ORIGINAL ARTICLE

Prevalence of Metabolic Syndrome in Children and Adolescents According to Different Diagnostic Criteria and their Correlation with Leptin and Adiponectin Levels

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ABSTRACT
The objectives of the study were to identify subjects with obesity, overweight and conditions that make up the Metabolic Syndrome (MS) in children and adolescents, as well as to determine the frequency of MS according to different criteria and to correlate them with Leptin and Adiponectin levels.

We evaluated 700 subjects between 6 and 19 years by standardized surveys, anthropometric and blood pressure measurements. In subjects with 1 or more components of MS (n: 138 -20 %), blood glucose, insulin, lipid profile, leptin and adiponectin were measured. MS was defined according to Cook, De Ferranti or Weiss criteria. A descriptive statistical analysis was made showing the mean and 95 % confidence intervals (CI). The association analysis was performed by t and chi-square tests, with a significance level of 5 %.

Based on body mass index, 14 % of subjects had obesity and 22 % had overweight. Based on waist circumference, 15 % had obesity and 6 % had overweight. There was a strong association of overweight/obesity with hypertension and to a lesser extent, with other risk factors such as HOMA index, HDL-cholesterol and triglycerides.

The prevalence of MS was 15 % according Cook, 18 % according to De Ferranti and 14 % according to Weiss. The higher percentage obtained with the De Ferranti criteria might probably be due to stricter percentiles and cut-offs. The mean value of leptin was significantly higher and the mean value of adiponectin was significantly lower in patients with MS according to the three criteria used (p <0.01).

It is necessary to establish standard criteria to characterize MS in childhood and adolescence because there is no agreement on the definition of this syndrome, as growth and development at these ages make it difficult to establish precise reference values. Rev Argent Endocrinol Metab 49:103-114, 2012.

The authors do not have conflicts of interest.

Key words: obesity, overweight, metabolic syndrome, leptin, adiponectin

INTRODUCTION
Rates of obesity have increased 2- to 4-fold in recent decades. This trend is of particular concern because overweight in childhood and adolescence has been associated with other cardiovascular risk factors and early atherosclerotic lesions, as well as persistence or increased risk of adult obesity and obesity-related morbidities and mortality in adulthood (1).

Obesity is a chronic, complex and multifactor disease that often begins in childhood or adolescence. It is the most common chronic nutritional disease in developed countries, with a global prevalence of 16% in ages between 6 and 12 years. Nader et al. showed, in the year 2006, that children who were obese during the preschool period were 5 times as likely to be overweight at adolescence (2). Forty percent of 7-year-old children and about 70% of adolescents with obesity maintain this condition in adulthood. Morbidity and mortality rates are higher in adults that have been obese during adolescence, even if they have achieved normal weights later in life (3).

The prevalence of obesity in children ranges between 12 and 22% in USA (4), it is 13.9% in Spain (5) and in Latin American countries such as Costa Rica and Mexico it
reaches 26.2% \(^{(6)}\) and 23.5% \(^{(7)}\), respectively. If overweight and obesity are grouped together, in the USA the prevalence reaches 33% of children aged 2 through 19 years old \(^{(6)}\). In Argentina, the prevalence of both conditions in childhood is similar to that of the USA\(^{(8,9,10)}\).

Furthermore, overweight and obesity favor complications and comorbidities that make up the concept of metabolic syndrome (MS) which, though initially reported in adults, it is recognized that some of its components are already detected in childhood \(^{(11)}\).

MS constitutes a group of metabolic abnormalities clustered in an individual at a higher frequency than expected at random. It is associated with an increased risk of cardiovascular disease and type 2 diabetes (when this condition is not already a component of the syndrome), which in children and adolescents occur earlier in life \(^{(12-14)}\). One of the pathophysiologic links would be insulin resistance (although not always apparent). The components of the MS include:

1 – **Central or abdominal obesity**, with marked discrepancies in cut-off values used to classify anthropometric variables and indicators.

