Metabolic syndrome (MetS) has been broadly studied in adults. However, because of the lack of a universal definition for MetS in pediatric populations, few studies have been conducted on this frequent disorder among children. Lifestyle factors play an important role in the pathogenesis of MetS. A cornerstone of the treatment in MetS patients is the use of a healthy diet to improve all abnormalities. Most of available studies focused on lifestyle changes for treatment of MetS in adolescents, and there are only few studies which assessed the specific role of diet therapy for MetS among children and adolescents. It is important since sometimes it is not applicable to encourage children to be more active. Hence, in the present article, we aimed to review the dietary intake and recommendations for treatment of pediatric MetS.

**Background**

In 1988, Reaven noticed that several risk factors commonly come together including obesity, high fasting triglycerides (TG), low levels of high-density lipoprotein cholesterol (HDL-C), high levels of low-density lipoprotein (LDL-C), increased fasting serum insulin, impaired glucose tolerance (IGT) and high blood pressure which seemed to be related to each other as metabolic syndrome (MetS) (1, 2). Several terms have been suggested to describe MetS such as “syndrome X” (3), “death quartet” (4) and “insulin resistance syndrome” (5). MetS is a constellation of interrelated cardiovascular disease (CVD) risks factors such as abdominal obesity, dyslipidemia, hyperglycemia, insulin resistance and hypertension (HTN)(6-8). Also, MetS is associated with higher risk for type II diabetes mellitus (T2DM) (9). Abdominal obesity and insulin resistance are the most important determinants of MetS (6, 10).

MetS is a common disorder among adults in both developed and developing countries in the last two decades (11-14). In adults, the MetS components have been developed by a number of expert groups which varies in the sense of their indicators and cut points (10, 15-20).

MetS has been broadly studied in adults during the past two decades. However, because of some barriers, there is no universal definition for MetS in the pediatric populations and few studies have been conducted in this age group (21, 22). Some limitations to define pediatric-MetS are due to lack of information regarding the normal range of serum insulin level in children, the use of adults cut-point for children or not sorting cut-points by age groups for children, physiological insulin resistance in puberty, lack of clear cut points for central adiposity which could predict the risk of co-morbidities and MetS in youths and varied baseline levels for lipid profile in specific ethnicities. Given the current epidemic of obesity, it is not surprising that the so-called ‘pediatric MetS’ is still a comparatively little-heard-of term (23).

Therefore, because of the lack of a ‘gold standard’ diagnostic test, researchers have modified the adult criteria in different ways to create their own definition for children and adolescents (Table 1)(24-30). The International Diabetes Federation (IDF) introduced a clear set of criteria to diagnose metabolic syndrome in children and adolescents (31). This single worldwide definition enables researchers to compare data from different studies, easily. The IDF criteria for MetS in children and adolescents have been shown in Table 2.

However, previous studies used different diagnostic criteria for the MetS in youths and reported different prevalence rates of MetS in children by different definition in the same population. For example, using NCEP ATP III and IDF criteria, a cross-sectional study of 923 Italian obese children showed a 36.2% and 56.7% prevalence of MetS, respectively (32), whereas a study of Chinese children and adolescents found a higher prevalence of MetS by NCEP ATP III versus IDF (38.2% vs. 33.9%, respectively) (33). Another study among 99 Australian overweight pre-pubertal girls compared the prevalence of MetS using six different definitions. The findings of this study showed the prevalence rates of 0% by US NCEP to 60%
by Lambert criteria (34). Using two different definition, Saffari et al. determined the prevalence rates of 50% and 66.2% versus 25% and 42.5% among overweight and obese, respectively, in a single data set of Iranian children and adolescents (35). Overall, a recent systematic review on eighty-five study reported the prevalence of MetS in children. The median (and range) of MetS in whole populations, overweight and obese children were 3.3% (0-19.2%), 11.9% (2.8-29.3%) and 29.2 (10-66%), respectively (36).Friend et al. (36) found higher prevalence rate among boys rather than girls (5.1% vs. 3.0%) and also in older compared with younger children (5.6% vs. 2.9%). However, the prevalence of MetS varies widely around the world. A summary of the prevalence of MetS by different criteria in adolescents is shown in Table 3.

