

CAROTID INTIMA MEDIA THICKNESS IN OBESE CHILDREN

Grosor de íntima-media carotídea en niños con obesidad

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Summary

Introduction: Childhood obesity has been a rising problem since the 70s. Currently 1 of 3 children and teenagers are overweight. Childhood obesity is accompanied by serious health problems such as type 2 diabetes, fatty liver, psychological problems and cardiovascular disease which requires lifelong treatment. Carotid intima media thickness (CIMT) measured on both arteries through ultrasound is an important predictive measure of cardiovascular events which result from atherosclerotic disease. **Objective:** To determine the relationship between CIMT and obesity in a children population resident in Bucaramanga. **Methods:** Transversal study which included children between the ages of 7 and 18, either as ambulatory non-complicated patients or accompanying children of patients from the radiology department of an institution. CIMT was quantified, anthropometric measures were taken and parents were asked about cardiovascular family history. **Results:** 103 patients were recruited, 18.6% were obese and 27.5% were overweight. Significant differences were found in the mean CIMT between normal children (0.37 ± 0.06) and obese (0.41 ± 0.07) and the left CIMT between the same groups ((0.38 ± 0.08) vs. (0.43 ± 0.07)) with a positive correlation between CIMT and abdominal perimeter with a Spearman Rho Coefficient of 0.2462 ($p: 0.018$). **Conclusions:** There is a relationship between CIMT and obesity in children from our population and at the same time, a direct relation between CIMT and abdominal perimeter. These variables of easy measurement allow identify children at higher cardiovascular risk and eventually diminish the impact of cardiovascular disease in the medium or long term.

Resumen

Introducción: La obesidad infantil es un problema en aumento desde los años setenta, actualmente uno de cada tres niños y adolescentes tiene sobrepeso, se acompaña de serios problemas de salud como la diabetes *mellitus 2*, hígado graso, problemas psicológicos y enfermedades cardiovasculares que requieren tratamiento de por vida. El grosor de íntima-media carotídea (GIMC) medido en arterias carótidas por medio de ultrasonido es un importante predictor de eventos secundarios a la enfermedad aterosclerótica. **Objetivo:** Determinar la relación entre el GIMC y la obesidad en una población de niños residentes en Bucaramanga (Colombia). **Métodos:** Estudio transversal que incluyó niños entre 7 y 18 años de edad que asistieron como pacientes ambulatorios no complicados o acompañantes de pacientes del servicio de radiología de una institución. Se cuantificó el GIMC, se tomaron medidas antropométricas y se interrogó sobre antecedentes familiares cardiovasculares. **Resultados:** Se reclutaron 103 pacientes, 18,6 % obesos y 27,5 % con sobrepeso. Se encontraron diferencias significativas en el GIMC promedio entre sujetos normales ($0,37 \pm 0,06$) y obesos ($0,41 \pm 0,07$) y en el GIMC izquierdo entre los mismos grupos ($[0,38 \pm 0,08]$ vs. $[0,43 \pm 0,07]$), con una correlación positiva entre el GIMC y el perímetro abdominal con un ρ de Spearman de 0,2462 ($p = 0,018$). **Conclusiones:** Existe relación entre el GIMC y la obesidad en niños de la población estudiada y, a su vez, una relación directa entre el GIMC y el PA. Estas variables permiten identificar niños con mayor riesgo para disminuir el impacto de la enfermedad.



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Introduction

Obesity in children is a growing concern since the seventies when for the first time, a progressive increase in children's weight of all social strata, race or ethnicity in the United States was observed. Currently one in every three children and adolescents is overweight, with a body mass index (BMI) in the 85 to 95 percentile for their age and sex. In Santander, Colombia, the overweight rate in children between the ages of 5 to 17 is of 13.1% and obesity in the same age range is of 5.7% (2).

Currently there are serious health problems related to excess weight and obesity, such as diabetes mellitus 2 (DM2) whose incidence has risen in the last two decades among adolescents of black and Hispanic descent. Since 1980, the connection of obesity with liver fat infiltration has been described, with a positive finding in one of every three children with obesity. Recently, psychological problems have been added, such as anxiety, depression and eating disorders as well as academic instability, among others.