2 – **Alterations in glucose homeostasis**, represented by impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) or type 2 diabetes mellitus (T2DM).

3 – **Hypertension** (HBP), with strong agreement in the use of the same percentiles (Pc) to evaluate blood pressure in children and adolescents \(^{(15-18)}\).

4 – **Dyslipidemia**, resulting from increased triglycerides (TG) and decreased HDL cholesterol (HDL-C) in relation to gender and age, considered as indexes of robust relationship with insulin resistance and body fat mass, particularly abdominal fat \(^{(15,19,20)}\).

Although LDL-c (LDL-cholesterol) is not part of the diagnostic criteria for MS in obese children and adolescents, it is emphasized that routine measurement of LDL-c identifies a potent cardiovascular disease (CVD) and atherosclerotic disease risk factor early in life \(^{(21,22)}\).

Puberty is a critical period for the development of MS, because of physiological resistance to insulin, which is accompanied by an increase in body fat percentage, changes in blood pressure and serum lipids, accentuated by sedentary lifestyle and overeating. This transitional stage does not allow for unified criteria in the definition of the MS and justifies increased rates when stricter cutoff values are used in pediatric populations \(^{(14,15,23)}\). As in adults, there are differences for defining MS in children and adolescents (Table 1) and modified ATP III \(^{(24)}\), WHO \(^{(25)}\) and EGIR (European Group for the Study of Insulin Resistance) \(^{(26)}\) guidelines are used.

Obesity is linked to insulin resistance, although the molecular mechanisms that support this link have not been clearly defined \(^{(34)}\). For a long time, adipose tissue has been considered only as a reservoir of lipids, but today it is recognized as an active participant in body energy homeostasis, with effects on insulin sensitivity and lipid and carbohydrate metabolism \(^{(35,36)}\). Furthermore, adipocytes produce signaling molecules by secreting adipocytokines such as the tumor necrosis factor-α (TNF-α), leptin, resistin, adiponectin and plasminogen activator inhibitor-1 (PAI-1), among others \(^{(37,38)}\).

Leptin regulates fat deposits by acting on appetite and thermogenesis \(^{(39)}\), with levels that decrease in animal models but increase in human subjects in direct proportion to the degree of obesity \(^{(40,41)}\). Fasting blood insulin correlates with increased blood leptin in subjects with insulin resistance \(^{(42,43)}\), but it is not known if insulin influences on leptin regulation \(^{(44,45)}\).

Adiponectin is an adipocyte-derived protein. It is an antiatherogenic, antidiabetic and anti-inflammatory protein involved in carbohydrate metabolism by increased insulin
sensitivity and peripheral glucose uptake, and in lipid metabolism, as it promotes fat acids oxidation and lipoprotein lipase activity \(^{(47, 48)}\). Serum concentration of adiponectin decreased in obesity, dyslipidemia, CVD and T2DM \(^{(49, 50)}\).

Within a complex scenario, this study seeks to detect the presence of obesity, overweight and conditions that make up the MS in a population of children and adolescents. In addition, we intend to establish the rate of MS according to different criteria in pediatrics and to compare leptin and adiponectin values on the basis of such criteria.

**TABLE I.** Population studies using different criteria for the definition of MS \(^{(20)}\)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Population studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook et al (^{(16)})</td>
<td>NHANES Third National</td>
</tr>
<tr>
<td>Duncan et al (^{(27)})</td>
<td>Health and Nutrition Examination Survey</td>
</tr>
<tr>
<td>Cruz and Goran (^{(28)})</td>
<td>SOLAR Diabetes Project – Study of Latinos at Risk; BP, blood pressure</td>
</tr>
<tr>
<td>de Ferranti et al (^{(29)})</td>
<td>NHANES</td>
</tr>
<tr>
<td>Lambert et al. 3 components (^{(30)})</td>
<td>Quebec Study</td>
</tr>
<tr>
<td>Weiss et al (^{(14)})</td>
<td>Cincinnati</td>
</tr>
<tr>
<td>Freedman et al (^{(31)})</td>
<td>Bolalusa Heart Study</td>
</tr>
<tr>
<td>Lambert et al 2 components (^{(30)})</td>
<td>Quebec Study</td>
</tr>
<tr>
<td>Morrison et al (^{(32)})</td>
<td>NHLBI, National Heart, Lung, and Blood Institute</td>
</tr>
<tr>
<td>Adult EGIR modified (^{(33)})</td>
<td>EGIR, European Group for the Study of Insulin Resistance</td>
</tr>
</tbody>
</table>

