

Clinical and metabolic alterations and insulin resistance among adolescents

Alterações clínicas, metabólicas e resistência à insulina entre adolescentes

Alteraciones clínicas, metabólicas y resistencia a la insulina en adolescentes

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Abstract

Objective: Analyzing the clinical and metabolic alterations and their relation to insulin resistance among adolescents.

Methods: Analytic study, carried out with 357 adolescents of state public schools in a municipality in Northeastern Brazil. The applied form contained the variables Body Mass Index, Waist Circumference, Neck Circumference, Taper Index, Average Blood Pressure, Triglycerides, Blood Sugar Level, High-Density Lipoprotein Cholesterol, Insulin, and Homeostasis Model Assessment Index, analyzed through descriptive measures for quantitative variables; and through frequency for qualitative variables. Association tests were made through Chi-Square test and through Odds Ratio.

Results: Prevalence of insulin resistance was 33.9%. The average values of waist circumference, neck circumference, taper index, average systolic blood pressure and average diastolic blood pressure were high in, respectively, 4.2%, 30%, 10.9%, 4.2% and 14% of adolescents. High-Density Lipoprotein Cholesterol levels were decreased in 30.5% of the sample, whereas triglycerides were high in 18.8%. No blood sugar alteration was identified. Those who presented altered values for body mass index, waist circumference, neck circumference, taper index, and triglycerides had higher chances to present insulin resistance (OD: 3.62, 11.54, 3.50, 4.49, 3.05, respectively). On the other hand, adolescents with altered average systolic blood pressure, average diastolic blood pressure and High-Density Lipoprotein Cholesterol did not present statistical significance ($p < 0.05$).

Conclusion: Insulin resistance is present among adolescents, with positive and significant association to clinical and metabolic alterations.

Resumo

Objetivo: Analisar as alterações clínicas, metabólicas e sua relação com a resistência à insulina entre adolescentes.

Métodos: Estudo analítico, realizado com 357 adolescentes de escolas públicas estaduais de um município do Nordeste brasileiro. O formulário aplicado continha as variáveis Índice de Massa Corporal, Circunferência da Cintura, Circunferência do Pescoço, Índice de Conicidade, Pressão Arterial Média, Triglicérides, Glicemia, *High – Density Lipoprotein Cholesterol*, Insulina e *Índice Homeostasis Model Assessment*, analisadas por medidas descritivas para variáveis quantitativas; e frequências para variáveis qualitativas. Foram realizados testes de associações através do Qui-quadrado e do teste Odds Ratio.

Resultados: A prevalência de resistência à insulina foi de 33,9%. As médias da circunferência da cintura, circunferência do pescoço, índice de conicidade, pressão arterial sistólica média e pressão arterial diastólica média estiveram elevadas respectivamente em 4,2%; 30%; 10,9%; 4,2% e 14% dos adolescentes. Os níveis de *High – Density Lipoprotein cholesterol* estiveram diminuídos em 30,5% da amostra, ao passo que os triglicérides estavam elevados em 18,8%. Não foi identificada alteração na glicemia. Aqueles que apresentaram índice de massa corporal, circunferência da cintura, circunferência do pescoço, índice de conicidade e triglicérides com valores alterados possuíam maiores chances de apresentar resistência à insulina (OD: 3,62; 11,54; 3,50; 4,49; 3,05, respectivamente). De maneira oposta, os adolescentes com pressão arterial sistólica média, pressão arterial diastólica média e *High – Density Lipoprotein cholesterol* alterados não apresentaram significância estatística ($p < 0,05$).

Conclusão: A resistência à insulina está presente entre os adolescentes, com associações positivas e significativas com alterações clínicas e metabólicas.

Resumen

Objetivo: Analizar las alteraciones clínicas, metabólicas y la relación con la resistencia a la insulina en adolescentes.

Métodos: Estudio analítico, realizado con 357 adolescentes de escuelas públicas provinciales/departamentales de un municipio del Nordeste brasileño. El formulario aplicado contenía las variables: índice de masa corporal, circunferencia de la cintura, circunferencia del cuello, índice de conicidad, presión arterial promedio, triglicéridos, glucemia, colesterol *High-Density Lipoprotein*, insulina e índice *Homeostasis Model Assessment*. Las variables cuantitativas fueron analizadas mediante medidas descriptivas, y las variables cualitativas mediante frecuencias. Se realizaron pruebas de relaciones a través de la prueba χ^2 de Pearson y Odds Ratio.

