 vs 75.01 ± 17.5 cm p= 0.001) than females. Insignificant change was present in MetS prevalence between females and males p= 0.55. Males BP (diastolic and systolic) was significantly higher than females (SBP 106.3 ± 14.7 vs.101.2 ± 14mmHg and DBP 69.2 ± 8.6 vs. 65.5 ± 6.3mmHG p< 0.0001). Regarding laboratory data males had significantly higher FG level than females, while, females had higher TGs, LDL and HDL levels than males **(Table.2)**.

MetS components occurrence among subjects revealed that Low HDL (<39.8) and central obesity (WC ≥ 90^{Th} percentile) were the most prevalent components (24% and 17.7 %) respectively. while 10% had high BP, 10% had high TG (≥150.4) and 9% had elevated FG (≥100.9) **(Table.3)**.

Comparing occurrence of MetS components between males and females showed that females had higher frequency of central obesity than males; 91(57%) vs. 70 (43%) **P=0.019**, while males had significant higher frequency of Low HDL-C than females 140(65%) vs. 70(35%), **P<0.0001.** Other components had matched prevalence between both sexes **(Table.4) (Figure.1)**.

According to residency there was significant difference between participants from urban and rural background in central obesity prevalence, high TG and elevated FG that were substantially greater in urban than rural subjects (60.9 % 85% 75%) vs. (39.1%, 15 %, 25%), respectively **(Table.5) (Figure.2)**.

DISCUSSION

MetS is an interconnected metabolic risk factors constellation which leads to atherosclerotic cardiovascular diseases progression. Increased triglycerides, reduced HDL-C, altered glucose metabolism and elevated BP are all common risk factors (16).

MetS diagnosis in adolescents and children is still ambiguous as gold standard diagnostic criteria for MetS are not yet identified (17). Diagnostic criteria utilized by studies involve IDF, WHO and age modified National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) criteria (18).

This study was performed on adolescents and children were between 6 and 18 years old who live in Benha city to assess MetS prevalence regarding IDF criteria mentioned above. In the current study, the participants mean age was 11.6 ± 3.4, and 53% of subjects were males. In agreement with our results, **Zhu et al.**(15) enrolled 15,045 individuals aged 7–18 years throughout seven provinces in China. and observed that 7711 (51.3%) were males and mean age of participants was 11.4±3. 1. **Gupta et al.**(19) also reported a slight majority of boys 1149 (54.7 %) out of 2100 sbjects were represented in the study whereas, boys average age was 13.4± 1.8 years, and girls mean age was 13.5 ±1.8 years.

Anthropometric measures in the present study were; mean weight (46.7 ± 18.9vKg), height (1.47 ± 0.17meter), BMI (20.5 ± 4.7), and waist circumference 73.2 ± 15.8 cm. Close results were reported by **Abou El-Ella et al.**(20) **and Zhu et al.**(15) the later study reported that the mean height was 1.49.0±16-meter, weight was 43.2±15.4 Kg and BMI was 18.8± 3.8.

Our study showed that 5% (49 subject) had MetS. Primary studies have provided supporting evidence by revealing a wide range of prevalence for MetS in general population, spanning from 0.4% to 24%. Similarly, within the obese population, MetS occurrence varies significantly, ranging from 6% to as high as 55.8%. Additionally, it's worth noting that there is considerable diversity in the diagnostic methods used to identify MetS within the pediatric population (21,22). **Zhu et al.**(15) found that the overall MetS prevalence was 2.3%. Moreover, **Singh et al.**(23) examined 1160 school-going adolescents, encompassing males and females about 10-18 years old. Their findings revealed that MetS occurrence among this group was 2.6%. **Gupta et al.**(19) stated that children in Indian schools had a prevalence of MetS of 3.3%. In Egypt, **Soliman et al**.(24) found that 13.12% of population were estimated to have MetS.

In Saudi Arabia, **Bahathiq** reported a prevalence of 17.1% among 1356 school girls aged from 6 to 18 years living in Makkah (25). Also, **Al-Hussein et al.** in 2014 reported a prevalence ranging from 2% to 18% by using six different definitions for MetS, among 2149 Saudi schools' boys and girls aged from 6 to 17 years living in Riyadh(26). Moreover, In a previous systematic review describing the worldwide epidemiology of MetS in children, authors have reported a median prevalence of 3.3%

(0–19.2%), in which the MetS prevalence in overweight children was 11.9% (2.8–29.3%) and 29.2% (10.0–66.0%) in obese children(27).

In the present study that the mean TC, TGs, LDL, HDL and FG were (149.5 ± 19.9, 94.1 ± 29.6, 104.3 ± 22.2 and 48.2 ± 7, 89.1 ± 8.1mg/dl) respectively. Close results were reported by **Zhu et al.**(15) and **Abou El-Ella et al.**(20) the later study found that the mean TG and cholesterol (mg/dl) of studied children were 132.4 ± 47.2 and 176 ± 37.4, respectively. The mean HDL (mg/dl), of studied children was 41.4 ± 9.1 and mean FG (mg/dl) was 101.9 ± 38.3

Regarding MetS occurrence, no substantial change was seen between males and females. According to two studies on the Indian population, no gender preference was present in of MetS distribution (28,29). In contrast to a previous meta- analysis, which revealed that MetS frequency in males is considerably greater compared to females in the majority of diagnostic approaches in general population (3.46 percent vs. 2.99 percent) and among overweight and obese subjects (26.63% and 24.05% respectively). Generally, females are at lower risk to have MetS than males. The scientists based their conclusion on the higher obesity occurrence between males than females, and assumed that family behaviors towards males usually encouraging consumption of excessive energy due to self and family perceived underweight and the contrary, towards female adolescents(18).

