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BODY MASS INDEX AND BLOOD PRESSURE IN ADOLESCENTS FROM AN URBAN AREA IN MEXICO

ÍNDICE DE MASA CORPORAL Y PRESIÓN ARTERIAL EN ADOLESCENTES DE UNA ZONA URBANA EN MÉXICO

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ABSTRACT

Introduction: The changes brought about by the COVID-19 pandemic in adolescent activities have affected recreational aspects due to limited contact to prevent virus spread. This has contributed to increased indicators of overweight and obesity and could impact blood pressure levels. **Objective:** To determine the degree of association between Body Mass Index (BMI) and systemic blood pressure in adolescents. **Methods:** Systemic blood pressure was measured using continuous ambulatory blood pressure monitoring over 24 hours (ABPM). The sample consisted of 42 high school students with similar urban geographic characteristics in Mexico. All participants underwent anthropometric evaluation to identify notable group characteristics. The correlation was assessed using Spearman's Rho test. **Results:** Of the 42 participants included, 28.5% showed obesity, 21.45% were overweight, and no patient had hypertension. However, 23.8% showed prehypertension. A significant correlation was evidenced between BMI and both systolic and diastolic blood pressure values, at 0.390 and 0.382, respectively (p-value: 0.013 and 0.015, respectively). Conclusion: BMI was significantly associated with systolic and diastolic blood pressure levels in adolescents from an urban area in Mexico.

Keywords: Adolescent; Body Mass Index; Obesity; Arterial Pressure; Hypertension. (Source: MESH-NLM)

RESUMEN

Introducción: Los cambios realizados por la pandemia de COVID-19 en las actividades de los adolescentes han afectado los aspectos recreativos debido a la limitación de contacto para evitar la propagación del virus. Esto ha contribuido a aumentar los indicadores de sobrepeso y obesidad y podría tener un impacto en las cifras de presión arterial. **Objetivo:** Determinar el grado de asociación entre el Índice de Masa Corporal (IMC) y la presión arterial sistémica en adolescentes. **Métodos:** La medición de la presión arterial sistémica se realizó utilizando el monitoreo de presión ambulatoria continua durante 24 horas (MAPA). La muestra consistió en 42 estudiantes de secundaria con características geográficas urbanas similares en México. Todos los participantes fueron evaluados antropométricamente para identificar características notables del grupo. Se evaluó la correlación a través de la prueba Rho de Spearman. **Resultados:** De los 42 participantes incluidos, el 28,5% mostró obesidad, el 21,45% presentó sobrepeso y ningún paciente tenía hipertensión. Sin embargo, el 23,8% mostró prehipertensión. Se evidenció una correlación significativa del IMC con los valores la presión arterial sistólica y diastólica de 0,390 y 0,382, respectivamente (valor de p: 0,013 y 0,015; respectivamente). **Conclusión:** El IMC se asoció significativamente con las cifras de presión arterial sistólica y diastólica en adolescentes de un área urbana de México.

Palabras clave: Adolescente; Índice de Masa Corporal; Obesidad; Presión Arterial; Hipertensión. (Fuente: DeCS-BIREME)

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INTRODUCTION

The COVID-19 pandemic has contributed to the development of sedentary practices, altering the routines of individuals and families. The closure of schools and social isolation have changed people's behavior, leading to problems such as poor eating habits, insomnia, and an increase in the use of electronic devices, all linked to augmented sedentary behavior[1,2].

Villaseñor et al. [3], in their study on lifestyle and nutrition changes during confinement in Mexico, reported that around 24% of the surveyed adults considered their diet unhealthy after isolation, due to an increased need to consume food frequently. In a similar study conducted in the United States, Bin Zarah et al.[4] found an increase in the intake of red meat, sweets, and refined cereals after three months of confinement, indicating significant dietary changes.

Initially, a healthy diet was recommended to strengthen the immune system and prevent disease. However, many Mexicans opted for products with high carbohydrate content available on the market, reducing the nutritional value of their diet [5]. A high percentage of people with chronic diseases, such as hypertension, diabetes, and obesity, have presented with overweight, a prevalent problem in both adults and young people [6]. Pérez-Herrera and Cruz López [7] report that one in twenty Mexicans under five years old already suffers from obesity, with a combined prevalence of around 33.2% in children. This increase in prevalence is due to changes in eating habits, increased sedentary behavior, and variations in body mass index (BMI)[8].