The already known complications of obesity can turn into conditions that require lifetime treatment, mainly due to coronary disease, renal failure, DM2 and hepatic steatosis that can progress to hepatitis and with a low probability of cirrhosis. According to some authors, child obesity can decrease life expectancy in the United States between 2 to 5 years by mid-century, a similar effect to that of all cancers combined (3).

Atherosclerotic disease (AD) is one of the main factors of cardiovascular risk in adults, being responsible for 25% of ischemic cerebrovascular accidents (4) and a great majority of acute myocardial infarcts (AMI) and episodes of sudden death (5,6). Likewise, a great percentage of apparently healthy individuals with atherosclerosis die without previous symptoms (4). Even though AD has been well documented in adults, early pathological vascular changes have also been described in children and infants, even in developing fetuses (7). This changes could be accelerated due to some risk factors (8), such as obesity (9).

The mortality rate due to cardiovascular disease has decreased in developed countries. However, in developing countries the complete opposite occurs (10,11). In Colombia the mortality rate due to cardiovascular disease in subjects between 20 to 84 years of age has increased from 58.5 per 1,000,000 subjects in 1980 to 103.2 in 1996 (12). This epidemic of cardiovascular diseases in the third world has postulated the presence of regional differences in its etiopathology, which are associated to socioeconomic and dietary factors (13).

On the other hand, it has been observed that the increase in the incidence of obesity is not exclusive to the adult population. In the United States the overweight and obesity rates in children has increased in the last 20 years, where the Hispanic and Afro-American children are the most affected with an excess weight of 120% over a period of 12 years, in comparison with an increase of 50% in Caucasian children (14). This rapid increase in excess weight and obesity in children has been accompanied by hypertension (14), dyslipidemia (15) and diabetes type 2 (16), diseases believed to be mostly exclusive to adults. Likewise, a strong relationship has been demonstrated between early development of atherosclerosis, obesity and cardiovascular disease in children and adolescents (17). Even

though some associated risk factors associated to this relationship have been described, the agents that influence in the early development of AD in children are still unknown (18).

The thickness of the carotid intima-media (CIMT), measured in the carotid arteries through ultrasound has been associated with known cardiovascular risk factors, for which it is considered an important predictor of secondary events to AD, an excellent marker of preclinical atherosclerosis and an independent risk factor for AD (19,20). This measurement is quickly performed, is of low cost and non-invasive, besides counting with an excellent inter-observer variability (21).

Studies done in developed countries have demonstrated that obese children present higher values in the CIMT and, at the same time, have more cardiovascular complications throughout their lives (17,22-24). Because of this, preventive strategies to reduce cardiovascular risk in young adults have been developed (17). Even though this relationship has been informed in several descriptive and prospective studies, and under different epidemic proposals, there are no statistics that shed light into the relationship between the degree of obesity and CIMT among children of the studied population.

The objective of this study is to determine the relationship between CIMT and obesity in a population of resident children in the metropolitan area of Bucaramanga.

Methods

A transversal study was designed that included children ages between 7 and 18 that assisted as ambulatory patients, without complications nor cardiovascular pathologies, or children accompanying patients, between June 2010 and February 2011.

All patients were recruited in a consecutive fashion in the Radiology and Diagnostic Imaging Department of the Clínica Carlos Ardila Lulle. None had a history of personal cardiovascular disease or an important disease.

Informed consent was obtained for each patient and, if the patients were minors, that of the parents or appropriate guardian. Next an interview for personal and familial risk factors was done, mainly cardiovascular history and medicine consumption. After the interview anthropometric measurements were taken such as BMI (weight [kg]/length²) (25,26), abdominal perimeter (AP), blood pressure, cardiac frequency and finally the CIMT, which was quantified by means of an ultrasound scan. The overweight and obesity diagnosis was determined by cut points in the BMI, established by the World Health Organization (WHO) for children (27).

Carotid intima-media thickness quantification

For the CIMT measurement, patients were set in supine position with the neck extended. All measurements were performed with a 7.5 MHz high frequency linear transducer, in a Xario Toshiba equipment. Both carotid arteries were evaluated to obtain the values in millimetres of the posterior wall of the artery, 2 cm from the carotid bifurcation along the longitudinal axis (figure 1). Both values were added and averaged. The AP measurement was taken with a standard metric tape in the intermediate point between the costal arch and the iliac crest.