The underlying causes of the MetS remain to be determined, but obesity is regarded as an important underlying factor. Genetics, sedentary lifestyle, aging, pro-inflammatory states, low birth weight (37) and hormone-related changes may also cause MetS (38, 39).

Obesity is linked to several metabolic abnormalities, specially insulin resistance and MetS. There is a close relation between the degree of obesity and MetS, while weiss et al (40) found that 38.7% and 49.7% of moderate and severe obese children were affected by MetS. The process of atherosclerosis, which begins at early age, is associated with obesity and other components of metabolic syndrome in children (41). These abnormalities are tracked from childhood to adulthood (42, 43).

Diabetes and heart disease are now increasing in children and the adolescent population. This is particularly of great concern because next generation will already have several health problems due to their childhood obesity. Therefore, obesity in these individuals means higher risk factor for their morbidity and mortality in their future life.

Abdominal fat measured by waist circumference is more symptomatic of MetSprolifer than BMI (44). In recent years, abdominal obesity in both genders of adolescents had considerable increase at global level (45, 46). An excess of adipose tissues (especially visceral fat tissues of the abdomen) releases inflammatory cytokines which can contribute to a rise in insulin resistance (47). Moreover, central obesity is linked to a lower level of adiponectin, the adipose-specific, collagen-like molecule found to have antidiabetic, anti-atherosclerotic and anti-inflammatory properties (48).

Insulin resistance is associated with wearing out of the beta cell of pancreas, hyperglycemia and type 2 diabetes (49). Insulin resistance in adipose tissue leads to a flux of free fatty acids from the adipose tissues to liver and causes insulin resistance in it and some tissues. Fatty acids cause to stop glucose oxidation and glucose transport. They also cause atherogenic dyslipidemia by inducing very low-density lipoprotein production in the liver that leads to an increase in serum TG. A rise in TG, accompanied with high LDL-C levels, markedly increases the risk for CVDs (50).

In addition to metabolic abnormalities, lifestyle factors such as diet play an important role in the pathogenesis of MetS. Hence, a cornerstone of the treatment in MetS patients is the use of a healthy diet to improve all abnormalities including excess body weight, dyslipidemia, hyperglycemia, hyperinsulinemia and hypertension. In this article, we review some dietary recommendation for pediatric MetS.

Methods

In order to search relevant English and non-English published papers, we used online databases of PubMed, ISI Web of Science, SCOPUS, Science Direct and EMBASE from January 1980 to February 2013. Following keywords were used in our search: Metabolic syndrome, syndrome X, insulin resistance syndrome, diet, adolescents, adolescence, childhood and their related Medical Subject Headings (MeSH terms). We found 103 English papers which published between 1980 and the February of 2013. Finally, we reached 57 papers which did not include lifestyle factors and physical activity in their study design. Around 30 papers of 57 papers were limited to the components of MetS, specifically obesity and insulin resistance, or assessed the effect of adolescent dietary intake on MetS in early young, or studied the effect of maternal diet on MetS of children. Few studies (n=27) assessed the role of diet in MetS specifically. We included these papers as the main search results in the present paper.

Dietary treatment of Metabolic syndrome

Diet as a modifiable risk factor plays an important role in the prevention of MetS consequences (51) by affecting on MetS-components such as blood glucose and lipid profile. Because of the strong relationship between obesity and MetS, it is reasonable to suggest that primary aim in the treatment of MetS should focus on weight loss. The most prevalent form of the MetS obese patients is excess visceral adiposity (52, 53). Dietary patterns by increasing dietary fiber consumption and decreasing fat consumption were associated with Insulin Resistance Syndrome (IRS) inversely among obese people and could reduce the risk of type 2 diabetes and CVD (54). Results of these studies implied that calorie content and diet composition are important factors in the prevention and treatment of metabolic syndrome in young people.

Dietary pattern

To resolve the concern regarding the interactions among nutrients or unknown components in foods and the solubility among food and nutrient intakes, studying dietary patterns has been suggested instead of studying single nutrients or foods or food groups (55-58). In addition, dietary pattern could reflect individuals’ dietary behaviors which may affect the etiology of chronic disease (56, 57).

