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# Cardiovascular risk and cardiovascular risk factors in adolescents

*Risco cardiovascular e fatores de risco cardiovascular em adolescentes*

*Riesgo cardiovascular y factores de riesgo cardiovascular en adolescentes*

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## ABSTRACT

**Objectives:** to identify cardiovascular risk and cardiovascular risk factors in adolescents and verify correlations between these variables and biochemical markers, and between blood pressure percentiles, Body Mass Index, and biochemical markers. **Methods:** a cross-sectional study, conducted at a Brazilian school, from August to September 2019, including 205 participants who were interviewed. After the interview, anthropometric assessments, including weight, height, arm circumference, blood pressure checking, and blood collection for laboratory tests were performed. Descriptive and inferential analysis using the chi-square test was conducted. **Results:** a total of 18.5% had blood pressure percentiles >95%, 25.4% were overweight, and 25.9% were at very high cardiovascular risk. Statistically significant associations were found between cardiovascular risk and sex, Body Mass Index and blood pressure percentiles, and between blood pressure percentiles and triglycerides. **Conclusions:** high prevalence of risk factors among school adolescents reinforces the need for interventions for cardiovascular risk reduction in this population.

**Descriptors:** Adolescent; School; Cardiovascular Diseases; Blood Pressure; Cardiovascular Risk.

## RESUMO

**Objetivos:** identificar o risco cardiovascular e os fatores de risco cardiovascular em adolescentes e verificar correlações entre essas variáveis e marcadores bioquímicos, e entre percentis de pressão arterial, Índice de Massa Corporal e marcadores bioquímicos. **Métodos:** estudo transversal, realizado em escola brasileira, de agosto-setembro de 2019, incluindo 205 participantes que foram entrevistados. Após a entrevista, foram realizadas avaliações antropométricas, incluindo peso, altura, circunferência do braço, aferição da pressão arterial e coleta de sangue. Foi realizada análise descritiva e inferencial por meio do Teste do Qui-Quadrado. **Resultados:** 18,5% apresentavam percentis de pressão arterial>95%, 25,4% com sobrepeso e 25,9% com risco cardiovascular muito alto. Foram encontradas associações estatisticamente significativas entre risco cardiovascular e sexo, Índice de Massa Corporal e percentis de pressão arterial e entre percentis de pressão arterial e triglicérides. **Conclusões:** a alta prevalência de fatores de risco em adolescentes escolares reforça a necessidade de intervenções para redução do risco cardiovascular nessa população.

**Descritores:** Adolescente; Escola; Doenças Cardiovasculares; Pressão Sanguínea; Risco Cardiovascular.

## RESUMEN

**Objetivos:** identificar riesgo cardiovascular y factores de riesgo cardiovascular en adolescentes y verificar las correlaciones entre estas variables y marcadores bioquímicos, y entre percentiles de presión arterial, Índice de Masa Corporal y marcadores bioquímicos. **Métodos:** estudio transversal, realizado en una escuela brasileña, de agosto a septiembre de 2019, que incluyó a 205 participantes que fueron entrevistados. Después de la entrevista, se realizaron evaluaciones antropométricas que incluyeron peso, talla, perímetro del brazo, medición de la presión arterial y extracción de sangre para pruebas de laboratorio. El análisis descriptivo e inferencial se realizó mediante la prueba de chi-cuadrado. **Resultados:** el 18,5% tenía percentiles de presión arterial>95%, el 25,4% tenía sobrepeso y el 25,9% tenía un riesgo cardiovascular muy alto.Se encontraron asociaciones estadísticamente significativas entre el riesgo cardiovascular y el sexo, el Índice de Masa Corporal y los percentiles de presión arterial, y entre los percentiles de presión arterial y los triglicéridos. **Conclusiones:** la alta prevalencia de factores de riesgo en estudiantes adolescentes refuerza la necesidad de intervenciones para reducir el riesgo cardiovascular en esta población.

**Descriptores:** Adolescente; Escuela; Enfermedades Cardiovasculares; Presión Sanguínea; Riesgo Cardiovascular.

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## INTRODUCTION

Research on cardiovascular risk factors in adolescents has been developed based on the perception that preventive actions are more effective when implemented in early life. Most cardiovascular diseases can be prevented by reducing exposure to behavioral risk factors such as inadequate diet, physical inactivity, tobacco use, and harmful alcohol use. The effects of behavioral risk factors can be manifested through high blood pressure, high blood glucose, hyperlipidemia, overweight, and obesity[1].

