

NONALCOHOLIC HEPATIC STEATOSIS: ASSOCIATION WITH METABOLIC SYNDROME AND CARDIOVASCULAR RISK FACTORS IN OBESE ADOLESCENTS

Esteatose hepática não alcoólica: relação com a síndrome metabólica e os fatores de risco cardiovascular em adolescentes obesos

Esteatosis hepática no alcohólica: relación con el síndrome metabólico y los factores de riesgo cardiovascular en adolescentes obesos

Original Article

ABSTRACT

Objective: To evaluate the association between nonalcoholic hepatic steatosis (NAHS), metabolic syndrome (MS) and cardiovascular risk factors (CRF) in obese adolescents. **Methods:** Cross-sectional observational study with a quantitative approach, carried out from June to August 2011. The volunteers were randomly selected and referred to clinical evaluation in the endocrinology and cardiology units at the clinics hospital of the Federal University of Uberlândia, being included 34 adolescents of 14-19 years above the 95th percentile of the growth curve. NAHS was assessed by ultrasonography. The MS and CRF were diagnosed by the International Diabetes Federation criteria. **Results:** The sample consisted of 14 male and 20 female patients aged 16.8 ± 1.6 and body mass index (BMI) of 35.7 ± 3.9 . The occurrence of NAHS and MS was 76.5% and 50%, respectively. Males had a higher incidence of NAHS (78.6%), SM (64.3%) and association of NAHS with MS (50%). Regarding the CRF, 100% (n=34), 61.8% (n=21) and 52.9% (n=18) of the adolescents had elevated values of waist circumference (WC), low-density lipoprotein cholesterol (LDL-C) and systolic blood pressure (SBP), respectively, and 52.9% (n=18) showed low levels of high-density lipoprotein cholesterol (HDL-C). There were correlations between MS and triglycerides; systolic and diastolic blood pressure and HDL-C; and between NAHS and BMI and WC. **Conclusion:** A high occurrence of NAHS, SM and CRF was observed in obese adolescents. A strong correlation was observed between MS and NAHS, and between FRC and NAHS and SM.

Descriptors: Adolescents; Obesity; Fatty Liver; Metabolic Syndrome X; Cardiovascular Diseases.

RESUMO

Objetivo: Avaliar a associação entre esteatose hepática não alcoólica (EHNA), síndrome metabólica (SM) e fatores de risco cardiovascular (FRCs) em adolescentes obesos. **Métodos:** Estudo observacional do tipo transversal com abordagem quantitativa, realizado de junho a agosto de 2011. Os voluntários foram aleatoriamente selecionados e encaminhados para avaliação clínica no setor de endocrinologia e cardiologia do hospital de clínicas da Universidade Federal de Uberlândia. Participaram 34 adolescentes de 14 a 19 anos, acima do percentil 95 da curva de crescimento. A EHNA foi analisada por ultrassonografia. A SM e os FRCs foram identificados pelos critérios da International Diabetes Federation. **Resultados:** A amostra foi composta de 14 indivíduos do sexo masculino e 20 do sexo feminino, com idade ($16,8 \pm 1,6$) e índice de massa corporal (IMC) ($35,7 \pm 3,9$). A ocorrência de EHNA e SM foi de 76,5% (n=26) e 50% (n=17), respectivamente. O sexo masculino apresentou maior ocorrência de EHNA (78,6%, n=11), SM (64,3%, n=09) e associação de EHNA com SM (50%, n=07). Em relação aos FRCs 100% (n=34), 61,8% (n=21) e 52,9% (n=18) dos adolescentes apresentaram valores aumentados da circunferência da cintura (CC), da low-density-lipoprotein cholesterol (LDL-C) e pressão arterial sistólica

Wener Barbosa Resende⁽¹⁾
Carlos Eduardo Caetano⁽¹⁾
Ana Maria Oliveira Caixeta
Nogueira⁽²⁾
Sandra Regina Xavier Santos⁽¹⁾
Rafael Dias da Costa e Silva⁽³⁾
João Elias Nunes⁽¹⁾
Heitor Santos Cunha⁽¹⁾
Nadia Carla Cheik⁽¹⁾

1) Federal University of Uberlândia
(Universidade Federal de Uberlândia -
UFU) - Uberlândia (MG) - Brazil

2) Municipal Health Secretariat of
Uberlândia (Secretaria Municipal de Saúde
de Uberlândia - SMSU) - Uberlândia (MG)
- Brazil

3) DCS Diagnostic Imaging (DCS
Diagnósticos por Imagem) - Birigui (SP)
- Brazil

Received on: 01/04/2013
Revised on: 02/06/2013
Accepted on: 02/01/2014

(PAS), respectivamente, e 52,9% (n=18) apresentaram baixos valores de high-density lipoprotein cholesterol (HDL-C). Houve correlações entre SM e triglicérides, PAS e diastólica e HDL-C, e entre EHNA, IMC e CC. **Conclusão:** Observou-se uma alta ocorrência de EHNA, SM e FRCs em adolescentes obesos. Uma forte correlação foi observada entre EHNA e SM, e entre FRCs com EHNA e SM.

Descritores: Adolescentes; Obesidade Infantil; Fígado Gorduroso; Síndrome X Metabólica; Doenças Cardiovasculares.