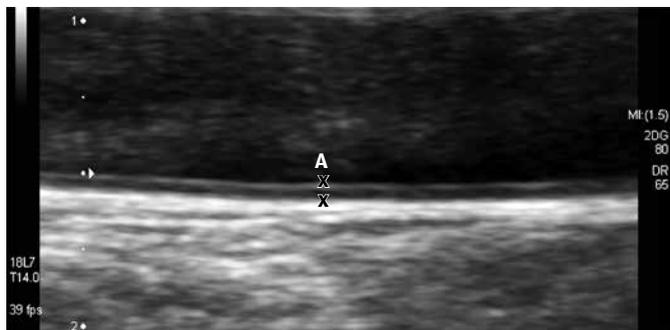


Figure 1. Image in the longitudinal plane of the common carotid artery proximal to the bifurcation. The measurement in the posterior wall corresponds to the intima-media thickness.

Statistical analysis

All information was stored in a database with the software Epi-Info 2000. It was typed in two independent archives, which were posteriorly compared to detect typing errors. For the statistical analysis, Stata version 9.2 software was used.

Descriptive: All quantitative variables were submitted to hypothesis tests to determine if they presented a normal behaviour. According to these results, variables were described through central tendency measurements (means, median) and dispersion measurements (standard deviation and interquartile ranges). Furthermore, they were grouped according to their distribution and frequency tables or histograms were done, depending on each case.

Qualitative variables were described as percentages, with their respective confidence intervals. Likewise, frequency tables and bar or pie plots were done depending on each case.

Bivariate: Hypothesis testing was performed to measure differences of the behaviour of the CIMT values between obese and non-obese. Likewise, hypothesis testing to measure differences of other variables was performed, such as: AP, blood pressure, cardiac frequency and cardiovascular personal and family medical history between obese and non-obese population.

The variables that showed a normal distribution were evaluated with the different statistical tests depending upon the nature of the variable: χ^2 or Fisher's exact test for qualitative variables, and for quantitative variables a Student's t test and variance analysis were employed. For variables that showed a non-normal distribution, statistical tests such as Kruskal Wallis or the most adequate for establishing differences were used. A $p < 0.05$ value was established as statistically significant.

Additionally the average CIMT correlation and the anthropometric measurement values were assessed. A multivariate analysis was also performed, through a linear regression with the CIMT as the output variable and the different anthropometric measurement variables and blood pressure as explanatory variables, adjusting the results by sex and family medical history.

Results

103 patients were recruited between June 2010 and February 2011 in a consecutive manner in the Radiology and Diagnostic Imaging Service of the centro médico Carlos Ardila Lulle, of which 51.5% were men ($n=53$) and 48.5% were women ($n=50$). The age average for both

sexes was of 11.8 ± 2.3 years (min. = 7,7 - max. = 17.2). The average age in the women group was of 12.09 ± 2.5 years and in the men group of 11.7 ± 2.1 years ($p=0.508$).

41% of the patients presented as a minimum one personal precedent where rhinitis is the precedent with the highest prevalence (26.8%). Medicine consumption of frequent or recent consumption among the studied population was low. Cetrizine, Ketotifene, Ritalin and Salbutamol each share a 1%. 87.4% of the patients had some family precedent, headed by HBP (64%), followed by DM2 (45.6%), dyslipidemia (40%), migraine (36.7%) and obesity (23.3%).

The clinical data of the patients and the anthropometric measurements are summarized in table 1 along with the mean values of the CIM.

Table 1. Anthropometric measurements

Variable	Average
TAS mm Hg ($n = 97$)	108.2 ± 12.1
TAD mm Hg ($n = 97$)	72.1 ± 9.8
FC ($n = 86$)	83.3 ± 15.1
AP boys	71.9 ± 9.5
AP girls	69.8 ± 9.7
Size m ($n = 102$)	1.48 ± 0.13
Weight kg ($n = 103$)	45.3 ± 12.6
CMI kg/m^2 ($n = 102$)	20.2 ± 3.6
CMI girls ($n = 50$)	20.4 ± 4.2
CMI boys ($n = 52$)	20.1 ± 3.0

According to the BMI, 27.5% of the patients were classified as overweight and an 18.6% as obese. Of the study group no patient was found in the low weight range.