In 2015, the period of commitments related to the Millennium Goals ended and was succeeded by the Target Plan. Then, countries began to set targets on noncommunicable diseases and measure progress against the 2010 benchmarks, which were enshrined in the Global Status Report on Noncommunicable Diseases 2014[2]. In Brazil, the Ministry of Health launched the Strategic Action Plan to tackle Chronic Noncommunicable Diseases (2011-2022), which defines and prioritizes some actions and investments to prepare the country to face such diseases in the following ten years. This plan prioritizes the reduction of the population's exposure to risk factors widely indicated in the literature (smoking, inadequate diet, physical inactivity, and alcohol abuse) and the incentive to protective factors, including the creation of public open spaces for physical activities (for example, the "Health Gym" Program), measures to prohibit cigarette advertising, and the creation of smoke-free environments, in addition to encouraging healthy eating[3].

In 2017, chronic non-communicable diseases (NCDs) accounted for 73.4% of deaths in the world[4]. It is believed that more than 85% of premature deaths from NCDs of people aged between 30 and 69 years occurred in low-income countries[5]. Ischemic heart disease (IHD) and cerebrovascular disease (CbV) accounted for 60% of deaths from cardiovascular diseases (CVD). Mortality from CVD had important regional variations in Brazil, with higher rates in the South and the Southeast, and convergence of mortality rates from IHD and CVD in the five regions[6].

In Brazil, CVD account for 20% of all deaths in people over 30 years of age, with the highest rates in the South and the Southeast. Mortality due to CVD has increased in the Northeast from 1980 to 2012[7]. In 1997, NCDs accounted for approximately one-third (32.7%) of the total deaths in the state of Ceará, Brazil, located in the Northeast. In 2016, this proportion reached almost half of all registered deaths (49.4%), representing an increase of 51.1% in 19 years[8].

Among the risk factors for CVD, arterial hypertension stands out, representing a serious public health problem globally and in Brazil. In Brazil, the disease affects 32.5% (36 million) of adults and more than 60% of older adults, contributing directly or indirectly to 50% of deaths from CVD[1-9]. Research also points to an increase in overweight and obesity in the Brazilian population. These rates, associated with a sedentary lifestyle, are also increasing in children and adolescents, making them susceptible to CVD in early life[10].

Studies involving children and adolescents revealed that blood pressure disorders and other morphological risk indicators, such as body fat distribution, may begin during adolescence[11]. Eating habits and exercise routines are formed while adolescents progressively attain their independence and thus can enhance or impair lifestyles and health in adulthood[12]. All these aspects can directly influence the emergence of CVD. Researching the presence of these risk factors in adolescents can contribute to planning strategies with this population, in order to prevent undesirable health situations in adult life.

The adoption of measures aimed at early control of cardiovascular risk factors may allow the primary prevention of CVD[13]. Therefore, it is necessary to extend programs and research that assess and monitor the cardiovascular health of adolescents.

As the most frequent NCDs (cardiovascular disease, diabetes and cancer) share several risk factors, WHO proposes an integrated prevention and control approach focused on all ages, including children and adolescents, and based on reduction of the following problems: arterial hypertension, smoking, alcohol use, physical inactivity, inadequate diet, obesity, and hypercholesterolemia[14]. Therefore, there is a need to investigate the existence of these factors in the study population.

A study on cardiovascular behavior and risk in adolescents emphasizes that it has been observed that the presence of two or more risk factors during adolescence is sufficient to predict a cardiovascular event during the following 10 years. This is because when these factors are present in combination they increase the extent and severity of vascular injuries, which predominantly emerge during adulthood[15].

Conducting research with the scope of identifying cardiovascular risk factors in adolescents is extremely important for early intervention and reduction of future disorders with the potential to generate serious diseases (such as heart attack and CbVs) and irreversible consequences for individuals and populations, leading to increasing costs to the health system that could have been avoided. It is also considered important to investigate the real existence of these factors in populations from different regions for more specific interventions, considering that they would be more effective.

## OBJECTIVES

To identify cardiovascular risk and cardiovascular risk factors in adolescents, verify associations between these variables and biochemical markers, and compare blood pressure percentiles with lifestyle habits, Body Mass Index, and biochemical markers.