**MATERIAL AND METHODS**

We evaluated 700 schoolchildren with an age range between 6 and 19 years old; 385 (55\%) were males and 315 (45\%) were females. Age distribution was: 11\% were 6 to less than 10 years old, 33\% were 10 to less than 13 years old and 56\% were 13 or older.

Surveys, anthropometric measurements and blood pressure recordings were performed.

The children’s parents or guardians signed an informed consent.

The variables analyzed included: gender, age, weight, height, body mass index (BMI), waist circumference, blood pressure and their respective percentiles (Pc), according to gender and age. Furthermore, biochemical measurements were performed, including: blood glucose, blood insulin, leptin, adiponectin and lipid profile with total cholesterol (TC), HDL-c, LDL-c and TG measurements.

Children were weighed barefoot on a CAM type platform or beam scale with a capacity of 150 kg, and their weight was fully recorded in kilograms and grams.

Standing height was measured with a Prader stadiometer.

Body mass index (BMI) was calculated as weight/height\(^2\) and Pcs were assessed according to gender and age.

Waist circumference was measured with a flexible, non-extensible, metal measuring tape with millimeters which is no more than 5 mm wide, at a midpoint between the
lower costal margin and the iliac crest, in standing position, after breathing out normally. Two measurements were performed and the mean was calculated \(^{(2)}\).

Blood pressure was measured with an aneroid sphygmomanometer with subjects in the sitting position and both feet flat on the floor. Two measurements were taken after a 5-minute rest and the average was recorded. The auscultatory-palpatory method was used \(^{(51)}\).

A multidisciplinary team of experts participating in the study team designed and validated the survey, which had the following features: it was an open, semi-structured, personalized survey based on direct dialogue with study subjects, who were interviewed about each of the items (demographic, socioeconomic, family history of T2DM and CVD, psycho-emotional and quality of life), with an approximate duration of 10 minutes for recording data.

Based on these records, the presence of MS components was determined according to the criteria proposed for children and adolescents by Cook \(^{(15)}\), De Ferranti \(^{(23)}\) and Weiss \(^{(25)}\) (Table 2).

**TABLE II. Criteria for the diagnosis of MS in children and adolescents**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of components</th>
<th>Adiposity</th>
<th>Blood pressure by age, gender and height</th>
<th>Serum lipids mg/dL</th>
<th>Blood glucose mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook et al (^{(16)})</td>
<td>≥3</td>
<td>WC ≥ P 90</td>
<td>≥ P 90</td>
<td>TG ≥ 110</td>
<td>Fasting ≥ 110</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HDL-c ≤40</td>
<td></td>
</tr>
<tr>
<td>de Ferranti et al (^{(23)})</td>
<td>≥3</td>
<td>WC ≥ P 75</td>
<td>≥ P 90</td>
<td>TG ≥ 100</td>
<td>Fasting ≥ 110</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HDL-c ≤50</td>
<td></td>
</tr>
<tr>
<td>Weiss et al (^{(15)})</td>
<td>≥3</td>
<td>BMI ≥ P 97</td>
<td>≥ P 95</td>
<td>TG ≥ 110</td>
<td>Fasting ≥ 110</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HDL-c ≤40</td>
<td>OGTT: at 2 h ≥140</td>
</tr>
</tbody>
</table>


MS components were initially defined by Cook criteria. For determining the presence of obesity and overweight, apart from waist circumference with a Pc ≥ 90, a BMI with Pc ≥ 97 was used, according to Weiss \(^{(14)}\).