Due to continued changes in adolescents’ dietary patterns and their long term effects in adulthood, assessing dietary patterns among them is important. However, few studies were conducted to assess such association among adolescents and most of these studies were limited to adults or specific components of MetS. One study of 14-y old Australian adolescents found that western dietary patterns is positively associated with increased odds ratio for the “high risk metabolic cluster” and also higher mean values of total cholesterol, waist circumference and BMI among girls while healthy dietary pattern was negatively associated with serum glucose in both gender and low HDL-C in boys (59). A systematic review on 3,168 Korean adolescents (13-18 yr) between 1998-2009 showed a direct association between western dietary pattern and MetSas well as its components such as hypertriacycledemia and obesity, whilst traditional dietary pattern had a negative association (60). Furthermore, the number of 16-18 year-old adolescents who had western dietary pattern
increased from 1998 to 2009 but no changes observed in the dietary pattern of 13-15 year old ones (60). Other studies assessed the association between various dietary patterns and the risk factors of MetS. A cross-sectional study using 1995 Australian National Nutrition Survey of participants aged 12-18 y showed that after adjustment for confounding factors, a fruit, salad, cereals and fish dietary pattern is inversely associated with high diastolic blood pressure in 16-18 year-old adolescents (61). Positive association between energy-dense, high-fat, low-fiber dietary patterns and fat mass index was reported by Ambrosini et al. (62). However, several studies have linked western, sweetened cereal and corn dishes, whole milk and sweet patterns to general and abdominal obesity and insulin resistance in different populations (63-65). Briefly, it seems that dietary patterns which characterized by high content of sugary cereals, sweetened beverages, industrial snack, cakes, whole milk, sweets, fried foods, burgers, and pizza and low intake of fruits, vegetable, dairy, whole grains without added fats, mixed dishes and soups were related to higher risk of different metabolic abnormalities (63, 66). Another noteworthy aspect of diet which is closely related to the whole diet is its quality. Although various diet quality indices such as healthy eating index (HEI) were suggested to reduce the burden of chronic diseases, few studies assessed the association between diet quality indices and MetS in adolescents. However, one study showed that higher HEI is inversely associated with the MetS prevalence among US adolescents (67).

Calorie intake and obesity in youths
Since obesity is the most important risk factors in the prevalence of metabolic syndrome, dietary interventions should be focused on weight reduction in obese people with metabolic syndrome. It is clear that obesity is the outcome of imbalance between energy intake and energy expenditure, therefore the first step in treating of obesity is by reducing the energy intake (67-70). Growth and development are two parameters which should be considered in weight reduction in adolescents. A substantial slowing of weight gain may be achieved by relatively small but consistent changes in energy intake, expenditure, or both (200 to 500 kcal per day) (71, 72).

The first goal of weight control in obese children and adolescents is weight maintenance because the normal growth and development with concurrent reductions in weight is a challenge in the treatment of overweight children. Professional recommendations to help the obese children and adolescents to achieve the healthy weight are consuming diets that include primarily nutritious foods and participating in regular moderate to vigorous physical activity most days of the week (73). If weight loss is desired, an appropriate starting goal is about 0.5 kg of weight loss per month (74). Satisfactory weight control could also be achieved by improving hyperlipidemia, hyperinsulinemia and hypertension (75).

Reduced calorie diet such as very low calorie diet (VLCD) used in weight management in adults could not be applied in children and adolescents because the normal growth and development in these age groups are important and reduced calorie diets may threaten the normal growth. Furthermore, the low-carbohydrate diet was associated with a greater improvement in some risk factors for CHD but the adherence is poor and larger and larger studies are required to determine the long-term safety and efficacy of low-carbohydrate, high-protein, high-fat diets in obese people especially in obese children (76).

On the other hand, general dietary recommendations of the AHA for children stress a diet that primarily relies on fruits and vegetables, whole grains, low-fat and nonfat dairy products, beans, fish, and lean meat (77). Finally, applying a maintenance diet for obese children and adolescents to achieve the normal growth is more important.