## METHODS

### Ethical aspects

The research protocol was approved by the Institutional Review Board of the *Universidade Federal do Ceará* in June 2018 and complied with all recommendations of Resolution 466/12 of the Brazilian National Health Council (*Conselho Nacional de Saúde*). The Informed Consent Forms were signed by adolescents and their parents.

### Study design, place, and period

A cross-sectional observational study was conducted at a secondary school located in Acarape, Ceará, Brazil. Data collection was performed between August 2016 and February 2018.The STROBE (STrengthening the Reporting of Observational studies in epidemiology) guidelines were used to ensure the quality of study dissemination.

### Population/sample and eligibility criteria

The study population consisted of adolescents enrolled in the selected school, totaling 520 students. The study sample was calculated using a formula recommended for cross-sectional studies involving finite populations[16]. The following parameters were considered: 95% confidence coefficient ($Z\alpha = 1.96$), sampling error of 5%, and event prevalence (arterial hypertension in adolescents) of 8%. The final sample consisted of 205 adolescents.

Adolescents from 10 to 19 years old, regularly enrolled in the selected school were included. Adolescents with clinical conditions that could make data collection unfeasible or fasting longer than 12 hours before the blood sample collection were excluded.

### Study protocol

Data were collected through individual interviews with the adolescents using a form with sociodemographic, personal, and family history of cardiovascular morbidity information and questions about physical activity and eating habits. After the interview, anthropometric assessments, including weight, height, arm circumference, waist, and hip measurements were made, followed by blood pressure checking and blood collection for laboratory tests (blood glucose, LDL and HDL, dosage of urea, creatinine, TGO, and TGP). The laboratory analyses were scheduled according to the capacity of the personnel responsible for blood sample collection.

The following equipment was used for anthropometric data collection: a tested and calibrated anthropometric scale with a capacity of 150 kg and accuracy of 100 g; an anthropometric scale with height assessment pole, capacity of 2m and sensitivity of 0.5 cm; and a non-distensible measuring tape with 0.1 cm intervals and 100 cm extension (for the measurement of waist and hip circumferences). Weight and height measurements were used for the calculation of participants' Body Mass Index (BMI).

Waist circumference measurement was made by positioning the non-distensible tape horizontally at the midpoint between the iliac crest and the lowest rib, asking participants to take a normal inspiration followed by a slow expiration, and taking the measure after that. Hip circumference measurement was taken around the widest point of the buttocks. These measures were taken with the tape firmly placed on the skin but without compressing the tissues. Waist and hip circumferences were used to obtain the waist-hip ratio.

Blood pressure was measured using the auscultatory method, using the following equipment: sphygmomanometers with aneroid manometers *Tycos* brand, properly tested and calibrated, double stethoscopes *Littmann* and sets of cuffs of variable widths (8cm, 9cm, 10cm, 11cm, 12cm, and 13cm). Blood pressure assessment was made based on the 7$^{th}$ Brazilian Guideline of Arterial Hypertension[17]. This was the reference material which contained the protocol adopted for measuring blood pressure.

Systolic pressure measurement was made by the appearance of the first sound (phase I of Korotkoff); on the other hand, diastolic pressure measurement was carried out of the disappearance of the sound (phase V of Korotkoff). Blood pressure measurements were obtained at two consecutive times with one-minute intervals between each assessment. If values were greater than 6mmHg, a third measurement was performed. The final value considered was the average of the measurements.

Blood pressure classification also followed the7$^{th}$ Brazilian Guideline of Arterial Hypertension[17]: without alteration (below the 90$^{th}$ percentile); borderline (between the 90$^{th}$ and 95$^{th}$ percentiles); and hypertension (above the 95$^{th}$ percentile).

Blood samples were collected at the school early in the morning, with students still fasting. The blood samples were collected over a week to contemplate all students and guarantee test reliability. Blood samples were taken daily to a laboratory near the collection site for centrifugation, refrigeration and stored until the end of the data collection period. By completing the collection of all blood samples, they were taken to a Clinical and Toxicological Analysis Laboratory.