In subjects with 1 or more components (n: 138, 20%) blood samples were collected by venous puncture under fasting conditions and blood glucose levels and lipid profile were measured with ROCHE methodology (HITACHI autoanalyzer).

The following analytes were also measured:

1) Insulin: with Axsym assay based on microparticle enzyme immunoassay (MEIA), with no cross-reactivity with proinsulin.

2) Leptin: using a two-site coated-tube radioimmunoassay (IRMA) with a DSL-23100 kit

3) Adiponectin: LINCO Research radioimmunoassay was used.

Impaired fasting glucose (IFG) was considered when fasting glucose ranged between 110 and 125 mg/dL. Impaired glucose tolerance was diagnosed when after the glucose
load (Oral Glucose Tolerance Test, OGTT), glucose levels ranged between 140 and 199 mg/dL at 2 hours.

The HOMA index was calculated as an estimate of insulin resistance\(^ {52, 53} \): baseline blood glucose (mmol/l) x baseline insulin (microIU/ml)/22.5 = with cutoff value: in 2.4.

A descriptive analysis was performed presenting summary measurements and 95% confidence intervals (CIs). The association analysis was performed using the T test and the chi square test with a significance level of 5%.

**RESULTS**

Based on the BMI, 14% of the population studied was found to have obesity and 22% was found to have overweight; with both totaling 36%. Based on waist circumference, 15% were obese, 6% had overweight and both totaled 21% (Table 3) (Figures 1 and 2).

When determining the presence of MS based on different criteria, 21 subjects had MS (15%, with 95% CI: 10-22%) according to Cook, 25 subjects had MS (18%, with 95%CI: 11-25%) according to De Ferranti and 19 subjects with MS (14%, with 95% CI: 8-21%) according to Weiss (Table 4).

When evaluating components of MS, 7% of the subjects had hypertension with a significant association with obesity and overweight (\( p < 0.0001 \)), as among subjects with normal blood pressure, 12% were obese and 18% had overweight, while among subjects with hypertension, 41% were obese and 44% had overweight (Figure 3).

The association between subjects with overweight or obesity and hypertension was highly significant (\( p < 0.0001 \)). There was a less significant association with the HOMA index (\( p = 0.862 \)), in HDL-c (\( p = 0.19 \)) and with TG (\( p = 0.61 \)).

When discriminating the number of children and adolescents with lab values outside the reference range, the HOMA index above 2.4 had 45% abnormality and represented the highest proportion of individuals, followed by dyslipidemia, with decreased HDL-c (31%) and increased TG (30%). Impaired hydrocarbon metabolism was only 1.6% as impaired fasting glucose (Figure 4).

The frequency of HOMA index above 2.4 was determined. Fifty-two percent of obese subjects and 46% of subjects with overweight had abnormal values (Figure 5).

**TABLE III.** Children and adolescents with obesity or overweight

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Obesity</th>
<th>%</th>
<th>Overweight</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (Figure 1)</td>
<td>98</td>
<td>14</td>
<td>154</td>
<td>22</td>
</tr>
<tr>
<td>WC (Figure 2)</td>
<td>35</td>
<td>15</td>
<td>42</td>
<td>6</td>
</tr>
</tbody>
</table>

*BMI: body mass index – WC: waist circumference*

Sixty-seven percent of obese subjects and 76% of children and adolescents with overweight had values of HDL-c below 40 mg/dl (Figure 6).

Forty-four percent of subjects with obesity and 32% of subjects with overweight had values of TG above 110 mg/dl (Figure 7).

The leptin mean was significantly higher and the adiponectin mean was significantly lower in subjects with a diagnosis of MS by any of the three criteria used (\( p < 0.01 \)) (Table 5).
Figure 1. Proportion of children and adolescents with obesity or overweight according to BMI.