If values are divided by sex, obesity was found to be 16% for women and 21.2% for men (table 2).

Table 2. Normality, overweight and obesity values according to BMI by sex

BMI	Women (%)	Men (%)
Normal	58	50
Overweight	26	28.8
Obesity	16	21.2

When comparing the BMI values with previously described variables, significant differences were found for diastolic blood pressure, cardiac frequency and AP between normal vs. overweight/obese patients. The AP in healthy patients was 64.8 ± 6.3 , in overweight patients 74.1 ± 5.2 and in obese patients 81.7 ± 9 ($p = 0.0001$). These differences and non-significant values are shown in table 3.

Table 3. BMI classification by age

	Normal (-2 to +1 SD)	Overweight (> +1 to +2 SD)	Obesity (> +2 SD)	p
Personal precedents (%)	(n = 53) 43.4	(n = 28) 32.1	(n = 18) 44.4	0.57†
Family precedents (%)	(n = 55) 85.5	(n = 28) 82.1	(n = 19) 100	0.17†
Systolic blood pressure (mmHg) §	(n = 50) 106.7 ± 10.0	(n = 27) 109.1 ± 17.0	(n = 19) 111 ± 8.9	0.11* 0.30 ‡ 0.11 ¶
Diastolic blood pressure (mmHg) §	(n = 50) 70.2 ± 8.2	(n = 27) 75.8 ± 11.4	(n = 19) 72.1 ± 10.6	0.045* 0.015 ‡ 0.45 ¶
Cardiac frequency (bpm) §	(n = 44) 83.0 ± 12.9	(n = 25) 85.8 ± 14.2	(n = 16) 78.6 ± 20.6	0.61* 0.46 ‡ 1.0 ¶
Abdominal perimeter (cm) §	(n = 50) 64.8 ± 6.3	(n = 26) 74.1 ± 5.2	(n = 19) 81.7 ± 9.0	<0.0001* <0.0001 ‡ <0.0001 ¶

BMI: Body mass index. SD: Standard Deviation. Bpm: Beats per minute.

§ Data presented as average ± standard deviation.

† Comparison of the 3 BMI groups (x2).

* Comparison normal vs. overweight/obesity.

‡ Comparison normal vs. overweight.

¶ Comparison normal vs. obesity.

CIMT

Average CIMT (right+left) was of 0.38 ± 0.07; differences were found among girls (0.37 ± 0.06)

and boys (0.40 ± 0.08) (p=0.030).

Right CIMT (n = 102) was of 0.38 ± 0.07 mm, and a difference among girls was found (0.36 ± 0.07) and boys (0.40 ± 0.08) (p = 0,022). For the right side (n = 102), CIMT was of 0.39 ± 0.08, without differences among girls (0.38 ± 0.07) and boys (0.40 ± 0.09) (p = 0,11).

Table 5. Relationship of CIMT with other precedents

Precedent	CIMT								
	Right			Left			Average		
	Precedent +	Precedent -	p	Precedent +	Precedent -	p	Precedent +	Precedent -	p
AMI	(n = 31) 0.38 ± 0.07	(n = 71) 0.38 ± 0.08	0.99	0.38 ± 0.07	0.39 ± 0.09	0.4	0.38 ± 0.06	0.39 ± 0.07	0.56
Obesity	(n = 21) 0.36 ± 0.07	(n = 81) 0.38 ± 0.08	0.13	0.38 ± 0.07	0.39 ± 0.09	0.36	0.37 ± 0.06	0.39 ± 0.07	0.18
DM	(n = 41) 0.36 ± 0.07	(n = 61) 0.39 ± 0.08	0.01*	0.37 ± 0.08	0.40 ± 0.08	0.042*	0.36 ± 0.06	0.4 ± 0.07	0.011*
Dyslipidemia	(n = 36) 0.37 ± 0.07	(n = 66) 0.38 ± 0.08	0.54	0.37 ± 0.08	0.40 ± 0.08	0.15	0.37 ± 0.07	0.39 ± 0.07	0.23
HBP	(n = 58)0.39 ± 0.08	(n = 44) 0.37 ± 0.07	0.21	0.39 ± 0.08	0.38 ± 0.09	0.21	0.39 ± 0.07	0.38 ± 0.07	0.26
Migraine	(n = 33)0.36 ± 0.07	(n = 69) 0.39 ± 0.07	0.04*	0.35 ± 0.08	0.41 ± 0.08	0.0018*	0.36 ± 0.06	0.40 ± 0.07	0.003*

* Comparison normal vs. overweight/obesity.