As the study population consisted of adolescents and, due to the lack of diagnostic information about health changes, it was not possible to use the Framingham classification to establish cardiovascular risk. Therefore, the waist-hip ratio was chosen as the main marker of cardiovascular risk, considering a study carried out Effect of potentially modifiable risk factors associated with myocardial infarction[18]. The following classification was used: (a) For females: low risk: <0.71, moderate risk: 0.71-0.77, high risk: 0.78-0.82, and very high risk: >0.82; and (b) For males: low risk: <0.83, moderate risk: 0.83-0.88, high risk: 0.89-0.94, and very high risk: >0.94.

The laboratorial parameters described by the manufacturers of the materials used in the blood testing and confirmed in the literature were adopted[19-20], as follows: (a) Blood glucose: hypoglycemia: <65 mg/dl; without alteration: 65-99 mg/dl; hyperglycemia: >99 mg/dl; (b) Total cholesterol: without alteration: <170 mg/dl; and high: ≥170 mg/dl; (c) Triglycerides: without alteration: <130 mg/dl; and high: >130 mg/dl; (d) HDL: without alteration: >45 mg/dl; and low: <45 mg/dl; (e) LDL: without alteration: <110 mg/dl; and high: >110 mg/dl; (f) Urea: without alteration: 8-36 mg/dl (for children aged 10 to 13 years) or 15-40 mg/dl (for children aged 14 years or more); (g) Creatinine: without alteration: 0.32-1 mg/dl; (h) TGO: without alteration: 4-36 U/ml; and (i) TGP: without alteration: 24-59 U/ml.

### Analysis of results and statistics

Data were tabulated in Microsoft Excel spreadsheets and analyzed using IBM SPSS Statistics, version 20, for descriptive and inferential analysis. The results were presented in tables displaying absolute and relative frequencies, central tendency, and dispersion measures. Pearson's chi-square and Fisher's exact tests were used to analyze the existence of categorical variables in the study, the latter being used when the data did not meet the chi-square assumptions. A 5% significance level and a 95% confidence interval were established, with a significant level of $p \leq 0.05$.

**Ethical approval**

The research was approved by the Institutional Review Board of the university in which the study took place, and parents signed an informed consent form and the adolescents signed the assent term.

## RESULTS

The sample calculation totaled 202 adolescents, but due to the possibility of losing participants during blood testing, three more participants were included, totaling 205 subjects.

Of the total participants, 27.3% (n = 56) were 11 years old, 25.4% (n = 52) were 13 years old, 20.5% (n = 42) were 12 years old, 20.0% (n = 41) were 14 years old, 3.9% (n = 8) were 15 years old, 1.5% (n = 3) were 10 years old, 0.5% (n = 1) were 16 years old, 0.5% (n = 1) were 17 years old, and 0.5% (n = 1) were 18 years old. There was a predominance of females, 61% (n = 125), with a mean age, in both sexes, of 12.54 years (SD: ±1.35). Regarding the level of maternal education, it was identified that most of students' mothers had low education, as 75.6% (n = 155) had elementary school education.

Table 1 shows factors that can lead to cardiovascular changes.

Many variables were normal in the sample of adolescents. However, it is worrying that 18.5%, 25.4%, 32.2%, and 31.2% of participants had blood pressure percentiles above 95, overweight, and high creatinine and TGO values, respectively. Moreover, alterations were identified in all remaining parameters.

Table 2 shows the classification of cardiovascular risk in adolescents.

As previously mentioned, cardiovascular risk assessment using Framingham's criteria is only established for adult individuals. Thus, the waist-hip ratio was used for the study population, and 27.3% presented high cardiovascular risk, while 25.9% were classified as very high risk.