Resultados: La prevalencia de resistencia a la insulina fue de 33,9%. Los promedios de circunferencia de la cintura, circunferencia del cuello, índice de conicidad, presión arterial sistólica promedio y presión arterial diastólica promedio fueron altos respectivamente en el 4,2%; 30%; 10,9%; 4,2% y 14% de los adolescentes. Los niveles de colesterol *High-Density Lipoprotein* fueron bajos en el 30,5% de la muestra, mientras que los triglicéridos fueron altos en el 18,8%. No se identificó alteración en la glucemia. Los que presentaron índice de masa corporal, circunferencia de la cintura, circunferencia del cuello, índice de conicidad y triglicéridos con valores alterados tenían mayores chances de presentar resistencia a la insulina (OD: 3,62; 11,54; 3,50; 4,49; 3,05, respectivamente). De forma contraria, los adolescentes con presión arterial sistólica promedio, presión arterial diastólica promedio y colesterol *High-Density Lipoprotein* alterados no presentaron significación estadística.

Conclusión: La resistencia a la insulina está presente en los adolescentes, con una relación positiva y significativa respecto a alteraciones clínicas y metabólicas.

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Introduction

The changes in life habits of the world population, with low levels of daily physical activity added to an inadequate diet that includes high calorie-density foods, influence the development of several chronic diseases, such as Systemic Arterial Hypertension (SAH), Dyslipidemias, Diabetes Mellitus, Obesity, and Insulin Resistance (IR). These changes happen independently from age group, as they are increasingly common among adolescents.

Due to those changes, adolescence is considered a critical time for the development of obesity and other metabolic disorders, since it is the context where the phenomena of nutrition transition happens, and excess weight is significantly increasing in that population group, thus it is considered a serious public health problem.⁽¹⁾

Accumulation of body fat during this age range may lead to the development of IR, an event that consists of unbalanced glucose metabolism, causing increased insulin production, decreased receptor concentration, cell-transit mechanism failure or impairment of some post-receptor mechanisms after its use. Furthermore, this excessive concentration of body fat, especially abdominal fat, is directly related to high values of Free Fatty Acids (FFA) in the bloodstream. Those disorders may hamper insulin signaling and, as a result, cause an IR case.⁽²⁾

A recent study with 121 obese children and adolescents, aged 6 to 17 years old, in Coimbra, Portugal, observed IR present in 38.1% of the sample, upon use of HOMA-IR.⁽³⁾ Another study carried out with 162 school-attending adolescents, aged 12 to 19 years old, revealed a prevalence of altered IR in 23.5% of the studied population.⁽⁴⁾ Other studies that were carried out with the same research public reinforced the assertion that dyslipidemic adolescents present higher IR levels when compared to eutrophic ones.⁽⁵⁻⁷⁾

Given the aforementioned facts, identification of IR in adolescents using HOMA-IR index, with additional assessment of anthropometric and metabolic variables of this population group, makes it possible to identify the risk factors that are more closely associated to IR development and of its sec-

ondary diseases, thus assisting on the implementation of intervention measures scoped on public health prevention of cardiovascular events and non-transmittable chronic diseases in adolescence and adulthood.^(3,6)

Therefore, a necessity for further clarification is observed when it comes to detection of IR in adolescents. Use of HOMA-IR index for that task enables a quick and early event diagnosis, making it possible to identify the cardiometabolic factors related to disorder development in epidemiologic studies.

Due to the scarcity of investigations concerning the theme at hand, carried out in the state of Piauí/Brazil, specifically with adolescents in public schools, assessing the connection of HOMA-IR index with anthropometric and metabolic variables becomes essential for identifying factors that may be changed in relation to the development/control of IR cases in adolescents, and for promoting cardiovascular health among this population group.

This research also holds noticeable impact for nursing, since professionals of the area are the coordinators of Health Ministry programs, such as *Programa Saúde na Escola (PSE – Health in School Program)*, thus knowledge of reality may guide intervention and health education actions, stimulating the population to take on healthy life habits and, therefore, share and build knowledge about the life quality theme, tied to the early onset of chronic-degenerative diseases.

In that perspective, it is undeniable that the most important metabolic disorders comprise hyperinsulinemia and insulin resistance, and those events are related, later on, to high blood sugar levels. Therefore, this study aimed at assessing clinical and metabolic indicators and their relation with insulin resistance among adolescents.