RESUMEN

Objetivo: Evaluar la asociación entre la esteatosis hepática no alcohólica (EHNA), síndrome metabólico (SM) y factores de riesgo cardiovascular (FRCs) en adolescentes obesos.

Métodos: Estudio observacional del tipo trasversal con abordaje cuantitativo realizado entre junio y agosto de 2011. Los voluntarios fueron seleccionados al azar y encaminados para evaluación clínica en el sector de endocrinología y cardiología del hospital de la Universidad Federal de Uberlândia. Participaron 34 adolescentes entre 14 y 19 años que estaban por encima del percentil 95 de la curva de crecimiento. La EHNA fue analizada con la ultrasonografía. La SM y los FRCs fueron identificados a través de criterios de la International Diabetes Federation.

Resultados: La muestra fue constituida de 14 individuos del sexo masculino y 20 del sexo femenino con media de edad de 16,8±1,6 años y media del índice de masa corporal (IMC) de 35,7±3,9. La ocurrencia de EHNA y SM fue del 76,5% (n=26) y 50% (n=17), respectivamente. El sexo masculino presentó mayor ocurrencia de EHNA (78,6%, n=11), SM (64,3%, n=9) y asociación de EHNA y SM (50%, n=7). Respecto a los FRCs, el 100% (n=34), 61,8% (n=21) y el 52,9% (n=18) de los adolescentes presentaron valores mayores de la circunferencia de cintura (CC), de la low-density-lipoprotein cholesterol (LDL-C) y tensión arterial sistólica (TAS), respectivamente, y el 52,9% (n=18) presentó bajos niveles de high-density lipoprotein cholesterol (HDL-C). Hubieron correlaciones entre SM y triglicérides, TAS y diastólica y HDL-C, y entre EHNA, IMC y CC. **Conclusión:** Se observó una elevada ocurrencia de EHNA, SM y FRCs en adolescentes obesos. Una fuerte correlación fue observada entre EHNA y SM, y entre FRCs y EHNA y SM.

Descritores: Adolescente; Obesidad Pediátrica; Hígado Gras; Síndrome X Metabólico; Enfermedades Cardiovasculares.

INTRODUCTION

The nonalcoholic fatty liver disease (NAFLD) covers all the spectrum of fatty liver diseases in individuals who drink little or no alcohol, ranging from hepatic steatosis to steatohepatitis and cirrhosis, being considered the main cause of chronic liver disease in both adult and pediatric populations^(1,2).

The nonalcoholic hepatic steatosis (NAHS) in children is associated with obesity, insulin resistance (IR), metabolic

syndrome (MS), and its components are cardiovascular risk factors (CRF)^(3,4).

This disease has reached epidemic proportions in Western countries. In the United States, nearly 20% of the adult populations is estimated to have some manifestation of NAHS. The prevalence increases in the obese population, ranging from 75% to 92%. In children and adolescents, this prevalence ranges from 9.6% to 14%, reaching 38% in obese individuals. Similar values have been found in countries of Europe and Asia^(5,6). In Brazil, there is no consistent data on the prevalence of NAHS in adult and pediatric population. However, studies have reported values ranging from 13.5% to 41.7% in the adult population, and occurrence from 2.6% to 57.4% in eutrophic and obese children, respectively⁽⁷⁻⁹⁾.

The association of NAHS with MS suggests that the NAHS can be a hepatic component of the MS, representing an emerging health problem in different ethnical populations worldwide^(10,11). In children and adolescents, it may lead to diabetes mellitus and cardiovascular diseases in adult life^(3,12).

The prevalence of MS in the pediatric population changes according to the population studied and the criteria used in the assessment. However, recent studies show an occurrence ranging from 4.2% to 38.7% in both sexes^(12,13). In the Brazilian population, the literature points to values ranging from 15.6% a 49.1%^(11,14). It is a public health problem for young obese people, especially at post-pubescent age, when obesity is very likely to remain throughout adult life⁽¹⁴⁾. In 10 years the prevalence of obesity and MS will considerably increase among age-transition individuals (from children and adolescents to young adults) from 21% to 33.4%, and from 2.8% to 17.9% respectively⁽¹⁵⁾.

Additionally, in Brazil, the number of overweight male adolescents aged 10-19 years increased from 3.7% (1974-1975) to 21.7% (2008-2009), and the number of overweight female adolescents went from 7.6% to 19.4% in the same period according to the *Pesquisa de Orçamento Familiar – POF* (Family Budget Survey)⁽¹⁶⁾.

Thus, this current study aimed to assess the association between nonalcoholic hepatic steatosis, metabolic syndrome and cardiovascular risk factors in obese adolescents. The results of this study will help in the development of strategies for health promotion and prevention and control of diseases in this population and hence minimize the onset of non-communicable chronic diseases in overweight adolescents.

METHODS

This is a quantitative observational cross-sectional study conducted from June to August 2011 in the city of Uberlândia, Minas Gerais (MG).

The sample comprised adolescents aged 14-19 years who were recruited through electronic and press publicity. Then, obese adolescents were referred to the department of endocrinology and cardiology of the *Universidade Federal de Uberlândia – SECHC-UFU* (Federal University of Uberlândia) for clinical assessment.