**Table 1** - Blood pressure percentiles, Body Mass Index, and biochemical markers in adolescents

| Variables | n | % | Mean | SD |
|---|---|---|---|---|
| Blood pressure percentiles | | | 91.86 | ± 3.55 |
| <90 | 159 | 77.6 | | |
| 90 – 95 | 8 | 3.9 | | |
| > 95 | 38 | 18.5 | | |
| BMI | | | 20.61 | ± 4.18 |
| Underweight | 16 | 7.8 | | |
| Eutrophic | 137 | 66.8 | | |
| Overweight | 52 | 25.4 | | |
| Blood glucose (mg/dl) | | | 81.80 | ± 8.75 |
| Hypoglycemia | 6 | 2.9 | | |
| Without alteration | 196 | 95.6 | | |
| Hyperglycemia | 3 | 1.5 | | |
| Total cholesterol (mg/dl) | | | 140.03 | ± 24.83 |
| Without alteration | 184 | 89.8 | | |
| High | 21 | 10.2 | | |
| Triglycerides (mg/dl) | | | 73.36 | ± 34.20 |
| Without alteration | 189 | 92.2 | | |
| Altered | 16 | 7.8 | | |
| HDL cholesterol mg/dl) | | | 58.82 | ± 13.60 |
| Without alteration | 173 | 84.4 | | |
| Altered | 32 | 15.6 | | |
| LDL cholesterol (mg/dl) | | | 66.60 | ± 20.84 |
| Without alteration | 200 | 97.6 | | |
| Altered | 5 | 2.4 | | |
| Uric Acid (mg/dl) | | | 3.06 | ± 0.91 |
| Without alteration | 204 | 99.5 | | |
| Altered | 1 | 0.5 | | |
| Urea | | | 19.61 | ± 7.45 |
| Low | 8 | 3.9 | | |
| Without alteration | 192 | 93.7 | | |
| High | 5 | 2.4 | | |
| Creatinine | | | 0.65 | ± 0.31 |
| Low | 9 | 4.4 | | |
| Without alteration | 130 | 63.4 | | |
| High | 66 | 32.2 | | |
| TGO | | | 37.17 | ± 12.53 |
| Low | - | - | | |
| Without alteration | 141 | 68.8 | | |
| High | 64 | 31.2 | | |
| TGP | | | 15.78 | ± 11.80 |
| Low | 174 | 84.9 | | |
| Without alteration | 27 | 13.2 | | |
| High | 4 | 1.9 | | |

*SD - Standard Deviation; BMI – Body Mass Index; HDL - High Density Lipoprotein; LDL - Low Density Lipoprotein; TGO - Oxalacetic Glutamic Transaminase; TGP - Pyruvic Glutamic Transaminase.*

**Table 2** - Cardiovascular risk assessment in adolescents

| Variables | n | % |
|---|---|---|
| Cardiovascular risk | | |
| Low | 43 | 21.0 |
| Moderate | 53 | 25.8 |
| High | 56 | 27.3 |
| Very high | 53 | 25.9 |
| Total | 205 | 100 |

In addition to identifying cardiovascular risk, we tested associations between the level of risk and other variables of interest, including blood pressure percentiles and laboratory findings, as shown in Table 3.

Statistically significant associations were found between cardiovascular risk and sex and between BMI and blood pressure percentiles. Despite the absence of significant associations between the other variables, altered laboratory findings were observed in all tests.

Considering that arterial hypertension is an important cardiovascular risk factor, associations between blood pressure percentiles, lifestyle factors, laboratory findings, and BMI were also tested (Tables 4 and 5).

No statistical association was found between blood pressure percentiles and the variables tested. However, cardiovascular risk-relevant lifestyle factors were present in the sample. A statistically significant association was found between BMI and blood pressure percentiles (normal BMI values were associated with low blood pressure percentile).

Table 5 shows that a statistically significant association between blood pressure percentiles and triglycerides was observed. Normal triglyceride values were associated with normal blood pressure percentiles.

**Table 3** - Associations between the level of cardiovascular risk, risk factors, blood pressure percentiles, and biochemical markers