Methods

This is an analytic, quantitative study, which was carried out in 18 state public schools located in the city of Picos, state of Piauí, Northeastern Brazil. Study population comprised 3,800 students from

both sexes, in state public schools, aged 10 to 19 years old, all duly enrolled and attending class in the schools where the study was performed. The sample size was estimated by the finite population formula, considering a 95% confidence level, 8% relative error, absolute error=4%, $t^2_{5\%} = 1,96$. The sample resulted in 357 participants stratified in 18 schools and selected by simple random sampling.

Inclusion criteria were: being enrolled to school and attend class regularly; being aged from 10 to 19 years old; and participating of all research steps. Those unable to participate on the gathering of anthropometric measurements (pregnant individuals and wheelchair users) were excluded, as well as people who were diagnosed with a disease or who used medication that could interfere with carbohydrate and lipid metabolism. Thus, twelve participants were excluded. After the exclusions were recorded, new randomized selection was carried out until the estimated number of adolescents from each school could be reached.

Data collection happened from August to December/2014 and March/2015. A structured instrument was used, presenting personal data, socioeconomic data, clinical variables and metabolic variables.

The following clinical variables were observed: Body weight (kg), Height (cm), Body Mass Index (BMI), Neck Circumference (NC), Waist Circumference (WC), Taper Index (TI), and Blood Pressure (BP).

Weight was measured with portable digital body scales, with maximum capacity of 150 kg and sensitivity at 100g, where the subject was assessed in the center of the equipment, wearing light clothes, no shoes, in erect posture, standing with feet next to each other and arms hanging alongside the body. Height was measured using an unextendible measuring tape of 0.5cm precision, which was attached perpendicularly to a flat wall. With those data, BMI (kg/m^2) adjusted for age and sex of participants was analyzed and sorted, so among nutritional diagnostic there are: < Percentile 0.1 = Acute Thinness, \geq Percentile 0.1 and < Percentile 3 = Thinness, \geq Percentile 3 and < Percentile 85 = Eutrophia, \geq 85 and < Percentile 97 = Overweight, \geq Percentile 97

and \leq Percentile 99.9 = Obesity, and > Percentile 99.9 = Acute Obesity.⁽⁷⁻¹⁰⁾

BMI was sorted according to parameters defined for adolescents by OMS (2007) and employed by *Sociedade Brasileira de Pediatria (SBP – Brazilian Pediatrics Association)* (2009) and by *Projeto Erica (Erica Project)* (2011). Neck circumference was measured with a 2-meter measuring tape which was flexible and inelastic. Participants were oriented to stand up straight, with their heads positioned in the horizontal plane. The top edge of the measuring tape was placed below the laryngeal prominence and it was applied perpendicularly around the neck axis.⁽¹¹⁾ For analysis, the cutoff points developed by Hingorjo, Qureshi, Mehdi⁽¹²⁾ were used, adapted to adolescents, which define overweight individuals as those with $\text{NC} > 35.5\text{cm}$ and $\text{NC} > 32\text{cm}$ on males and females, respectively.

Waist circumference measurements were obtained using an inelastic measuring tape placed on the skin, with the subject standing up straight, on the average point between the last rib and the top edge of the iliac crest at the end of expiratory movement, and sorted according to the age, sex and race, thus being

The Taper Index proposed by Valdez⁽¹⁴⁾ has an equation where TI considers the measurements of WC, body weight, height and a 0.109 constant, which presents the conversion of volume and weight into length measures. TI calculation was made according to the following formula:

$$\text{Taper Index} = \frac{\text{Waist circumference (m)}}{0,109 \sqrt{\frac{\text{Body weight (kg)}}{\text{Height (m)}}}}$$

TI was deemed adequate or inadequate, according to the cutoff point established for men and women, respectively: 1.25 and 1.18.⁽¹⁵⁾

Blood pressure was measured by the classic auscultatory method with a research validated device. Blood pressure checking followed the procedures recommended by the VII Brazilian Hypertension Directives.⁽¹⁶⁾ Cuffs of appropriate size for the circumference of adolescents' arms were used, and a

protocol was developed for blood pressure verification, which considered the two measurements of systolic and diastolic blood pressure taken from the adolescent, after five minutes of rest. In case the difference between the first and second measurements of systolic blood pressure or diastolic blood pressure was higher than 5mmHg, a third measurement was taken and the average between the second and third results of systolic blood pressure and diastolic blood pressure as considered. In order to sort blood pressure results, this study used the curves for definition of percentile of child/adolescent height according to age and sex, as presented on the United States' National High Blood Pressure Education Program, and the percentile table of blood pressure.