Of a total of 175 adolescents referred to SECHC-UFU, 34 adolescents (14 males and 20 females) were selected through simple random probability sampling, meeting the inclusion criteria: body mass index (BMI) above the 95th percentile in the growth curve of the Center for Disease Control (CDC)⁽¹⁷⁾ and sexual maturation^(18,19). The study excluded adolescents who consumed alcohol and tobacco, and those who presented disabling diseases like rheumatic, neuromuscular, osteoarticular or degenerative disorders informed through medical reports.

Adolescents wore light clothes and no shoes and then were weighted using a FilizolaTM scale with a 150kg capacity and 100g accuracy. Height was measured using a SannyTM wood stadiometer with 0.1cm accuracy. Body Mass Index (BMI) was calculated by dividing body mass (kg) by the square of the height (m).

Presence of steatosis, measurements of visceral fat (VF) and subcutaneous fat (SF) were assessed using ultrasonography. The ultrasonographic aspect of steatosis was determined by the diffuse increased echogenicity, which can be noticed by comparing liver echogenicity with the echogenicity of the renal cortex or spleen⁽²⁰⁾. According to the diagnosis, steatosis was classified into degrees: mild (I), moderate (II) and severe (III)⁽²¹⁾.

VF was measured by placing a 3.5 MHz convex probe at 1 cm above the umbilical scar, considered as the measure between the rectus abdominis muscle and the anterior wall of abdominal aorta, quantified in centimeters⁽²²⁾. SF was measured using a 7.5MHz linear probe placed at 1 cm above the umbilical scar considering the measure between the skin and the external surface of the fascia of rectus abdominis muscle, quantified in centimeters⁽²²⁾.

Metabolic syndrome among adolescents was characterized according to the criteria proposed by the International Diabetes Federation (IDF)⁽²³⁾, which considers that, for adolescents aged 10-16 years, the metabolic syndrome can be diagnosed by the presence of obesity and two other alterations (hypertriglyceridemia, low levels of high-density lipoprotein cholesterol (HDL-C), systemic blood pressure and fasting hyperglycemia)⁽²³⁾.

The reference values used for adolescents aged 10-16 years were: waist circumference (WC) $\geq$ the 90th percentile, triglycerides $\geq$ 150 mg/dL, HDL-C $<$ 40 mg/dL, systolic blood pressure $\geq$ 130 and/or diastolic $\geq$ 85 mm Hg, fasting glycemia $\geq$ 100 mg/dL⁽²³⁾. For adolescents over 16 years old:

waist circumference (WC) $\geq$ 90 cm for men and $\geq$ 80 cm for women⁽²⁴⁾, and two other factors: triglycerides $\geq$ 150 mg/dL or specific treatment for this lipid disorder, HDL-C $<$ 40 mg/dL for boys and $<$ 50 mg/dL girls or specific treatment for HDL-C, systolic blood pressure (SBP) $\geq$ 130 and/or diastolic (DBP) $\geq$ 85 mmHg or treatment for previously diagnosed hypertension and fasting glycemia $\geq$ 100 mg/dL or previous diagnosis of type 2 diabetes⁽²³⁾.

The lipid and glucose profiles were determined by collecting 8 ml of blood through venous puncture after a 12-hour night fasting with previous normal diet. The lipid profile was determined using the spectrophotometric enzyme assay through the clinical chemistry kit (Abbott), except the high-density lipoprotein cholesterol (HDL-C), which was verified using the DiaSys Diagnostic Systems GmbHTM kit. The low-density lipoprotein cholesterol (LDL-C) was determined using Friedewald's formula: $LDL-C = TC - HDL-C - (Triglycerides/5)$ ⁽²⁵⁾. The cutoff points adopted for the lipid profile were the values proposed by the *III Diretriz Brasileira sobre Dislipidemia* (Brazilian Guidelines for Dyslipidemia)⁽²⁵⁾.

Plasma glucose level was measured using the spectrophotometric enzyme assay with the clinical chemistry kit (Abbott). The cutoff point used was the one established by the International Diabetes Federation (IDF)⁽²⁶⁾.

Waist circumference was measured using SANY unextendable anthropometric tape which verified the millimeters of the medium point between the last rib and the iliac crest⁽²⁷⁾.

The normality of data was verified through the Shapiro-Wilk test. Student's t-test was used to check for differences of means between male and female genders. Pearson's correlation test was applied to verify the relation between quantitative vs quantitative variables. The existing associations between qualitative variables were assessed by the Chi-squared test or Fisher's Exact test when necessary. Data were analyzed using softwares SPSS version 17.0 and BioEstat version 5.0. The significance level was set at 5% ($p \leq 0.05$).

The study was approved by the *Comitê de Ética em Pesquisa da Universidade Federal de Uberlândia – CEP/UFU* (Ethics Research Committee of the Federal University of Uberlândia) (No. 498/10). All the volunteers and their parents/caretakers were informed about the study and signed a free informed consent form (FICF) prior to participating in the research, respecting the Resolution 196/96 of the National Health Council.

RESULTS

In this current study, of the 175 adolescents referred to the research, 19.4% (n=34) were obese. In the sample

(n=34), it was observed that the mean BMI of volunteers corresponds to class II obesity (Table I).

No significant difference was found between genders for the variables age (M=16.5±1.7; F=16.9±1.5; p=0.42), BMI (M=35.2±3.9; F=35.2±4.1; p=0.97) and waist circumference

(WC) (M=116.3±9.1; F=112.5±10.9; p=0.30). Only height (M=174.4±6.8; F=163.6±7.3; p=0.0001) and body mass (BM) (M=88.2±15.6; F=95.4±15.1; p=0.018) presented significant difference between genders, with a higher mean value for males.