In the overweight and obesity range, according to the WHO standard deviations, significant differences were found in the average CIMT between normal subjects (0.037 ± 0.06) and obese subjects (0.41 ± 0.07) and the left CIMT between the same groups ([0.38 ± 0.08] vs. [0.43 ± 0.07]) (table 4).

Table 4. CIMT vs. BMI

Classification of BMI by age				
	Normal (-2 to +1 SD)	Overweight (> +1 to +2 SD)	Obesity (> +2 SD)	p
Carotid intima media thickness	(n = 55)	(n = 27)	(n = 19)	
Right	0.37 ± 0.07	0.38 ± 0.07	0.40 ± 0.08	0.10 * 0.26 ‡ 0.12 ¶
Left	0.38 ± 0.08	0.38 ± 0.10	0.43 ± 0.07	0.39 * 0.77 ‡ 0.037 ¶
Average	0.37 ± 0.06	0.38 ± 0.08	0.41 ± 0.07	0.18 * 0.72 ‡ 0.037 ¶

BMI: Body mass index. SD: Standard Deviation. Bpm: Beats per minute.

Data presented as average ± standard deviation.

* Comparison normal vs. overweight/obesity.

‡ Comparison normal vs. overweight.

¶ Comparison normal vs. obesity.

When comparing the CIMT values with family medical history, statistically significant differences were found between the absence and presence of the DM and migraine precedents. In the case of diabetes, patients with family precedent had average CIMT values lower than the patients without the precedent (0.36 ± 0.06 vs. 0.4 ± 0.07). Likewise for the migraine precedent, 0.36 ± 0.06 (with precedent) vs. 0.40 ± 0.07 (without precedent). These values and the relationship of CIMT with the other precedents are summarized in table 5.

A positive correlation between CIMT and AP was found with a Spearman's ρ of 0.2462 ($p=0.018$) (figure 2).

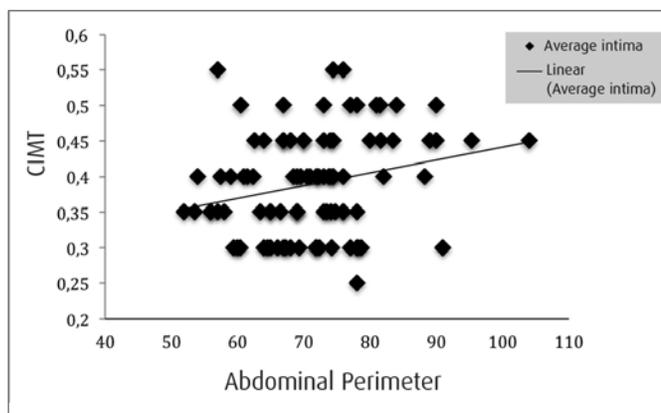


Figure 2. Positive correlation between CIMT and AP

In a multivariate analysis through linear regression, an initial statistically significant relationship between CIMT and AP was found ($\text{CIMT} = 0.261 + 0.00118 \times \text{AP}$; $p = 0.019$). Next, a positive relationship between CIMT and AP adjusted by DM and migraine family precedent was found ($p = 0.012$). Given that it was observed in the bivariate analysis that sex showed differences in the CIMT between groups, a stratified analysis was done for the multivariate model where a relationship between CIMT and AP adjusted for family precedent and migraine in men continued to be significant ($p = 0.029$), though in the women group the significance of the multivariate model was lost ($p = 0.0343$).