| Variables | Cardiovascular risk | | | | | | *p* value |
|---|---|---|---|---|---|---|---|
| | Low | | Moderate | | High / Very high | | |
| | n | % | n | % | n | % | |
| Sex | | | | | | | **<0.001[a]** |
| Female | 5 | 4.0 | 27 | 21.6 | 93 | 74.4 | |
| Male | 38 | 47.5 | 26 | 32.5 | 16 | 20.0 | |
| BMI | | | | | | | **<0.001[a]** |
| Underweight | 7 | 43.8 | 3 | 18.8 | 2 | 37.5 | |
| Eutrophic | 32 | 23.4 | 43 | 31.4 | 62 | 45.3 | |
| Overweight | 4 | 7.7 | 7 | 13.5 | 41 | 78.8 | |
| Blood pressure percentiles | | | | | | | **0.05[b]** |
| 90 | 36 | 22.6 | 45 | 28.3 | 78 | 49.1 | |
| 95 | 3 | 37.5 | 2 | 25.0 | 3 | 37.5 | |
| 99 | 4 | 10.5 | 6 | 15.8 | 28 | 73.7 | |
| Blood glucose | | | | | | | 0.43[b] |
| Without alteration | 42 | 21.4 | 52 | 26.5 | 102 | 52.0 | |
| Altered | 1 | 11.1 | 1 | 11.1 | 7 | 77.8 | |
| Total cholesterol | | | | | | | 0.21[a] |
| Without alteration | 38 | 20.7 | 51 | 27.7 | 95 | 51.6 | |
| Altered | 5 | 23.8 | 2 | 9.5 | 14 | 66.7 | |
| Triglycerides | | | | | | | 0.92[a] |
| Without alteration | 39 | 20.6 | 49 | 25.9 | 101 | 53.4 | |
| Altered | 4 | 25.0 | 4 | 25.0 | 8 | 50.0 | |
| HDL | | | | | | | 0.15[a] |
| Without alteration | 9 | 28.1 | 11 | 34.4 | 12 | 37.5 | |
| Altered | 34 | 19.7 | 42 | 24.3 | 97 | 56.1 | |
| LDL | | | | | | | 0.41[b] |
| Without alteration | 42 | 21.0 | 53 | 26.5 | 105 | 52.5 | |
| Altered | 1 | 20.0 | - | - | 4 | 80.0 | |
| Uric acid | | | | | | | 0.21[b] |
| Without alteration | 42 | 20.6 | 53 | 26.0 | 109 | 53.4 | |
| Altered | 1 | 100.0 | - | - | - | - | |
| Urea | | | | | | | 0.81[a] |
| Without alteration | 41 | 21.4 | 50 | 26.0 | 101 | 52.6 | |
| Altered | 2 | 15.4 | 3 | 23.1 | 8 | 61.5 | |
| Creatinine | | | | | | | 0.71[a] |
| Without alteration | 26 | 20.0 | 32 | 24.6 | 72 | 55.4 | |
| Altered | 17 | 22.7 | 21 | 28.0 | 37 | 49.3 | |
| TGO | | | | | | | 0.44[b] |
| Without alteration | 33 | 23.4 | 36 | 25.5 | 72 | 51.1 | |
| Altered | 10 | 15.6 | 17 | 26.6 | 37 | 57.8 | |
| TGP | | | | | | | 0.26[a] |
| Without alteration | 3 | 11.1 | 6 | 22.2 | 18 | 66.7 | |
| Altered | 40 | 22.5 | 47 | 26.4 | 91 | 51.1 | |

*[a]Pearson's chi-square; [b]Fisher's exact test; BMI – Body Mass Index; HDL - High Density Lipoprotein; LDL - Low Density Lipoprotein; TGO - Oxalacetic Glutamic Transaminase; TGP - Pyruvic Glutamic Transaminase*

**Table 4 -** Associations between blood pressure percentiles, lifestyle habits, and Body Mass Index

| Variables | Blood pressure percentiles <90 | | 90 - 95 | | > 95 | | *p* value |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | |
| Vegetable consumption | | | | | | | 0.55[a] |
| Yes | 69 | 76.7 | 5 | 5.5 | 16 | 17.8 | |
| No | 90 | 78.3 | 3 | 2.6 | 22 | 19.1 | |
| Fruit consumption | | | | | | | 0.22[a] |
| Yes | 128 | 79.5 | 7 | 4.4 | 26 | 16.1 | |
| No | 31 | 70.4 | 1 | 2.3 | 12 | 27.3 | |
| Fat consumption | | | | | | | 0.24[b] |
| Yes | 141 | 75.8 | 8 | 4.3 | 37 | 19.9 | |
| No | 18 | 94.7 | - | - | 1 | 5.3 | |
| Physical activity practice | | | | | | | 0.18[a] |
| 0 - 149 min/week | 60 | 70.6 | 4 | 4.7 | 21 | 24.7 | |
| ≥ 150 min/week | 99 | 82.5 | 4 | 3.3 | 17 | 14.2 | |
| BMI | | | | | | | **<0.001[a]** |
| Without alteration | 121 | 88.3 | 5 | 3.7 | 11 | 8.0 | |
| Altered | 38 | 55.9 | 3 | 4.4 | 27 | 39.7 | |