In the current study, BMI, and waist circumference, were higher in females than males. In agreement with **Sekokotla et al.** study which reported that among the 255 females included in the study, 47.5% were either overweight or obese, while 24.1% of the males fell into this category. Additionally, the BMI z-scores were substantially greater in females (1.2±0.05) compared to males (0.7±0.01). When examining obese individuals in comparison to those with a lower body mass index (BMI), it was found that BMI z-scores were significantly elevated in both females (1.9±0.04 for obese vs. 0.62±0.05 for lean, $P < 0.01$) and males (1.8±0.13 for obese vs. 0.32±0.07 for lean, $P < 0.01$) (30). Furthermore, **Zhu et al**.(15) revealed that obesity occurrence, as measured by BMI for age, was 9.2% among Chinese children and adolescents, with a greater rate among males (13.3%) than females (4.8%).

In the current study SBP and DBP were lower in females than males also males had greater TGs level and lower HDL-c than females parallel to **Zhu et al.**(15) who found a substantially greater high BP rates, increased FG and low HDL-C level in boys (4.6%, 4.1% and 15.8%) compared to girls (2.7%, 1.8% and 12.9%) the author contributed these differences to gender disparity. However, **Lee et al.**(31) found that The occurrence of low HDL cholesterol levels (hypo HDL cholesterolemia) was notably more frequent in girls compared to boys, with rates of 18.1% versus 11.5%, respectively ($P < 0.001$). Conversely, high blood sugar levels (hyperglycemia) and high BP (hypertension) occurrence was roughly twice as high in boys than girls ($P < 0.001$).

As regards distribution of components of MetS in our study, Low HDL (<39.8 mg/dl) was the most prevalent component (23%) followed by central obesity (WC≥90Th percentile) which found in 17.7% of the subjects. As reported by **Al-Daghri et al.**(32) Low HDL-cholesterol was the most common among all MetS risk factors, impacting 86% of the participants (CI 85.0–88.6). Hypertriglyceridemia was the second most prevalent, affecting 33% of the participants (CI 30.6–35.8). At the same time, **Khashayar et al.**(33) in the study involving 5738 Iranian adolescents aged 10 to 18 years, discovered that a low level of HDL-C was the prevailing component of MetS, accounting for 43.2% of the entire study group. Also, **Gupta et al.**(19) showed that among the participants, 9.2% exhibited elevated triglyceride levels (≥150 mg/dl), while 16.9% had a low HDL level (<40 mg/dl). Additionally, 3.8% were identified as having abdominal obesity (WC ≥90th percentile), and 20.5% were found to be hypertensive. Also, Tehran Lipid and Glucose Study, by **Azizi, et al.**(34) also showed HDL cholesterol is the most prevalent metabolic component. In the majority of investigations, low HDL was the most frequent component of MetS, indicating that it is the biggest MetS indicator.

In the current study the gender distribution of MetS components showed that abdominal obesity occurrence was substantially higher in females 57% vs 43% while low HDL was more frequent in males 65% vs 35%. In accordance with **Amer et al.** (6) who reported that MetS occurence was greater in boys than girls in 2019 and 2015 data with substantially greater low HDL-C levels rates and increased triglycerides in boys than in girls. Also, this finding was supported by **Haroun et al.**(35) research using IDF criteria in UAE. In contrast, the study by **Dejavitte et al**.(36) revealed that no substantial changes were seen among male and female groups concerning WC, BP, TG, and HDL-C, and blood glucose.

Global industrialization and the marching urbanization resulted in enormous lifestyle transitions in terms of eating behaviors, physical inactivity and sedentary behavior(5). In the present study, 60% of subjects were from urban regions moreover, central obesity, hypertriglyceridemia, and elevated blood sugar were substantially greater in urban than rural subjects. Supporting this assumption **Singh et al.** (23) study revealed that MetS prevalence was somewhat greater in urban area (2.80%) compared to rural area (2.52%). Furthermore, the epidemiologic data of the Indian urban population showed that 250,000–500,000 adolescents have MetS, and at a great risk of having diabetes and CVDs in the next 15–20 years(37). In contrasts **Sarkar, et al.**(38) regarded that MetS may not always be an urbanization result and may be due to ethnic characteristics and eating traditions. The greater incidence in urban populations can be related to their sedentary lifestyles and rising intake of energy-dense foods and sugar-sweetened drinks.

CONCLUSION

This study revealed that MetS prevalence (regarding IDF definition) among children and adolescents living in Benha city, Egypt was 5%, that was equal in both sexes with almost equal distribution of components of metabolic syndrome. Central obesity and dyslipidemia were the most prevalent MetS risk factors specially in urban dwellers. This frequency in such age highlights the necessity for effective preventive and therapeutic interventions to preserve good health during and after this particular age.

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