Discussion

Given that CIMT is an important marker of subclinical atherosclerosis and an independent cardiovascular risk factor in adults and, recently, also in children, it is necessary to focus prevention and intervention efforts in children at risk. Currently there is no existing data that defines the normal percentiles by age of the CIMT nor of AP in healthy children of the Colombian population. Thus, it is required to develop strict protocol to quantify this values and have a reference measurement. Recently, in a study that included 3,806 Chilean children, recruited from different areas of the city of Santiago, the AP percentiles for children between ages 6 and 14 was established, keeping in mind that the sample was significant and representative. However, this study did not include the CIMT among its variables (28).

In this study, CIMT quantification was easily and quickly carried out, it was well tolerated by all patients, who were all evaluated with the same equipment and by the same observer. There were no measurements made by other evaluators. The number of patients included in this study is comparable to other similar descriptive studies with 52 to 197 participants.

In this study the results show a significant difference for the CIMT between healthy and obese children diagnosed by BMI, specifically obese children showed a higher left CIMT and average CIMT value, with a positive correlation between CIMT and AP (figure 1). With regards

to the significance loss in the multivariate model for women, it can be suggested that perhaps girls have a protective factor in oestrogens.

Previous studies have described the relationship obesity-CIMT. However, these studies include patients with characteristics that are not comparable with the average or with the results obtained with a mestizo sample. For example, the average AP for obese children in Europe is between 0.86-0.96 m, while Colombian children have average ranges of 0.81-0.82 m. Something similar occurs with BMI. Likewise, in adults, the AP value related with cardiovascular risk factors in developing countries is lower than those in developed countries. For example, in Colombia, an AP of 88 cm identifies subjects with cardiovascular risk with a sensitivity of 83.7% and a specificity of 84.8%, values lower to those established in Caucasian populations for which the IDF (International Diabetes Federation) established different ranges of AP according to the region and ethnica of the patient (29). Given these differences, there exists controversy with respect to applying the normality-abnormality parameters resulting from studies in European patients to children in Colombia.

Not always has a relationship between CIMT and obesity been found. In 2001 French investigators (30) described an increase in arterial wall rigidity of common carotids in 48 obese children as compared to controls. However, no significant differences for CIMT between both groups was found.

There are few studies that have related CIMT in children with AP. In 2006 Meyer and collaborators (31) described elevated values for CIMT in obese children and the relationship with alterations in their lipid profile, inadequate vasodilation mediated by flow and a direct relationship with AP. These children became very high cardiovascular risk patients when associated with other risk factors such as arterial hypertension, low grade inflammation and sedentarism. In 2011 Elkiran and collaborators (32) also found significant differences in 64 obese children and 24 overweight children in comparison with healthy children in the CIMT and AP values with a positive correlation between CIMT and the AP and MBI values. These authors suggests that the AP is associated with cardiovascular complications and is a useful predictor of central obesity, thus AP should be quantified in all epidemiological studies that include paediatric obese patients. These findings present similarities with the results of this study. However, there exists the limitation of not having biochemical markers measured in the blood to establish relationships between CIMT and insulin resistance levels and low grade inflammation.

The INTERHEART study (33) described the cardiovascular risk factors for AMI in participants of 52 developed and developing countries: Tobacco, hypertension, dyslipidemia, abdominal obesity, diabetes and psychosocial stress were related with ischemic disease in all regions of the worlds, without differences between men and women. In a subsample of said study that included 1,237 patients belonging to Argentina, Brazil, Chile and Colombia (34), it was demonstrated that central obesity was the most important risk factor associated to AMI, much more than in all the rest of the population of the study. This finding has lead to postulate that the biological response to obesity is different in developed countries and would be modulated by epigenetics. In this order of ideas, recent exposition to new lifestyle changes in the population of the subsample would determine a high level of biological maladaptation; the lower the exposition time to bad lifestyle habits,

the lower the biological adaptation and the higher the cardiovascular risk (35). This relationship could explain, in part, that patients with diabetes and migraine family background had lower values of CIMT when compared to patients without this precedent. It would be hasty to say that children with cardiovascular family background are in an adaptation process. However, no other possible explanations could be postulated, given the limited number of patients and the absence of blood inflammation markers.

Besides AP correlating directly with CIMT, it is also the most important predictor of arterial hypertension in children. Thus, efforts in cardiovascular prevention in Colombia should include these two parameters, that besides being tolerable are easy to perform and of a very low cost.