Carbohydrate
Carbohydrates as the main part of the diet play an important role to produce of daily energy requirement. In severely obese subjects with a high prevalence of diabetes and the metabolic syndrome, carbohydrate-restricted diet induces more weight loss in comparison with fat- and calorie-restricted diet (78). Carbohydrate composition of diets, including the glycemic index (GI) is another factor which affects calorie intake due to satiety responses. In a randomized crossover study in 16 obese adolescents (8 female and 8 male) to investigate the effect of a low-GI and high-GI meal on metabolic, hormonal, and satiety responses in overweight adolescents the results showed that prolonged satiety associated with low GI foods may provide an effective method for reducing caloric intake and achieving long-term weight control in obese adolescents (79). An ad libitum low glycemic load (GL) diet comparing with a low fat diet led to greater reduction in BMI and fat mass and a small but significant increment in insulin resistance after 12 months. In both treatment groups, the dietary GL was the principle predictor of treatment response while dietary fat was not (80).

Furthermore, the low-carbohydrate diet is associated with a greater improvement in some risk factors for CHD, insulin resistance and obesity (76, 81, 82). However, there are some controversial findings. Demol et al (81) compared the impact of three isonenergetic diets containing low-carbohydrate and different fat content (low or high) to high-carbohydrate low-fat diet on weight and metabolic markers. Findings showed that all three diets lead to a significant weight loss and metabolic markers improvement. However, only both low carbohydrate diets were associated with lower insulin level and homeostasis model assessment (HOMA). A recent well-designed study showed that a low carbohydrate diet (42% energy from CHO) vs. a standard diet (55% of energy from CHO) could not cause a greater decrement in body weight but favorably affect the homeostasis of glucose and insulin up to 3 hours postigestionand decreased significantly the serum TG concentration among African-American obese girls (82). However, based on some findings longer and larger studies are required to determine the long-term safety and efficacy of low-carbohydrate diet in weight management specially in obese children because there are some evidences which show that consuming a low-carbohydrate high-protein diet over six weeks could increase the calcium loss (83). In contrast, among obese patients, weight loss was associated with longer diet duration, restriction of calorie intake, but not with reduced carbohydrate content. Low-carbohydrate diets had no significant adverse effect on serum lipid, fasting serum glucose, and fasting serum insulin levels, or blood pressure (84).

Among the dietary carbohydrates, consumption of simple carbohydrate especially sugar and sugar-sweetened beverages have important role in the prevalence of the obesity in adolescents. There are evidences about the adverse effect of sugar-sweetened beverages and their consumption of sugar-sweetened beverages in children and adolescents. They consume 10% to 15% of total calories from sugar-sweetened beverages (SSB). Fruit juice drinkers consumed, on average, 148 (ages 2–5), 136 (ages 6–11), and 184 (ages 12–19) kcal/day (85). SSB consumption is independently and positively associated with HOMA-IR, waist circumference, systolic blood pressure and BMI, and inversely with HDL-C concentrations (86).

Dietary Fat
Fat is the most energy-dense macronutrient and is a target for reducing the energy content. A diet high in fat and fast food is often associated with obesity and metabolic syndrome. However, traditional foods which are high in fiber and low in fat (e.g. beans and squash) as a part of healthy eating patterns could prevent obesity and its consequences such as CVD and diabetes (87). Reinehr et al (88) showed that a low-fat high-carbohydrate diet decreases significantly body weight and serum insulin and leptin levels, and increases adiponectin. However, another study showed that dietary composition is more important rather than physical activity (89). This study reported that while higher carbohydrate intake is associated with higher WC, TG and serum glucose, a diet with high-
er intake of fat is associated with smaller WC and lower TG and glucose (89). Overall, daily fat intake of 25-35% of total calories is advocated in management and control of metabolic syndrome components (69).

The majority of studies were aimed at reducing cardiovascular risk-factors in the form of a decreased consumption of saturated fat, total fat, cholesterol, sodium, and sugar and an increased consumption of complex carbohydrates. Most of the studies concerned both behavioral changes and changes in attitudes and knowledge (90-92).