Blood samples were used for biochemical measurements. A day before blood collection, parents and other responsible parties were contacted by telephone to remind them of the importance of fasting for 12 hours, in order to obtain lab data. Lab exams were all conducted in a laboratory that was contracted for that end, and they included HDL-C serum dosage, triglycerides, insulin and fasting blood sugar. Blood samples were drawn by venipuncture after 12 hours of fasting. Blood was drawn into vacuum tubes containing separating gel without anticoagulant. After collection, blood was centrifuged for 10 minutes at 3,000 rpm to separate serum from the other components, so it was used to conduct analysis.

Levels of triglycerides, HDL-cholesterol and blood sugar were determined by using a calorimetric enzyme kit processed in the Autohumalyzer A5 device, (Human GMBH, Kaiserslautern, Germany). Insulin was determined in the ACS-180 Automated Chemiluminescence System device (Ciba Corning, Diagnostics Corp; Medifield, USA). Results of triglycerides and HDL-cholesterol were compared to the reference values for childhood and adolescence of the V Brazilian Directive of Dyslipidemias and Atherosclerosis Prevention⁽¹⁷⁾. Fasting blood sugar followed the values of *Sociedade Brasileira de Diabetes* (Brazilian Diabetes Society).⁽¹⁸⁾

HOMA-IR index was used to assess resistance to insulin, and it was obtained by calculating the multiplication of fasting plasma insulin (um/mL)

and fasting blood sugar (mmol/L) divided by 22.5. The cutoff point in use was equal or higher than 3.16 for both sexes.⁽¹⁹⁾

Initially, calculations were of averages, standard deviation, minimum and maximum values, for quantitative variables; and of simple frequency and percentual for qualitative variables. Multiple logistic regression method was used for data analysis, where the dependent variable is binary, given by "Insulin Resistance" in order to assess the co-variables that are associated to this result and avoid possible confusion factors. Odds Ratio measurement was used to quantify the association strength between the co-variables and the result. At first, co-variables were brought to the model according to their significance in bivariant association with the study result, considering a significance level of 0.2 at this stage; sex and age variables were also added to the model. In the final model, co-variables remained whose estimated parameters were significative to a 0.05 level of significance.

Data were processed and analyzed in International Business Machines Statistics Package Social Science version 20.0 (IBM SPSS20.0) and in software R version 3.5.1 for data modeling. As soon as they were analyzed, data were presented in tables so disclosure and organization of information regarding the research objective could become clearer.

The research project was approved by the Research Ethics Committee of *Universidade Federal do Piauí* (UFPI), under Opinion n. 853.499.

Results

357 adolescents of both sexes were included in the study. Out of the sample, 63.0% of adolescents were female. Age varied from 10 to 19 years old, averaging 14.99 ± 2.4 , considering that the predominant age group ranged from 15 to 19 years old (60.2%).

Pertaining self-identified color/race, 53.5% were mixed. Regarding economic class, it was observed that most (66.9%) belonged to "C-class" (i.e., lower-middle class), whereas no student belonged to "A-class" (i.e., wealthy). Considering labor, 88.2% of adolescents stated that they exclusively studied.

The clinical variables in the sample were investigated, where 18.5% of students were overweight, according to BMI, averaging 20.5 ± 3.83 . Concerning WC, students presented an average of 70.8 ± 8.23 , and only 4.2% presented excessive central adiposity. Regarding NC, 30.0% presented inadequate NC. TI was found inadequate in 10.9% of adolescents. High SBP and DBP levels were found in 4.2% and 13.8% of the sample, with average and standard deviation of 103.1 ± 11.46 and 676 ± 9.55 for SBP and DBP.

Concerning the characteristics of metabolic variables among adolescents, it was possible to observe that the component that presented no kind of alteration was blood sugar, which was normal in 100% of adolescents with an average of 75.9 ± 10.37 . Nonetheless, triglycerides were limit-high in 11.2%, and high in 7.6% of the study sample, averaging 78.2 ± 36.0 . HDL-C had values under the recommended in 30.5% of adolescents, varying with minimum and maximum values of 29.30-85.90, respectively. From the total sample, 100 adolescents (28%) were diagnosed with IR, with minimum 2.0 and maximum 11.