Table I - Anthropometric, biochemical and physiological data of obese adolescents. Uberlândia-MG, 2011.

	AGE (years)	HEIGHT (m)	BM (kg)	BMI (kg/m ²)	WC (cm)	GLY (mg/dL)	TG (mg/dL)	HDL-C (mg/dL)	SBP (mmHg)	DBP (mmHg)
Mean	16.8	1.7	101.2	35.7	114.3	82.5	134.7	45.8	127.06	81.18
SD	1.6	0.1	16.4	3.9	10.2	9.7	75.9	9.2	13.82	7.18

SD: standard deviation; BM: body mass; BMI: body mass index; WC: waist circumference; GLY: fasting glycemia; TG: triglycerides; HDL-C: *high-density lipoprotein cholesterol*; SBP: systolic blood pressure; DBP: diastolic blood pressure.

Table II - Distribution of metabolic syndrome (MS) and nonalcoholic hepatic steatosis (NAHS) according to gender of obese adolescents. Uberlândia-MG, 2011.

Variable	Male (n=14)		Female (n=20)		p
	n	%	n	%	
MS	9	64.3%	8	40%	0.2*
MS + NAHS	7	50%	7	35%	0.4*

*Chi-squared test.

Table III - Distribution of nonalcoholic hepatic steatosis (NAHS) and metabolic syndrome (MS) and disease staging according to gender of obese adolescents. Uberlândia-MG, 2011.

Variable	Male (n=14)		Female (n=20)		p
	n	%	n	%	
NAHS	11	78.6%	15	75%	0.6 [#]
NAHS + MS	7	50%	7	35%	0.4*
Stage I	6	42.8%	9	45%	0.9*
Stage II	4	28.6%	4	20%	0.4 [#]
Stage III	1	7.1%	2	10%	0.6 [#]

*Chi-squared test. [#]Fisher's Exact test.

Table IV - Correlation between cardiovascular risk factors in obese adolescents. Uberlândia-MG, 2011.

	BM	BMI	WC	GLY	TG	HDL-C	SBP	DBP	TC	LDL-C
BM	-	0.74**	0.85**	-0.07	0.04	-0.32	0.58**	0.48**	-0.22	-0.17
BMI	0.74**	-	0.82**	-0.28	-0.10	-0.05	0.37*	0.26	-0.16	-0.11
WC	0.85**	0.82**	-	-0.22	-0.02	-0.21	0.41*	0.36*	-0.18	-0.12
GLY	-0.07	-0.28	-0.22	-	-0.37	0.17	-0.09	-0.15	-0.02	0.09
TG	0.04	-0.10	-0.02	-0.37	-	-0.28	0.01	0.07	0.45*	0.08
HDL-C	-0.32	-0.05	-0.21	0.17	-0.28	-	-0.47**	-0.27	0.15	-0.00
SBP	0.58**	0.37*	0.41*	-0.09	0.01	-0.47**	-	0.71**	-0.28	-0.17
DBP	0.48**	0.26	0.36*	-0.15	0.07	-0.27	0.71**	-	-0.30	-0.29
TC	-0.22	-0.16	-0.18	-0.02	0.45*	0.15	-0.28	-0.30	-	0.88**
LDL-C	-0.17	-0.11	-0.12	0.09	0.08	-0.00	-0.17	-0.29	0.88**	-

BM: body mass; BMI: body mass index; WC: waist circumference; GLY: fasting glycemia; TG: Triglycerides; HDL-C: *high-density lipoprotein cholesterol*; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; LDL-C: *low-density lipoprotein cholesterol*. Pearson's correlation test. *p<0.05 and **p<0.01.

All the volunteers presented an increase in WC, and 26.5% (n=9), 52.9% (n=18), 32.3% (n=10), 35.3% (n=12) and 61.8% (n=21) of adolescents presented increased values of triglycerides, SBP, DBP, total cholesterol and LDL-C, respectively. Additionally, 52.9% (n=18) presented HDL-C values below reference values (64.3% for males and 45% for females). Only 8.8% (n=3) presented values above the cutoff point for fasting glucose.

Half of the studied sample presented MS (n=17) and 82.3% (n=14) of individuals who had MS also presented NAHS (Table II). There was a high incidence of NAHS (76.5%, n=26), with a higher prevalence of cases (88.5%, n=23) at the initial stages of the disease, and 53.8% (n=14) of individuals who had NAHS also presented MS (Table III). There was an association ($p=0.02$) between MS and NAHS in the studied sample (n=34).