On the other hand, the results of this study shows figures of higher diastolic blood pressure values in overweight children, though this was not observed in obese children. Neither were there significant differences found when comparing these values to the CIMT. This difference could be conditioned by the number of obese patients included in the study.

With regards to the CIMT values obtained in healthy and obese children, it can be said that they are similar to those of other studies. Meyer and collaborators (31) found a CIMT in healthy children of 0.39 ± 0.05 mm and in obese children of 0.49 ± 0.08 mm. Beauloye and collaborators (22) described a CIMT of 0.43 ± 0.0 mm in healthy children and of 0.47 ± 0.0 mm in obese children. Recently, Torrejon and collaborators (36) found a CIMT values in healthy children of 0.34 mm over the bulb and 0.56 mm in obese children with metabolic syndrome. Similar studies are found in the literature that include other important variables, such as the fatty liver ranges, body fat values and of course serum lipid levels, insulin, PCR, cytokines, and HOMA index. All these variables could be quantified in an eventual follow-up of the recruited patients to establish new relationships between the CIMT, obesity and metabolic syndrome in children of the studied population.

Conclusions

With the results of this study it can be concluded that there is a relationship between CIMT and obesity in children of the target population of the study and, at the same time, there also exists a direct relationship between CIMT and AP. These two variables of easy measurement allow to identify children with a higher cardiovascular risk and eventually decrease the impact of cardiovascular disease in the medium to long term.

It is possible that patients with parents or grandparents with diabetic or migraine precedents could be adapting to a metabolically altered state. However, this relationship cannot be established with the sample and the parameters evaluated in this study.

Even though the sample was sufficient to establish the relationship between CIMT and AP, it is necessary to perform other studies that can be applied to the full urban and rural child population, not just of Santander, and that include among its variables, serum lipid levels, inflammatory markers and presence of hepatic steatosis, as well as performing a follow up and control of these children throughout the adolescence and adult life.