Furthermore, the co-variables that initially were part of the model ($p < 0.20$) were identified, which were: BMI, WC, NC, TI and TG (triglycerides). Variables Age and Sex were added to the model to assess their influence upon insulin resistance. In or-

der to carry out the technique, 357 cases were validated out of the 357 sampled. 28% cases of insulin resistance were observed, and 72% without insulin resistance.

Table 1 presents the complete model, generated with the selected co-variables. It is noticeable that co-variables Sex, BMI and WC did not influence insulin resistance significantly ($p > 0.05$), therefore they shall leave the model.

The updated model, without not-significative variables, can be observed in Table 2. In order to analyze the adjustment quality of the final model, the *Omnibus* test was carried out ($\chi^2 = 119.24$ gl=5; $p < 0.001$), where the hypothesis of the updated model being equal to the model without co-variables was rejected. Applying the *Hosmer and Lemeshow* Test it is seen that $\chi^2 = 12.56$, gl=8, com p-value=0.128, i.e., the values predicted in the model are not significantly different from those observed.

With model adjustment quality approved, as well as adequation of proposed distribution, it was necessary to interpret the estimated parameters (Table 2). It was discovered that age is a protection factor for insulin resistance, where the addition of a year decreases chances of insulin resistance by 10.4%. for variable NC, it was identified that adolescents who have inadequate NC present approximately 3 times more chance to be insulin resistant when compared to adolescents with adequate NC. A similar situation is noticeable regarding inadequate TI levels and high TG levels, which show an OR of about 3.2 and 2.8, respectively.

Aiming at ensuring that the distribution proposed for the model is adequate, residue analysis was made using the simulated envelopes graph (Figure 1), where it was verified that Pearson residues are above line and within confidence interval of 95%, making it evident to assume adequate distribution for the study model.

Table 1. Multiple (complete) binary logistic regression model for insulin resistance

Model variables	Estimated coefficient	Standard error	Wald Statistic	P value	OR	(95%) CI
Sex (Female)	-0.286	0.269	1.124	0.289	0.752	0.44-1.27
Age (years)	-0.097	0.016	36.418	<0.001*	0.908	0.88-0.94
BMI (Altered)	0.28	0.354	0.623	0.43	1.323	0.66-2.65
NC (Inadequate)	0.875	0.299	8.552	0.003*	2.399	1.33-4.31
TI (Inadequate)	1.014	0.401	6.399	0.011*	2.758	1.26-6.05
TG (High)	0.94	0.357	6.948	0.008*	2.561	1.27-5.15
WC (Enlarged)	1.044	0.734	2.023	0.155	2.84	0.67-11.96

OR - Odds Ratio; (95%) CI - 95% Confidence Interval

Table 2. Multiple (updated) binary logistic regression model for insulin resistance

Model variables	Estimated Coefficient	Standard error	Wald Statistic	L.D.	P value	OR	(95%) CI
Age (years)	-0.109	0.012	86.712	1.000	<0.001	0.896	0.876 0.917
NC (Inadequate)	1.095	0.272	16.184	1.000	<0.001	2.988	1.753 5.094
TI (Inadequate)	1.167	0.371	9.900	1.000	0.002	3.213	1.553 6.647
TG (High)	1.030	0.346	8.893	1.000	0.003	2.802	1.424 5.516

OR - Odds Ratio; (95%) CI - 95% Confidence Interval; L.D. - liberty degree

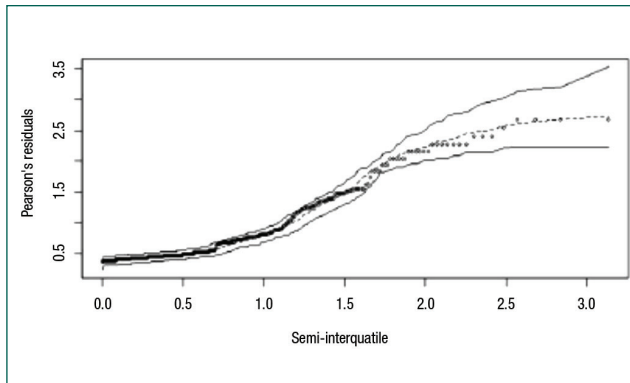


Figure 1. Residue analysis

Discussion

Study result limitations are related to cross-sectional design, which does not allow one to define cause-and-effect relations between studied variables.