Referencias de la figura:
Obeso: obese
Sobrepeso: overweight
IMC: BMI
Normal: normal
Bajo peso: low weight

Figure 2. Proportion of children and adolescents with obesity or overweight according to waist circumference.

Referencias de la figura:
Porcentaje de pacientes: percentage of patients
Normal: normal
Sobrepeso: overweight
Circunferencia de cintura: waist circumference
Obesidad: obesity
Figure 3. Association between hypertension, obesity and overweight.

Referencias de la figura:
Normal: normal
Presión arterial: blood pressure
Alta: high
Normopeso: normal weight
Sobrepeso: overweight
Obeso: obese

TABLE IV. Percentages of children and adolescents with Metabolic Syndrome according to three authors’ criteria

<table>
<thead>
<tr>
<th>Authors</th>
<th>Metabolic Syndrome</th>
<th>No. of subjects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook et al</td>
<td></td>
<td>21</td>
<td>15 (CI 95 10-22)</td>
</tr>
<tr>
<td>de Ferranti et al</td>
<td></td>
<td>25</td>
<td>18 (CI 95 11-25)</td>
</tr>
<tr>
<td>Weiss et al</td>
<td></td>
<td>19</td>
<td>14 (CI 95 8-21)</td>
</tr>
</tbody>
</table>

Figure 4. Percentage of patients with abnormal values (outside the reference range) in complementary labs.

Referencias de la figura:
c-HDL: HDL-c
trigliceridos: triglycerides
leptina: leptin
adiponectina: adiponectin
glucosa: glucose
Cambiar comas por puntos en los decimales
### TABLE V. Relationship between MS by different criteria and Leptin and Adiponectin values (n = 138)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Metabolic Syndrome</th>
<th>Leptin ng/ml</th>
<th>Adiponectin ng/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook</td>
<td>Present (n = 21)</td>
<td>14.1</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>Absent (n = 117)</td>
<td>10.4</td>
<td>12.4</td>
</tr>
<tr>
<td>de Ferranti</td>
<td>Present (n = 25)</td>
<td>14.6</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Absent (n = 113)</td>
<td>10.4</td>
<td>12.3</td>
</tr>
<tr>
<td>Weiss</td>
<td>Present (n = 19)</td>
<td>15.3</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Absent (n = 119)</td>
<td>10.2</td>
<td>12.5</td>
</tr>
</tbody>
</table>

**DISCUSSION**

It is estimated that the likelihood of persistence of obesity from childhood or adolescence into adulthood is high, which is of particular concern when accompanied by co-morbidities such as hypertension, dyslipidemia or impaired glucose tolerance. Childhood obesity is a predictive factor for MS in adults and the predictive potential increases if obesity is associated with co-morbidities. To this we should add the time of evolution of these conditions until middle age, with a long period of exposure to conditions that lead to early cardiovascular disease or diabetes, with severe consequences on life expectancy and quality of life. Hence the importance of identifying the components of MS in childhood and adolescence with the aim of intervening to prevent (54-56).

There are strong controversies over the definition of MS in adults, although there is agreement as regards the components (central obesity, IFG/IGT or T2DM, hypertension and dyslipidemia) but not on reference or cut-off values for each condition or on the strategy about how many and which components should be included to define the syndrome. There is also debate as to whether insulin resistance is the pathophysiologic factor (57-69). This is further accentuated in pediatrics, where different criteria have been reported to define components and reference values (Table 2) because no classification or cut-off values have been validated in children and adolescents; therefore, definitions are partly derived from MS concepts for adults (14, 15, 30).

Thus, this study was intended first to identify subjects with obesity, overweight and conditions that constitute MS in a population of children and adolescents, then to determine the frequency of MS according to different criteria and to compare the values of leptin and adiponectin, two hormones with different behavior in obesity and insulin resistance states. In agreement with IDF(4), children under 6 were not included, because there is not enough data available on this group.