References

- Ludwig DS. Childhood Obesity-The shape of things to come. *N Engl J Med*. 2007;357:2325-7.
- Profamilia, Instituto Nacional de Salud, ICBF. Encuesta Nacional de Situación Nutricional, Colombia 2010. Bogotá: Profamilia.
- Olshansky SJ, Passaro DJ, Hershow RC, et al. A potential decline in life expectancy in the United States in the 21st century. *N Engl J Med*. 2005;352:1138-45.
- Weinberger J. Diagnosis and prevention of atherosclerotic cerebral infarction. *CNS*. 2005;10:553-64.
- Naghavi M, Libby P, Falk E, et al. From vulnerable plaque to vulnerable patient: a call for new definitions and risk assessment strategies-part I. *Circulation*. 2003;108:1664-72.
- Naghavi M, Libby P, Falk E, et al. From vulnerable plaque to vulnerable patient: a call for new definitions and risk assessment strategies-part II. *Circulation*. 2003;108:1772-8.
- Napoli C, D'Armiento FP, Mancini FP, et al. Fatty streak formation occurs in human fetal aortas and is greatly enhanced by maternal hypercholesterolemia. Intimal accumulation of low density lipoprotein and its oxidation precede monocyte recruitment into early atherosclerotic lesions. *J Clin Invest*. 1997;100:2680-90.
- Wissler RW, Strong JP. Risk factors and progression of Atherosclerosis in youth: PDAY Research Group: Pathological Determinants of atherosclerosis in Youth. *Am J Pathol*. 1998;153:1023-33.
- Berenson GS, Srinivasan SR, Bao W, et al Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa heart study. *N Engl J Med*. 1998;338:1650-6.
- Yusuf S, Reddy S, Ounpuu S, et al. Global burden of cardiovascular disease. Part I. general considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation*. 2001;104:2746-53.
- Lopez AD. Assessing the burden of mortality from cardiovascular diseases. *World Health Stat Q*. 1993;46:91-6.
- López-Jaramillo P, Casas JP, Bautista L, et al. An integrated proposal to explain the epidemic of cardiovascular disease in a developing country. From socioeconomic factors to free radicals. *Cardiology*. 2001;96:1-6.
- López-Jaramillo P, Pradilla LP, Castillo VR, et al. Socioeconomic pathology as a cause of regional differences in the prevalence of metabolic syndrome and pregnancy-induced hypertension. *Rev Esp Cardiol*. 2007;60:168-78.
- Strauss RS, Pollack HA. Epidemic increase in childhood overweight, 1986-1998. *JAMA*. 2001;286:2845-8.
- Freedman DS, Dietz WH, Srinivasan SR, et al. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart study. *Pediatrics*. 1999;103:1175-82.
- Hannon TS, Rao G Arslanian SA. Childhood obesity and type 2 diabetes mellitus. *Pediatrics*. 2005;116:473-80.
- Srinivasan SR, Bao W, Wattigney WA, et al. Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart study. *Metabolism*. 1996;45:235-40.
- Meyer AA, Kundt G, Steiner M, et al. Impaired flow-mediated vasodilation, carotid intima-media thickening, and elevated endothelial plasma markers in obese children: The impact of cardiovascular risk factors. *Pediatrics*. 2006;117:1560-7.
- Touboul MG, Ennerici S, Meairs H, et al. Mannheim carotid intima-media thickness consensus (2004-2006). *Cerebrovasc Dis*. 2007;23:75-80.
- de Goot E, Hovingh GK, Wiegman A, et al. Measurement of arterial wall thickness as a surrogate marker for atherosclerosis. *Circulation*. 2004;109:III33-8.
- Barrera JG, Mateus L, Saaibi JF, et al. Arteria carótida y placa "Carótida un órgano" *Rev Colomb Cardiol*. 2006;13:117-27.
- Beauloye V, Zech F, Tran HT, et al. Determinants of early atherosclerosis in obese children and adolescents. *J Clin Endocrinol Metab*. 2007;92:3025-32.
- Zhu W, Huang X, He J, et al. Arterial intima-media thickening and endothelial dysfunction in obese children. *Eur J Pediatr*. 2005;164:337-44.
- Iannuzzi A, Licenziati MR, Acampora C. Increased carotid intima-media thickness and stiffness in obese children. *Diabetes Care*. 2004;27:2506-8.
- Organización Mundial de la Salud. Obesidad y sobrepeso [internet]. 2006 [citado 2014 dic. 15]. Disponible en: www.who.int
- Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*. 2000;320:1240-3.
- World Health Organization (WHO). BMI-for-age (5-19 years) [internet]. 2015 [citado 2015 ene. 10]. Disponible en: http://www.who.int/growthref/who2007_bmi_for_age/en/
- Ávalos C, Diaz C, Martínez A, et al. Waist circumference percentiles in children and adolescents between 6 and 14 years from Santiago, Chile. *Endocrinol Nutr*. 2012;59:296-303.
- Katzmarzyk PT, Janssen I, Ross R, et al. The importance of waist circumference in the definition of metabolic syndrome: prospective analyses of mortality in men. *Diabetes Care*. 2006;29:404-9.
- Tounian P, Aggoun Y, Dubern B, et al. Presence of increased stiffness of the common carotid artery and endothelial dysfunction in severely obese children: a prospective study. *Lancet*. 2001;358:1400-4.

31. Meyer A, Kundt G, Steiner M, et al. Impaired flow-mediated vasodilation, carotid artery intima-media thickening, and elevated endothelial plasma markers in obese children: the impact of cardiovascular risk factors. *Pediatrics*. 2006;117:1560-7.
32. Elkiran O, Yilmaz E, Koc M. The association between intima media thickness, central obesity and diastolic blood pressure in obese and overweight children: A cross-sectional school-based study. *Int J Cardiol*. 2013;165:528-32.
33. Yusuf S, Hawken S, Ounpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet*. 2004;364:937-52.
34. Lanas F, Avezum A, Bautista LE, et al. INTERHEART investigators in Latin America. Risk factors for acute myocardial infarction in Latin America: the INTERHEART Latin America study. *Circulation*. 2007;115:1067-74.
35. López-Jaramillo P, Silva S, Rodríguez N. Are nutrition-induced Epigenetic changes the link between socioeconomic pathology and cardiovascular diseases? *Am J Therap*. 2008;15:362-72.
36. Torrejón C, Hevia M, Ureta E, et al. Grosor de la íntima-media de la arteria carótida en adolescentes obesos y su relación con el síndrome metabólico. *Nutr Hosp*. 2012;27:192-7.

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