Results herein presented brought important contributions to the Northeastern area of Brazil, especially to the countryside of Piauí, revealing relevant data to literature, mostly due to the absence of papers that tried to analyze insulin resistance among adolescents in public schools. Those data support intervention planning, in nursing practice, aiming at controlling the factors that lead to insulin resistance development in adolescents.

After result presentation it was possible to characterize research participants, who were, mostly, female, aged between 10 and 19 years old, with self-identified brown skin, belonging mainly to economic “C class”. Likewise, studies carried out with this public to investigate risk factors and/or excessive weight, as well as other studies that investigated community health/illness situation, portrayed that the female sex was the most frequent one.⁽²⁰⁾

Regarding the distribution of clinical variable among adolescents, it was noticed that 18.5% of adolescents presented excessive weight (overweight/obesity) when assessed for BMI, split between 12.9% overweight and 5.6% obese. This is a higher result than the one in a study carried out with 305 adolescents in Petrolina, state of Pernambuco, which showed excessive weight in 16% of students.⁽²¹⁾ Despite its causes being preventable, excessive weight has been growing worse in this age gap,

thus becoming the health issue in largest evolution worldwide.⁽⁵⁾

Prevalence observed in literature suffers slight differences when compared to the data presented in this study. They vary between minimum values at 11.2% to maximum at 38% of overweight children and adolescents. Thus, it may be said that this study leads to average prevalence equivalent to those identified in the researches under discussion. In some studies, no significant difference was found between sexes either, however, the association with age points that the older the individuals, the higher are overweightness indexes.⁽²²⁾

Such findings are deemed worrisome, because obesity is currently seen as a global epidemic, and its predominance is growing both in developed and underdeveloped countries.⁽⁴⁾ Moreover, overweightness and obesity may cause psychosocial problems among adolescents due to media and societal pressure to achieve at any cost a body shape considered ideal.⁽²³⁾

Since obesity is acknowledged as a disease of multifactor etiology, it is expected that studies involving adolescents show different comorbidity standards. Consequently, it is necessary that educational measures be incentivized to raise adolescents’ awareness to take on a more active life style to favor negative energetic balance, such as food and nutritional education, because it is less burdensome to public resources and more efficient against obesity and its harmful consequences.

Regarding abdominal adiposity, in this study 4.2% of the study sample presented enlarged values, whereas 95.8% presented eutrophic values. The opposite prevalence was found in a research carried out with 1030 adolescents in the countryside of the state of Rio Grande do Sul (Southern Brazil), which identified abdominal obesity in 24% of adolescents;⁽²⁰⁾ and a study carried out in Fortaleza, state of Ceará (Northeastern Brazil), with 702 students, which showed a prevalence of enlarged WC in 13.6% of participants.⁽²⁴⁾

Considering NC levels, it was observed that 30% of the sample present inadequate parameters. A similar frequency was found in a study carried out with the same public of the research

with 2,866 participants, which made the predominance of altered NC evident in 30.1% of the study sample.⁽²⁵⁾ Those results agree with conclusions presented by research with female adolescents, which showed that NC is an important indicator of core fat assessment, so the inclusion of this clinical parameter is necessary in the assessment of adolescents' nutritional state.⁽²⁶⁾

With the aforementioned in mind, several body makeup assessment techniques have been in development, however many of them present high financial costs to be performed. It is necessary, therefore, to develop simple techniques, more inexpensive and with good accuracy levels to be applied both to adolescents and to the population at large.⁽²⁷⁾

Regarding TI, it was found that 10.9% of participants presented altered values, with minimum at 0.98 and maximum at 1.35. In a study carried out in public schools in the city of Viçosa, state of Minas Gerais (Southeastern Brazil), with 113 adolescents, it was brought to light that TI was not a good indicator of body mass and total body fat.⁽²⁶⁾

In what pertains altered BP levels, this investigation presented it in 17.2% of the sample. Likewise, a cross-section research developed with 653 adolescents observed the prevalence of factors associated to high BP levels in adolescents in the city of Ponta Grossa, state of Paraná (Southern Brazil), and, in a similar way, it found that 12.4% of the sample had high BP, with positive and significative correlation to overweightness ($p < 0.001$).⁽²⁸⁾

Other investigations revealed similar values to this study, as observed in a study carried out in the Northeastern area of Brazil, with 211 adolescents, which had 13.7% of its assessment sample presenting SAH⁽²⁹⁾. Higher results were observed in the research involving adolescents from municipal schools in the countryside of Rio Grande do Sul state,⁽²⁰⁾ with SAH prevalence in 30.4% of the sample, given that 17.9% were deemed at stage I and 12.5% at stage II.