In the population sample studied, the rate of overweight and obesity was higher when calculated by BMI (36%) than when determined by waist circumference (21%) (Table 3, Figures 1 and 2). When discriminating figures by BMI, 22% of subjects were found to have overweight and 14% had obesity. Results were partly similar to those published by Kovalskys, Bay et al in 2003 on BMI in the Argentine population in various regions, where the rate of overweight was found to be 20.8%. Instead, in this study, obesity rates exceeded the 5.4% reported by Kovalskys, Bay et al (60). Waist circumference results are in agreement with those reported by NHANES-III for children in the US, with a prevalence of 22% (46). While the rate of obesity by BMI was similar to that found in the Spanish enKid study, where it was 15.9% in the group aged 6 to 9, the proportion
of overweight was higher, being 22% vs. the 14.5% rate representing the whole Spanish community (61).

In agreement with other authors, different components of MS in children and adolescents have been detected: abdominal obesity, dyslipidemia (a decline in HDL-c and an increase in TG), hypertension and a high percentage of individuals with an elevated HOMA index (Table 4).

The percentage of 7% of hypertension found in this study exceeds the prevalence of 4.3% of hypertension and 1.9% of prehypertension in children and 1.7% in adolescents in an Argentine rural population (62), and also the 1 to 3.5% found in a comparable population of subjects under 16 years old (63), but it was lower than the 9.4% rate detected by Szer, Kovalskys et al in schoolchildren aged 6 to 9 years old (in Santa Teresita, Argentina) (64). Furthermore, a strong association was found between obesity and overweight, and hypertension (p < 0.0001) in agreement with other studies (63, 65, 66) (Figure 3).

Hypertension is being increasingly diagnosed in children, and within the context of other risk factors, its potential cardiovascular risk increases. It is still difficult to compare the rate of hypertension in pediatric populations because there are great discrepancies as regards methodology, ethnicity, age and lifestyle in reports, but there is a consistent opinion about the difference in hypertension rates between children with normal weight and children with overweight/obesity and particularly, about the high association with central obesity in childhood (63).

The percentage of children and adolescents with MS varied moderately according to the criterion used (Table 4). Based on Weiss criteria, 14% of subjects were found to have MS; based on Cook criteria, the proportion was 15%, and when following de Ferranti, the rate of subjects with MS was 18%. It is hypothesized that the higher rate found based on de Ferranti criteria would be due to stricter Pc and cut-off values.

The study includes obese children and adolescents with one or more components of MS, which makes comparison with prevalence studies difficult and shows a higher proportion of affected subjects than that reported in adolescents under the ATP III criteria in US (12%) (67), or by the NHANES III based on modified ATP III criteria for adolescents (12 to 19 years old) with 10% or a recent study where the two criteria are used adjusted for age and gender to adolescents, being 7.6% under the ATP III criteria and 9.6% under the IDF (International Diabetes Federation) criteria, values which are twice those of the previous decade (69).

Elevated HOMA index was the most common alteration found in complementary studies (Figures 4 and 5). In agreement with studies published by Hirschler, Jadzinsky et al (70), insulin resistance estimated by HOMA index in obese children and adolescents was found to be associated with MS components. The HOMA index is acceptable as a simple and economical method for epidemiological research, but its use in the clinical setting remains debatable. It has been compared and validated against the gold standard method --the glucose clamp technique-- and against the insulin tolerance test (71, 72) and it remains as the surrogate procedure most widely used in pediatric populations. It has a high correlation with fasting insulin because blood glucose has narrow ranges in (even obese) children, while blood insulin shows a strong physiological variability (73, 74).

Based on these evaluations, results are consistent with those reported by other authors, as insulin resistance was found to be particularly greater in subjects with central adiposity (increased visceral adipose tissue) (75).
Obese children and adolescents were found to have early alterations in lipid profile, typical of MS, particularly high blood triglycerides and decreased HDL-c, consistent with Cook's (15) findings (Figures 6 and 7). Instead, alterations in blood glucose levels were less common. Nevertheless, impaired fasting glucose and/or impaired glucose tolerance may appear early in childhood obesity and be a prelude to diabetes. It is a matter of growing concern in other parts of the world.