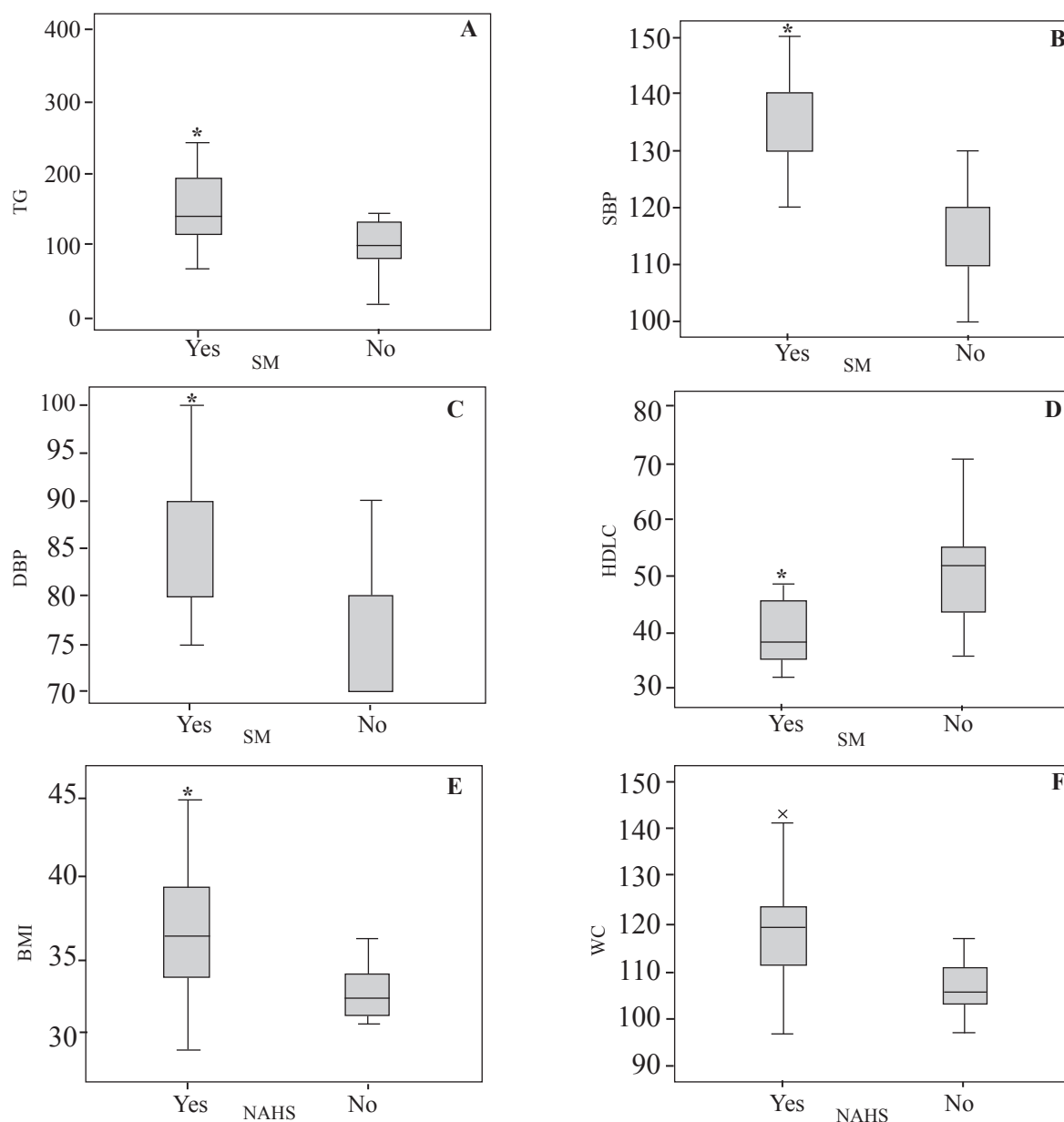


Figure 1 - Associations of cardiovascular risk factors in obese adolescents with and without metabolic syndrome and nonalcoholic hepatic steatosis. TG: Triglycerides in mg/dL; SBP: systolic blood pressure in mmHg; DBP: diastolic blood pressure in mmHg; HDL-C: high-density lipoprotein cholesterol in mg/dL; SM: metabolic syndrome; BMI: body mass index in kg/m²; WC: waist circumference in cm; NAHS: nonalcoholic hepatic steatosis. A) TG in volunteers with and without SM. * $p \leq 0.05$; B) SBP in volunteers with and without SM. * $p \leq 0.01$; C) DBP in volunteers with and without SM. * $p \leq 0.05$; D) HDL-C in volunteers with and without SM. * $p \leq 0.01$; E) BMI in volunteers with and without NAHS. * $p \leq 0.01$; F) WC in volunteers with and without NAHS. * $p \leq 0.05$. All correlations were verified through Pearson's correlation test.

After the stratification by gender, males (n=14) presented a higher occurrence of MS along with NAHS (Table II and III). There was no association between MS and genders, NAHS and genders, and NHAS and its stages (Tables II and III).

It has also been verified in the sample (n=34) the occurrence of positive and negative correlations between cardiovascular risk factors: body mass and BMI, WC, SBP, DBP; body mass index and WC and SBP; waist circumference and SBP and DBP; total cholesterol and LDL-C and TG; HDL-C and SBP; SBP and DBP (Table IV).

Figure 1 shows that individuals with MS (n=17) are significantly related to high levels of triglycerides, SBP, DBP and low levels of HDL-C when compared to individuals without MS. Adolescents with NAHS (n=26) are related to higher values of BMI and WC when compared to individuals without NAHS.

DISCUSSION

In this current study, 19.4% of individuals were obese, with BMI above the 95th percentile in the growth curve, and, according to the mean BMI, they presented class II obesity, which is associated with high risks of comorbidities⁽²⁸⁾.