Identifying SAH in early ages is a relevant action for controlling and preventing SAH during adulthood. Despite that, most adolescents do not get frequent BP checks, thus monitoring becomes so difficult.⁽³⁰⁾

Regarding metabolic variable distribution among adolescents, it was found that TGs were altered in 18.8% of analyzed subjects. Those results meet what was observed in a study that analyzed cardiovascular risk factors, anthropometric and lipidic profile of adolescents. It showed high TG alteration levels (45.5%).⁽³¹⁾ Those metabolic disorders enhance IR, which is considered a central event in generation of metabolic disease risks.⁽³²⁾

Literature highlights, furthermore, that TG alteration appears mainly in students of lower socioeconomic class, as people with low income are associated with incidence of and mortality due to cardiovascular disease, probably because of accumulation of risk factors.⁽³²⁾

Concerning HDL-cholesterol, 30.5% of adolescents presented it below recommended levels. These results are lower than the ones found in a research that aimed to assess 113 obese individuals aged between 7 and 18 years old, where HDL-c was below recommendation in 69% of the study sample.⁽⁷⁾ It is probable that the difference is due to different methodologies or cutoff points of lab exams, but, also, to different life style standards, including meals and physical activities.

In this study, IR was the most prevalent of metabolic alterations. It was presented with altered levels in 28% of the research subjects, and it is considered one of the complications of obesity. This result is similar to the data collected in a study carried out with 186 adolescents aged 10 to 19 years old, which observed IR predominance in 42.5% of research participants;⁽⁵⁾ and to the research carried out with 121 obese children and adolescents, aged 6 to 17 years old, in Coimbra, Portugal, which observed the presence of IR in 38.1% of them, using HOMA-IR with 3 as a cutoff point; in that same study, 12.5% of individuals had some form of dyslipidemia.⁽³⁾

Moreover, higher frequencies were found in a research with 321 obese adolescents aged 10 to 17 years old, with 65% of assessed subjects presenting IR.⁽³³⁾ In another study, the authors concluded that IR levels must be monitored in overweight adolescents, since they observed the higher is IR, the wider is presence of cardiovascular risk factors.⁽³⁴⁾

As observed in the aforementioned studies, in spite of different authors noticing high prevalence of alterations in glycemic and lipidic profiles, results are variable. It is probable that it happened due to different methodologic approaches or cutoff marks in lab exams, but, also, due to different life style standards, including meal quality and practice of physical activities.

Still regarding this research, it was verified that IT presented significative association to all the indicators of bodily makeup (BMI, WC and NC), as well as TI and TG, and it is in line with other works.⁽³⁵⁾

In this study there was no significative correlation between variables Sex, BMI, and WC, and insulin resistance. It was possible to find divergent studies in another paper, which observed that male adolescents who were overweight or obese presented more than double prevalence of insulin resistance.⁽⁴⁾ It was found, still in our study, that adolescents with inadequate NC had approximately 3 times more chances of developing insulin resistance (OR: 2.988).

It must be highlighted that the relation observed between IR and analyzed variables, in this study, point to increasing development risk, as adults, of cardiovascular disease, diabetes type II and metabolic syndrome.

Thus, health promotion actions must be taken in schools with adolescents, especially in the school environment itself. Considering the population under study is young, and the earlier regular physical activity, healthy food consumption and specific actions of collective nature are offered to this age group, the better future results will be. In that sense, it is of utmost importance to emphasize that adolescence is a transition phase to adulthood, and adolescents must be encouraged to lead a healthy life style.

Conclusion

Findings in this study showed adolescents' high frequency of insulin resistance and alterations in clinical and metabolic variables, especially excessive body adiposity, neck circumference, high tri-

glycerides, and low HDL-cholesterol with positive and significative associations to the clinical and metabolic variables.

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Collaborations

Guimarães MR, Santos AA, Moura TFR, Rocha MR, Moura IH and Silva ARV contributed to project conception, data analysis and interpretation, article writing, relevant critical review of intellectual content and final version approval for publication.

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