*[a]Pearson's chi-square; [b]Fisher's exact test; [*]BMI – Body Mass Index.*

**Table 5** -Associations between blood pressure percentiles and biochemical markers

| Variables | Blood pressure percentiles <90 | | 90 - 95 | | > 95 | | *p* value |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | |
| Blood glucose | | | | | | | 0.26[b] |
| Without alteration | 153 | 78.0 | 7 | 3.6 | 36 | 18.4 | |
| Altered | 6 | 66.7 | 1 | 11.1 | 2 | 22.2 | |
| Total cholesterol | | | | | | | 0.27[b] |
| Without alteration | 144 | 78.3 | 6 | 3.2 | 34 | 18.5 | |
| Altered | 15 | 71.4 | 2 | 9.5 | 4 | 19.1 | |
| Triglycerides | | | | | | | **0.03[b]** |
| Without alteration | 145 | 76.7 | 6 | 3.2 | 38 | 20.1 | |
| Altered | 14 | 87.5 | 2 | 12.5 | - | - | |
| HDL | | | | | | | 1.00[a] |
| Without alteration | 134 | 77.5 | 7 | 4.0 | 32 | 18.5 | |
| Altered | 25 | 78.1 | 1 | 3.1 | 6 | 18.8 | |
| LDL | | | | | | | 0.38[b] |
| Without alteration | 156 | 78.0 | 8 | 4.0 | 36 | 18.0 | |
| Altered | 3 | 60.0 | - | - | 2 | 20.0 | |
| Uric acid | | | | | | | 1.00[b] |
| Without alteration | 158 | 77.5 | 8 | 3.9 | 38 | 18.6 | |
| Altered | 1 | 100.0 | - | - | - | - | |
| Urea | | | | | | | 0.58[a] |
| Without alteration | 149 | 77.6 | 7 | 3.6 | 36 | 18.8 | |
| Altered | 10 | 76.9 | 1 | 7.7 | 2 | 15.4 | |
| Creatinine | | | | | | | 0.31[a] |
| Without alteration | 102 | 78.5 | 3 | 2.3 | 25 | 19.2 | |
| Altered | 57 | 76.0 | 5 | 6.7 | 13 | 17.3 | |
| TGO | | | | | | | 0.63[a] |
| Without alteration | 107 | 75.9 | 5 | 3.5 | 29 | 20.6 | |
| Altered | 52 | 81.2 | 3 | 4.7 | 9 | 14.1 | |
| TGP | | | | | | | 0.28[a] |
| Without alteration | 18 | 66.7 | 7 | 3.7 | 8 | 29.6 | |
| Altered | 141 | 79.2 | 7 | 3.9 | 30 | 16.9 | |

*[a]Pearson's chi-square; [b]Fisher's exact test; HDL - High Density Lipoprotein; LDL - Low Density Lipoprotein; TGO - Oxalacetic Glutamic Transaminase; TGP - Pyruvic Glutamic Transaminase.*

## DISCUSSION

In this research, a high and very high cardiovascular risk was identified in 53.2% of adolescents, and associations between cardiovascular risk, BMI, sex, and blood pressure percentiles were observed. Blood pressure percentiles were associated with BMI and triglycerides.

Adolescents with altered blood pressure, BMI, and laboratory findings were identified. Although the presence of altered blood pressure does not necessarily determine a diagnosis of arterial hypertension, these changes may indicate a risk of developing cardiovascular problems in adulthood[9]. Considering BMI in childhood and the risk of coronary events in adulthood, each increased BMI unit represents an increase in the probability of future coronary events, and this association can increase even more with aging[3].

A study conducted with students from two public schools in Rio de Janeiro, Brazil, showed that capillary blood glucose was normal in all students, while approximately 40% were overweight or obese. Furthermore, about 50% of students had high triglyceride values[21]. As to the lipid and glycemic profile, one study found high values of total cholesterol (57.1%) and LDL (35%) and low values of HDL (32.9%) in a sample of adolescents[22]. Another study has shown that about 17% of Americans have cholesterol levels equal to or above 240 mg/dl, which has been considered a relevant risk factor for developing heart diseases[23]. In the present study, all laboratory variables were altered in at least part of the sample. This aspect is worrying, since it indicates exposure to risk of possible changes or complications in adult life.