Because the major sources of saturated fat and cholesterol in children’s diets are full-fat milk and cheese and fatty meats, use of low-fat dairy products and lean cuts of meat in appropriate portion sizes will be critical in meeting dietary needs and nutrient requirements (73). In other words, not only the amount of fat but also the type of dietary fat intake play significant role in achieving weight loss and health promotion.

In sum, the primary goal of childhood obesity interventions is regulation of body weight and fat with adequate nutrition for growth and development. Ideally, these interventions are should modify eating and exercise behaviors such that new, healthier behaviors develop and replace unhealthy behaviors, thereby allowing healthier behaviors to persist throughout development and into adulthood (68). Recent public health dietary guidelines emphasizes in low intakes of saturated and trans fat, cholesterol, and added sugar and salt; appropriate calorie intake and physical activity for achieving the normal weight for height; and adequate intake of micronutrients (93).

Dietary recommendations

Gouvenier et al. (94) indicated that following the Mediterranean diet can reduce the prevalence of metabolic syndrome and, consequently, prevent diabetes mellitus and CVDs. On the other hand, some other researches have demonstrated that an empty calorie eating pattern, which includes high percentages of total fat and sweetened beverages intake, or patterns predominated by refined cereals or sweets and cakes, are closely linked with the elevated risk of metabolic syndrome (95).

Links between carbohydrate quality and other components of metabolic syndrome in overweight adolescents have been shown in a number of studies. The findings showed that the total amount of sugar and sweetened beverages were associated with poor beta-cell function and beta-cell compensatory reaction deteriorates in people with increased sugar intakes (96).

Obesity prevention and treatment have a profound impact on reducing MetS risk in youth. The number of studies on dietary interventions aimed at reducing the incidence of metabolic syndrome in overweight youths is very limited. Most of the interventional studies included physical activity components besides dietary changes. However, because of the important role of obesity in MetS, diet and exercise are two key components of the treatment of obesity and consequently the metabolic abnormalities and MetS.

In many developing countries which are in nutritional transition most of adolescents consume a high-carbohydrate and saturated fat diet with sugar-rich beverages (97, 98). Therefore, dietary strategies should include an emphasis on regular meals and increased fiber intake.

In some studies, high-fat diets in comparison with high-carbohydrate diets had deteriorate insulin action in the body. Although several studies have demonstrated the relationship between fat-containing foods and insulin resistance, other research implied the role of sub-types of fat in the diet and the importance of this effect needs to be investigated (99). Dietary intake of saturated fatty acids (SFA) was associated with insulin resistance while, polyunsaturated fatty acids (PUFA) intake had a protective effects against the obesity processes and insulin resistance. Adding PUFA or monounsaturated fatty acids (MUFA) to SFA-rich diets can reduce the total cholesterol and LDL-C (100). However, an observational study of 2128 adolescents (12-19 yr old) showed that dietary fiber intake and nutrient density are inversely associated with MetS in US adolescents while, neither SFA nor cholesterol indices were associated with MetS (101). Another long-term interventional study did not find any significant difference between a low-GI diet and low-fat diet on MetS, BMI and insulin resistance among adolescents after two years (102).

Some evidence implied that only dietary soluble fiber was associated with components of metabolic syndrome. According to Ventura et al. (96) people with no features of metabolic syndrome consumed more soluble fiber than people who had three features of metabolic syndrome. So, increasing daily consumption of soluble fiber through using one extra serving of fruit, vegetables, or legumes in the diet could reduce the risk of metabolic syndrome and metabolic health in obese children. Interestingly, the effect of dietary intake modification including sugar and fiber intake with diabetes and adiposity have shown that only increasing in the total dietary fiber and insoluble ones after two years is associated with lower visceral adipose tissue among the overweight children and adolescents (87). Therefore, small to moderate decrease in dietary whole grains have been known as good fiber sources with some benefits in weight management and prevention of metabolic syndrome. The Framingham Offspring Cohort study indicated that higher consumption of cereal fiber and whole-grain was associated with lower prevalence of metabolic syndrome (103). These findings were supported by another study (104).