The percentage of obesity found in this research is higher than the percentage (16.9%) found in the USA between 2009 and 2010⁽²⁹⁾ and the percentage (14.4%) found in a study conducted with Brazilian children and adolescents⁽³⁰⁾. It is significantly higher (5.9% in boys and 4% in girls) than the percentage described by the POF conducted in Brazil between 2008 and 2009⁽¹⁶⁾.

The results found in this study, together with the results of other researchers^(31,32), show that obesity in the pediatric population has significantly increased within a short time, pointing to a failure, up to now, in reverting this worldwide trend, which has major consequences on the quality of life and longevity of the human being.

Environmental changes associated with modern society are responsible for the largest part of epidemic obesity, which results from a high percentage of fat that is kept through abnormal energy homeostasis⁽³³⁾. The main causes of this positive energy balance are the sedentary life and hypercaloric diet.

In addition, overweight and obesity in the pediatric population is associated with puberty⁽³⁴⁾, and there is a bigger change of the obese adolescent become an obese adult⁽²⁸⁾. A study conducted with Brazilian children and adolescents showed that overweight and obesity are directly related to sexual maturation. In this study, authors identified that 23.1% of interviewees were overweight or obese,

with a higher prevalence of overweight in individuals who reported signs of sexual maturation, with no significant difference in overweight between genders⁽³⁴⁾. These results are similar to the results of this current study, in which there was no significant difference between the BMI of male and female post-pubescent adolescents.

Obesity in children and adolescents is strongly associated with increased risks of premature cardiovascular diseases, MS and NAHS, leading to an increased rate of premature death for this population^(29,31,32,35). Thus, this current study is in accordance with the literature because more than 50% of obese adolescents presented high occurrence of cardiovascular risk factors like WC, SBP, LDL-C above reference values and HDL-C below the reference values besides a great occurrence of NAHS and MS.

The most common cardiovascular risk factor among the adolescents of this study was waist circumference. In all, 100% of adolescents presented values above the cutoff point preconized by the IDF^(23,24). The percentages found are above 55% rate found by researchers in another study that was also conducted with Brazilian adolescents⁽³⁶⁾. The percentage found for waist circumference above the cutoff points is worrisome, for it suggests that, at least for boys, high values of waist circumference in adolescents may predict MS in adults⁽³⁷⁾.

The findings of this current research did not show a significant occurrence of fasting hyperglycemia (8.8%). However, this has also been observed by other studies^(13,14,36). In other studies conducted with adolescents, authors reported that fasting hyperglycemia was the less frequent risk factor^(13,14). Another study conducted in Brazil showed an occurrence (2%) of fasting hyperglycemia as a risk factor; however, this percentage is still below the one found by research⁽³⁶⁾.

The occurrence of NAHS (76.5%) found in this study was above the one found in the literature for obese adolescents (38%)⁽⁵⁾. However, another study⁽³⁸⁾ also found a high incidence of NAHS. In a sample of 861 obese children and adolescents, 587 (68.2%) presented NAHS.

This high incidence of NAHS in the studied population points to a worrying situation since individuals with NAHS present a mortality rate that is 34% to 86% higher than the general population. One of the main causes of death are cardiovascular diseases⁽⁴⁾, for they are related to factors that predict the development of coronary disease, dyslipidemia, central obesity and MS⁽³⁸⁾.

Another worrying finding was that the metabolic syndrome was present in 50% of the participants of this study. This is above the 38.7% rate described for the general pediatric population⁽¹³⁾ and above the 25.7%

incidence found in Asian children and adolescents⁽³⁸⁾ whose waist circumference parameters are used as a reference to the South American population in the characterization of MS^(23,24).

It has also been observed a joint occurrence of NAHS and MS (53.8%). The joint occurrence of NAHS and MS found in this study was similar to the one observed in a North American study in which researchers reported that 50% of children and adolescents with NAHS presented MS⁽³⁾.

In fact, there was a correlation between MS, NAHS and cardiovascular risk factors. This finding is in accordance with a study that showed that the presence of hepatic steatosis can be considered a hepatic manifestation of the MS⁽¹⁰⁾.

Additionally, there was a higher incidence of NAHS (78.6%) and MS (64.3%) among men versus 75% of NAHS and 40% of MS among women. Another Brazilian study conducted with adolescents also found a higher incidence of NAHS among men (19.5%) in relation to women (13%)⁽³⁹⁾ but with a percentage difference that is smaller than the one found in this current research.

Regarding the high prevalence of MS among men, a research conducted with North American adolescents using the criteria of the International Diabetes Federation for the identification of MS – the same criteria used in this current research – also found a higher incidence in men. However, it presented an incidence of 6.7% in men and 2.1% in women⁽⁴⁰⁾, values a lot smaller than the ones found in this study.

During the same period of the study conducted in the USA, Brazilian researchers identified differences in the occurrence of MS between genders. The percentages found for Brazilian adolescents were 34.8% for men and 15.6% for women⁽¹¹⁾. The percentage found for Brazilian adolescents was smaller than the one found in the USA; however, this percentage is still smaller than the one identified in this current study.

Recently, a research conducted with Brazilian adolescents found values similar to the ones found in this study. Researchers verified an incidence of 49.1% of MS in men; however, the occurrence (26.9%) in women⁽¹⁴⁾ was still smaller than the percentage found in this study.