In the present study, a high percentage of adolescents with cardiovascular risk was found, and more than half of the sample was at high or very high risk. In Minas Gerais, Brazil, a population-based epidemiological study was carried out with 1,397 children aged 6-10 years in public and private schools. This study adopted waist circumference for cardiovascular risk prediction. The results showed that waist circumference was an important predictor of metabolic syndrome in children, and it was also effective in predicting low HDL, high blood pressure, and hypertriglyceridemia[24].

Besides, many adolescents assessed in the present study had cardiovascular risk factors related to lifestyle, altered blood pressure percentiles, and altered laboratory findings. Significant associations were also found between cardiovascular risk, BMI, and blood pressure percentiles, and between blood pressure and BMI percentiles. A high prevalence of cardiovascular risk factors (obesity, altered waist circumference, and high blood pressure) was found in a cohort study conducted in Texas from 2007 to 2010 with Hispanic adolescents. The authors suggest the need for comprehensive interventions to prevent future CVD in adolescents[25]. Another study on the association between intima-media thickness in the carotid bifurcation, age, and cardiovascular risk factors in children and adolescents found a significant correlation between BMI and the cardiovascular risk score[26].

The prevalence of arterial hypertension increases in the adolescent population due to environmental and lifestyle factors[27]. Together with thisstudy's findings, this fact reinforces the need for interventions in this population.

Most adolescents who regularly ate fruits and vegetables and practiced physical activity regularly presented normal blood pressure percentiles. On the other hand, many students reported eating fats (mainly in snacks), and, apparently, this had not been reflected in their blood pressure percentiles. However, studies indicate that this habit, in the long run, may cause damage to cardiovascular health[11,28]. Eating habits and physical exercise practices adopted in childhood and adolescence can be reflected in adulthood, since there is evidence that atherosclerosis starts in the first years of life, progressing slowly over time[28]. Lifestyle behaviors and modifiable risk factors for CVD can be observed from childhood and its persistence is associated with early diagnosis of CVD in adulthood[29].

Identifying factors related to cardiovascular changes and that increase cardiovascular risk in a portion of the young population is important, in order to establish strategies for implementing more effective interventions. Monitoring metabolic and hemodynamic changes together with the identification of risk groups during youth are necessary actions to formulate effective preventive strategies[30]. It is worth noting that the clinical impact of cardiovascular complications, at advanced ages, can cause individual, collective, and social damage. Therefore, the need to identify these changes as early as possible is justified.

Additional strategies must be implemented, in addition to monitoring the adolescents through primary health care services. Public health policies must be established to early detect cardiovascular changes and improve the prevention of cardiovascular disorders in adolescents, aiming to mitigate such diseases.

It is noteworthy that, in this study, even identifying statistical associations between cardiovascular risk, BMI, sex and blood pressure percentiles, and between blood pressure percentiles, BMI and triglycerides, this does not mean a causal association, as there is no temporality, an important criterion to establish causality itself. Thus, it is important to emphasize that causality was not identified in this study, as this is a cross-sectional study.

It is also important to emphasize that this study was carried out in a city in the countryside of northeastern Brazil. Thus, factors such as socioeconomic level, school absenteeism and regional characteristics may have influenced the results found. Therefore, further research on the topic using different approaches and locations is recommended.

### Study limitations

The cross-sectional design of the study is a limitation, as it does not allow for casual inferences.

### Contributions to nursing and health

Identifying cardiovascular risk factors in the young population is important to establish early and effective interventions. Besides, the clinical impact of cardiovascular complications at advanced ages can bring individual, collective, and social losses. Therefore, it is expected that the findings of this study provide insights for the need for implementing preventive measures against CVD in children and adolescents.

## CONCLUSIONS

Upon meeting the objectives of this research, it was possible to verify that adolescents had cardiovascular risk and several risk factors for cardiovascular alterations. The main findings were: (1) high and very high cardiovascular risk in 53.2% of the sample;

(2) alterations in blood pressure (>95 percentile) in 18.5% of the sample; (3) overweight in 25.4% of the sample; (4) altered cholesterol in 10.2% participants; (5) altered HDL values in 15.65% of the sample; (6) high creatinine in 32.2% of the sample; (7) high TGO values found in 31.2% participants; (8) statistical association between cardiovascular risk, sex, BMI, and blood pressure percentiles; and (9) significant association between blood pressure percentiles, triglyceride levels, and BMI values.

The study participants were under cardiovascular risk and exposed to cardiovascular risk factors that may result in diseases in adulthood.

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