Soft drinks contain relatively higher calories due to their sugar contents and are linked with obesity (105). Relationship between metabolic syndrome and soft drink consumption is reported by some studies. The findings indicated that daily soft drink consumption was associated with high prevalence of metabolic syndrome, increased waist circumference, impaired fasting glucose, higher blood pressure, hypertriglyceridemia and high LDL-C levels (106). It was postulated that limiting the consumption of soft drinks would reduce the prevalence of multiple CVD risk factors.

Dietary pattern also have an important role in weight control and could normalize the lipid profile in obese children. Healthful eating patterns among this group of population should be encouraged in order to improve their lipid profile. Parents and caregivers should be educated to substitute the consumption of fruits, vegetables, and whole grains with unhealthy snacks such as soft drinks, cookies, and crackers (107).

Even short-duration and strict diet and exercise program can help the youths to improve the metabolic syndrome components (108). Such studies suggest that lifestyle modifications improve the insulin resistance and body weight in young people with metabolic syndrome.

The biggest benefit for individuals with the metabolic syndrome can be derived from effective lifestyle interventions. Major lifestyle intervention programs involve weightloss in overweight or obese individuals, enhanced physical activity and the alteration of diet composition which contribute to dyslipidemia and impaired glucose tolerance (109). Because childhood metabolic syndrome is likely to continue into adulthood, early diagnosis may help target interventions to control future CVD risk (21). Sweetened beverages, high saturated and trans fat-containing foods should be restricted and empty calorie snacks between meals should be discouraged (95). Having diets which are rich in
fruits, vegetables, and low-fat dairy products and low salty foods and processed food products are most suitable for children and adolescents to prevent chronic non-communicable diseases notably diabetes mellitus and CVDs in their future life.

Table 1: various definitions of metabolic syndrome in children and adolescents

<table>
<thead>
<tr>
<th>Definition</th>
<th>Obesity</th>
<th>Dyslipidemia</th>
<th>HDL-cholesterol</th>
<th>blood pressure</th>
<th>fasting blood glucose</th>
<th>More explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weiss et al (40)</td>
<td>WC ≥ 75th percentile for age and sex</td>
<td>Fasting TGs ≥ fifth percentile for age and sex</td>
<td>HDL&lt; fifth percentile for age and sex</td>
<td>SBP/DBP &gt; 95th percentile for age and sex</td>
<td>FBS&lt;100mg/dL</td>
<td>3 or more of the mentioned abnormalities</td>
</tr>
<tr>
<td>Cook et al (24)</td>
<td>WC ≥ 90th percentile for age and sex</td>
<td>Fasting TGs ≥ 110mg/dL</td>
<td>HDL-C&lt;40 mg/dL for all ages and sexes</td>
<td>≥90% for age, sex, and height</td>
<td>FBS≥110mg/dL (ADA)</td>
<td>3 or more of the mentioned abnormalities</td>
</tr>
<tr>
<td>de Ferranti et al (23)</td>
<td>WC ≥ 75th percentile for age and sex</td>
<td>Fasting TGs ≥ 1.1 mmol/L (or ≥100 mg/dL)</td>
<td>HDL-C&lt;1.3 mmol/L (&lt;50mg/dL)‡</td>
<td>SBP/DBP &gt; 90th percentile for age and sex</td>
<td>FBS≥6.1 mmol/L (or ≥110mg/dL)</td>
<td>3 or more of the mentioned abnormalities</td>
</tr>
<tr>
<td>Cruz (25)</td>
<td>WC ≥ 90th percentile for age, sex and race specific</td>
<td>Fasting TGs ≥ 90th percentile for age and sex</td>
<td>HDL-C&lt; tenth percentile for age and sex</td>
<td>≥90% for age, sex, and height</td>
<td>FBS≥110mg/dL (ADA)</td>
<td>3 or more of the mentioned abnormalities</td>
</tr>
<tr>
<td>Lambert et al (26)</td>
<td>BMI ≥ 85th percentile for age and sex</td>
<td>Fasting TGs ≥ 75th percentile for age and sex</td>
<td>HDL-C&lt; 25th percentile for age and sex</td>
<td>SBP &gt;95th or 75th percentile for age and sex</td>
<td>FBS≥6.1 mmol/L</td>
<td>3 or more of the mentioned abnormalities</td>
</tr>
<tr>
<td>Rodríguez-Morán et al (110)</td>
<td>BMI ≥ 90th percentile for age and sex</td>
<td>Fasting TGs ≥ 90th percentile for age and sex</td>
<td>-</td>
<td>SBP/DBP ≥ 90th percentile for age and sex</td>
<td>FBS&gt;6.1 mmol/L</td>
<td>This definition includes a screening stage which subjects should have ≥2 of following risks: - having one or more family phenotype of HTN, obesity and T2DM, - having low or high birth weight - being obese or HTN</td>
</tr>
<tr>
<td>Seo et al (111)</td>
<td>WC ≥ 90th percentile for age and sex</td>
<td>Fasting TGs ≥ 110 mg/dL</td>
<td>HDL-C≤40 mg/dL</td>
<td>-</td>
<td>FBS≥110mg/dL</td>
<td>3 or more of the mentioned abnormalities</td>
</tr>
</tbody>
</table>