Additionally, similarities were found with the study conducted by Hirschler et al, who reported a high association between excess fat around the trunk and the presence of metabolic alterations in obese boys and girls in Argentina. High waist circumference values adjusted for gender and age were associated with increased insulin resistance, decreased HDL-c, elevated TG and limited glucose impairments. These authors estimated that waist circumference is a good indicator of metabolic disorders during the growth period (76, 77).

Results confirm that children and adolescents with obesity or overweight had higher leptin values than subjects with normal weight (p = 0.001) (Table 5). This has been reported by various authors, as obese subjects have higher serum leptin levels than subjects with normal weight from the newborn period to elderly age (78-80). In agreement with several authors, it is demonstrated that leptin positively correlates with adiposity (81-84). Furthermore, elevated leptin is considered as a risk factor for CVD and it is thought that it might even be the most sensitive marker to predict the accumulation of risk factors of CVD (85) and the presence of MS in schoolchildren, as leptin and adiponectin sharply worsen when any component of the MS manifests in a child (86).

In the studied population adiponectin values below 5 ng/ml were found only in obese subjects and in subjects with overweight, but not in children or adolescents with normal weight. The difference in adiponectin means between subjects with MS and subjects without MS (under any classification) were studied (Table 5). Results are comparable to those found in a study of 230 subjects of both genders with an age range between 10 and 19 years old, without diabetes, where adiponectin levels were found to have an inverse relationship with BMI, body fat percentage, insulin concentration, TG levels and a direct relationship with HDL-c levels (87,88).

Investigators consider that adiponectin is not only a maker of central adiposity, but in the case of girls, it contributes to metabolic impairment as there is a complex regulation of secretion and an age- and gender-dependent adiponectin clearance (53). Findings in the pediatric population regarding the relationship between adiponectin and metabolic

Figure 5. Proportional distribution of the HOMA index in children and adolescents with obesity or overweight. HI; Homa index

Referencias de la figura:
IH mayor de 2.4: HI above 2.4
IH hasta 2.4: HI up to 2.4
Obeso: obese
Sobrepeso: overweight
markers have been consistent in different racial and ethnic groups. Adiponectin would have insulin-sensitizing effects and provide cardiovascular protection. Several population studies show that biological inflammation markers predict CVD. Thus, increased serum levels of reactive C protein (RCP), interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α) and leptin and decreased levels of adiponectin and interleukin-10 (IL-10) have the highest correlation with alterations constituting the MS.

Figure 6. Proportional distribution of HDL-c in children and adolescents with obesity or overweight.

Referencias de la figura:
HDL 40 y más: HDL 40 and above
HDL menor de 40: HDL below 40
Obeso: obese
Sobrepeso: overweight

Figure 7. Association between TG and obesity – overweight

Referencias de la figura:
TG más de 110 mg/dL: TG above 110 mg/dL
TG hasta 110 mg/dL: TG up to 110 mg/dL
Obeso: obese
Sobrepeso: overweight

We conclude that there are no marked differences in the number of subjects with MS detected in childhood and adolescence based on definitions provided by Cook, Weiss or de Ferranti, although the latter appears to determine a higher rate, probably as a consequence of stricter percentiles and cut-off values (although sensitivity and specificity have not been determined). The number of obese children with hypertension as well as the rate of HOMA index alteration were significant. The leptin mean was significantly higher and the adiponectin mean was significantly lower in patients with a diagnosis of MS according to the three classifications used.

Efforts are needed to establish unified diagnostic criteria for MS in childhood and adolescence. In the meanwhile, pediatricians should actively screen obese or
overweight children and adolescents for the presence of components of MS and intervene in an early manner (particularly focusing on lowering body weight) to avoid or delay the appearance of co-morbidities (hypertension, dyslipidemia, impaired glucose tolerance or type 2 diabetes) that are highly threatening for health, at all ages.

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