The physiological relations between the high incidence of NAHS and MS in male adolescents are still not described by the literature. However, it is believed that this higher incidence of NAHS and MS in male post-pubescent adolescents may be strongly related to the topographic difference of the distribution of body fat between genders and the influence of sexual hormones.

The size of the sample is a limitation to this current study. Therefore, there should be studies conducted with a larger number of individuals to confirm the findings in the studied population.

However, this is an important issue since there are high chances, from 50% to 70%, of obese adolescents remain obese in adult life⁽²⁸⁾. There is a need to develop effective therapeutic, preventive, educative and health promotion strategies for this population since NAHS, MS, cardiovascular diseases and obesity can be prevented through physical activity and a healthy diet.

CONCLUSION

There was a high incidence of NAHS, MS and cardiovascular risk factors in obese adolescents, with a higher prevalence among men. It was also verified that NAHS and MS are related to cardiovascular risk factors like the body mass index, waist circumference, triglycerides, systolic and diastolic blood pressure, and low levels of HDL-C.

Also, there was a strong correlation between NAHS and MS and CRF since obese adolescents with NAHS presented higher chances of developing MS and cardiovascular diseases, pointing to the need for multiprofessional interventions.

REFERENCES

1. Chalasani N, Younossi Z, Lavine JE, Diehl AM, Brunt EM, Cusi K, et al. The Diagnosis and Management of Non-Alcoholic Fatty Liver Disease: Practice Guideline by the American Association for the Study of Liver Diseases, American College of Gastroenterology, and the American Gastroenterological Association. *Hepatology*. 2012;55(6):2005-23.
2. Tiniakos DG, Vos MB, Brunt EM. Nonalcoholic Fatty Liver Disease: Pathology and Pathogenesis. *Ann. Rev Pathol Mech Dis*. 2010;5:145-171.
3. Schwimmer JB, Pardee PE, Lavine JE, Blumkin AK, Cook S. Cardiovascular Risk Factors and the Metabolic Syndrome in Pediatric Nonalcoholic Fatty Liver Disease. *Circulation*. 2008;118(3):277-83.
4. Perazzo H, Poynard T, Dufour JF. The Interactions of Nonalcoholic Fatty Liver Disease and Cardiovascular Diseases. *Clin Liver Dis*. 2014;18(1):233-48.
5. Feldstein AE, Charatcharoenwithaya P, Treeprasertsuk S, Benson JT, Enders FB, Angulo P. The natural history of non-alcoholic fatty liver disease in children: a follow-up study for up to 20 years. *Gut*. 2009;58(11):1538-44.

6. Erickson SK. Nonalcoholic fatty liver disease. *J Lipid Res.* 2009;50(Suppl):S412-S416.
7. Ferolla SM, Ferrari TC, Lima ML, Reis TO, Tavares-Jr WC, Couto OF, et al. Dietary patterns in Brazilian patients with nonalcoholic fatty liver disease: a cross-sectional study. *Clinics (Sao Paulo).* 2013;68(1):11-17.
8. Cotrim HP, Parise ER, Oliveira CP, Leite N, Martinelli A, Galizzi J, et al. Nonalcoholic fatty liver disease in Brazil. Clinical and histological profile. *Ann Hepatol.* 2011;10(1):33-7.
9. Souza FIS, Amâncio OMS, Sarni ROS, Pitta TS, Fernandes AP, Fonseca FLA, et al. Doença hepática gordurosa não alcoólica em escolares obesos. *Rev Paul Pediatr.* 2008;26(2):136-41.
10. Soler GLN, Silva AWSM, Silva VCG, Teixeira RJ. Doença hepática gordurosa não-alcoólica: associação com síndrome metabólica e fatores de risco cardiovascular. *Rev. SOCERJ.* 2008;21(2):94-100.
11. Caranti DA, Lazzer S, Dâmaso AR, Agosti F, Zennaro R, de Mello MT, et al. Prevalence and risk factors of metabolic syndrome in Brazilian and Italian obese adolescents: a comparison study. *Int J Clin Pract.* 2008;62(10):1526-32.
12. Angurana SK, Angurana RS. Prevalence of metabolic syndrome in adolescents: Reason to worry. *Indian J Endocrinol Metab.* 2013;17(6):1135-6.
13. Moraes ACF, Fulaz CS, Oliveira Netto ER, Reichert FF. Prevalência de síndrome metabólica em adolescentes: uma revisão sistemática. *Cad Saúde Pública.* 2009;25(6):1195-202.
14. Campos L de A, Amancio OMS, Costa e Forti A. Impact of obesity on metabolic syndrome in Brazilian adolescents - a population-based study. *Diabetes Care.* 2013;36(9):e139-40.
15. Stanley TL, Chen ML, Goodman E. The typology of metabolic syndrome in the transition to adulthood. *J Clin Endocrinol Metab.* 2014;99(3):1-9.
16. Instituto Brasileiro de Geografia e Estatística – IBGE. Pesquisa de Orçamentos Familiares - POF 2008-2009. Comunicação Social 27 de agosto de 2010 [acesso em 2014 Jan 4]. Disponível em: http://saladeimprensa.ibge.gov.br/index.php?option=com_saladeimprensa&view=noticias&id=1&paginar=1&quantidade=10&pagina=1&busca=1&Itemid=1719&data-inicio=&data-fim=&alvo=obesidade+na+adolescencia.
17. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, et al. 2000 Centers for Disease Control (CDC) growth charts for the United States: methods and development. *Vital Health Stat.* 2002;11(246):1-190.
18. Marshall WA, Tanner JM. Variations in pattern of puberal changes in girls. *Arch Dis Childh.* 1969;44(233):291-303.
19. Marshall WA, Tanner JM. Variations in pattern of puberal changes in boys. *Arch Dis Childh.* 1970;45(239):13-23.
20. Moll AJ. Esteatose hepática: avaliação por ultrasonografia. *Informativo Med D'Or (RJ).* 2006;6:6-7.
21. Saadeh S, Younossi ZM, Reme EM, Gramlich T, Ong JP, Hurley M, et al. The utility of radiological imaging in nonalcoholic fatty liver disease. *Gastroenterol.* 2002;123(3):745-50.
22. Diniz ALD, Tomé RAF, Debs CL, Carraro R, Roevers LB, Pinto RMC. Avaliação da reprodutibilidade ultrassonográfica como método para medida da gordura abdominal e visceral. *Radiol Bras.* 2009;42(6):353-7.
23. Zimmet P, Alberti G, Kaufman F, Tajima N, Silink M, Arslanian S, et al. The metabolic syndrome in children and adolescents: the IDF consensus. *Diabetes Voice.* 2007;52(4):29-32.
24. Zimmet P, Magliano D, Matsuzawa Y, Alberti G, Shaw J. The Metabolic Syndrome: A Global Public Health Problem and A New Definition. *J Athrosclerosis Thrombosis.* 2005;15(6):295-300.
25. V Diretrizes Brasileiras de Dislipidemias e Prevenção da Aterosclerose. *Arq Bras Cardiol.* 2013;101(4Supl.1):1-22.
26. International Diabetes Federation – IDF. The IDF consensus worldwide definition of the metabolic syndrome [acesso em 2014 Jan 10]. April 14, 2005. Disponível em: <http://www.idf.org/metabolic-syndrome>
27. Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome: a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabetic Medicine.* 2006;23(5):469-80.
28. Associação Brasileira para o Estudo da Obesidade e da Síndrome Metabólica - ABESO. Diretrizes brasileiras de obesidade 2009/2010 [acesso em 2014 Jan 20]. Disponível em: http://www.abeso.org.br/pdf/diretrizes_brasileiras_obesidade_2009_2010_1.pdf.