Table 2: IDF metabolic syndrome criteria for children and adolescents by age groups.

<table>
<thead>
<tr>
<th>Age groups (yr)</th>
<th>Obesity (waist circumference)</th>
<th>TG (mmol/l)</th>
<th>HDL-C (mmol/l)</th>
<th>B.P* (mmHg)</th>
<th>F.B.S* (mmol/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to &lt;10</td>
<td>≥90th percentile</td>
<td>Metabolic syndrome cannot be diagnosed, but further measurements should be made if there is a family history of metabolic syndrome, T2DM, dyslipidemia, CVD, hypertension, and/or obesity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 to &lt;16</td>
<td>≥90th percentile or adult cutoff if lower</td>
<td>≥ 1.7</td>
<td>&lt; 1.03</td>
<td>Systolic ≥130 or diastolic ≥85</td>
<td>≥5.6 T2DM or known</td>
</tr>
<tr>
<td>16+</td>
<td>Use existing IDF criteria for adults: Central obesity plus any two of the following four factors: - Raised triglycerides: ≥1.7 mmol/l - Reduced HDL-C &lt; 1.03 mmol/l in males and &lt; 1.29 mmol/l in females or specific treatment for these lipid abnormalities - Raised blood pressure: systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 - mmHg or treatment of previously diagnosed hypertension - IFG: fasting serum glucose ≥ 5.6 mmol/l or previously diagnosed T2DM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‡ except in boys aged 15 to 19 years, in whom the cut-point was 45 mg/dl
*B.P: Blood pressure; F.B.S: Fasting blood sugar; IFG: Impaired fasting glucose.

Table 3: Summary of the prevalence of the Mets in children and adolescents by different criteria

<table>
<thead>
<tr>
<th>Study</th>
<th>Country/population</th>
<th>Criteria</th>
<th>Prevalence of MetS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Csábiet al. (2000)</td>
<td>Hungary/ 8–18-y-old obese girls and boys</td>
<td>Presence of hyperinsulinemia, HTN, IGTT and dyslipidemia (high cholesterol and/or high TG and/or low HDL cholesterol)</td>
<td>8.9% in obese children. three risk factors occurred in 0.4% of controls</td>
</tr>
<tr>
<td>Cook et al. (24)</td>
<td>USA/12–19-y-old female and male</td>
<td>Modified-ATP III</td>
<td>4.2% (6.1% in males, 2.1% in females), 28.7% in overweight adolescents</td>
</tr>
<tr>
<td>Cruz et al. (25)</td>
<td>USA/8–13-y-old obese children</td>
<td>Presence of at least three of the following: abdominal obesity, low HDL cholesterol, hypertriglyceridemia, hypertension and/or impaired glucose tolerance</td>
<td>30% in obese children</td>
</tr>
<tr>
<td>Esmailzadeh et al. (112)</td>
<td>Iran /10-19-y-old overweight and at risk of overweight</td>
<td>Modified ATPIII</td>
<td>10.1%</td>
</tr>
<tr>
<td>Kelishadi et al. (113)</td>
<td>Iran /6-18-y-boy and girl</td>
<td>Modified ATPIII</td>
<td>14.1% with no difference between boys and girls where, was higher in boys</td>
</tr>
</tbody>
</table>
REFERENCES

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