29. Van Grouw J, Volpe SL. Childhood obesity in America. *Current Opinion in Endocrinology, Diabetes & Obesity*. 2013;20(5):396-400.
30. Travi MIC, Bastos PRHO, Pontes ERJC. Prevalência de sobrepeso, obesidade e circunferência abdominal alterada em escolares de 6 a 11 anos de idade em Campo Grande/MS. *Rev Bras Promoç Saúde*. 2011;24(1):54-62.
31. Balakrishnan PL. Identification of Obesity and Cardiovascular Risk Factors in Childhood and Adolescence. *Pediatr Clin North Am*. 2014;61(1):153-71.
32. Franks PW, Hanson RL, Knowler WC, Sievers ML, Bennett PH, Looker HC. Childhood obesity, other cardiovascular risk factors, and premature death. *N Engl J Med*. 2010;362(6):485-93.
33. Corey KE, Kaplan LM. Obesity and liver disease: the epidemic of the twenty-first century. *Clin Liver Dis*. 2014;18(1):1-18.
34. Ramos MLM, Pontes ERJC, Ramos MLM, Barros VRSP. Sobrepeso e obesidade em escolares de 10 a 14 anos. *Rev Bras Promoç Saúde*. 2013;26(2):223-32.
35. Yilmaz Y, Younossi ZM. Obesity-Associated Nonalcoholic Fatty Liver Disease. *Clin Liver Dis*. 2014;18(1):19-31.
36. Rizzo AC, Goldberg TB, Silva CC, Kurokawa CS, Nunes HR, Corrente JE. Metabolic syndrome risk factors in overweight, obese, and extremely obese Brazilian adolescents. *Nutr J*. 2013;12(19):1-9.
37. Barzin M, Asghari G, Hosseiniapanah F, Mirmiran P, Azizi F. The association of anthropometric indices in adolescence with the occurrence of the metabolic syndrome in early adulthood. *Pediatr Obes*. 2013;8(3):170-7.
38. Fu JF, Shi HB, Liu LR, Jiang P, Wang CL, Liu XY. Non-alcoholic fatty liver disease: An early mediator predicting metabolic syndrome in obese children? *World J Gastroenterol*. 2011;17(6):735-42.
39. Fernandes MTB, Ferraro AA, Azevedo RA, Fagundes Neto U. Metabolic differences between male and female adolescents with non-alcoholic fatty liver disease, as detected by ultrasound. *Acta Paediatrica*. 2010;99(8):1218-23.
40. Ford ES, Li C, Zhao G. Prevalence of the Metabolic Syndrome Among U.S. Adolescents Using the Definition From the International Diabetes Federation. *Diabetes Care*. 2008;31(3):587-9.

Mailing address:

Nadia Carla Cheik
 Faculdade de Educação Física / UFU
 Rua Benjamin Constant, 1286
 Bairro Aparecida
 CEP: 38400-678 - Uberlândia - MG - Brasil
 E-mail: wener_educa@hotmail.com