These factors are interrelated and show how obesity in children is linked to the risk of developing chronic diseases[9]. Obesity in children and adolescents not only affects self-esteem and causes discrimination but also leads to serious health complications, such as reduced respiratory reserve volume and decreased functional capacity. Additionally, obesity is associated with a chronic inflammatory state that increases morbidity related to COVID-19 infections [10,11]. In recent years, the relationship between obesity and high blood pressure in young people, from school-aged children to adolescents, has been clearly established, attributing it to excess body fat [12]. This etiology is also related to factors such as overweight, high salt intake, alcohol consumption, and sedentary behavior. The increase in blood pressure in children persists into adulthood, causing cardiovascular diseases in the future [13]. This study aims to determine the degree of association between BMI and systemic blood pressure in adolescents.

METHODS

Design and study area

This research has a quantitative, analytical, observational, and cross-sectional approach. It was conducted among adolescents at Colegio Técnico N° 24 in the State of Aguascalientes during 2022. The research environment is an urban context characterized by high population density, developed infrastructure, and access to various public and private services, providing a variety of social and environmental influences on the studied population.

Population and Sample

The study population consisted of adolescents from Colegio Técnico N° 24 in the first to third years of secondary school, aged between 12 to 15 years. Those adolescents who gave their assent and whose parents provided informed consent were included, while those who were withdrawn from the school year, did not complete the ambulatory blood pressure measurement (ABPM), or lacked parental consent were excluded. The study included all available individuals, totaling 53; however, only 42 met the selection criteria.

Variables and Instruments

The independent variables of the study were: age, sex, weight, height, BMI (defined as weight in kilograms divided by height in meters squared; considered normal if between -1 and +1 standard deviations, overweight if greater than +1 standard deviation, and obesity if greater than +2 standard deviations), waist circumference, hip circumference, abdominal perimeter, brachial perimeter, tricipital, bicipital, subscapular, and suprailiac skinfolds, total body fat

percentage, total body water, total muscle mass, hours of sports per week, hours of TV or computer per week, plasma atherogenic index (calculated as the logarithm of the ratio between triglycerides and HDL cholesterol), metabolic age, and parents' weight and height. The waist-to-height ratio was used as a cardiometabolic index, considering a waist circumference greater than 0.5 as a relevant indicator. Patients' weight was measured using a TANITA BC-568 digital scale, and height was measured with a SECA 216 mechanical stadiometer for children and adults.

The dependent variable was systolic blood pressure (SBP) and diastolic blood pressure (DBP) ambulatory (total average, daytime average, and nighttime average). The following categories for blood pressure were defined: normotensive up to the 90th percentile for age and height; prehypertension or high blood pressure between the 90th and 95th percentiles; and systemic arterial hypertension: greater than the 95th percentile for systolic and/or diastolic pressure. A reduction in blood pressure greater than 12% was defined as "Dipper". For ABPM, a CONTEC ABPM50 blood pressure monitor was used.

Procedures

To measure hip circumference, a flexible tape measure was used at the level of the largest protrusion of the gluteal region, with the patient standing, feet together, and weight evenly distributed between both feet. The triceps skinfold was measured on the back of the arm, halfway between the acromion (the highest point of the shoulder) and the olecranon (the point of the elbow), with the arm relaxed and hanging freely. To calculate body fat percentage in the study, formulas developed by Jackson and Pollock were applied. To measure the patients' blood pressure, the guidelines of the Task Force 2008 were followed. Blood pressure was taken with a cuff covering 75% of the length of the forearm between the olecranon and acromion, placing the stethoscope bell in the cubital fossa outside the cuff. Blood pressure was analyzed over 24 hours, with both parents instructed on the system's management.

Anthropometric data such as hip circumference, triceps skinfold, suprailiac skinfold, and body fat percentage were collected through direct measurement in adolescents.

Weight was taken with the patient in an upright position with arms hanging laterally, without moving; height was measured in an upright position without shoes. Additionally, information was collected through surveys with parents about physical activity and screen or TV time.

Statistical Analysis

Data were analyzed and processed using the statistical software SPSS version 23. Descriptive statistics were used to characterize the study population, presenting means and standard deviations for continuous variables, and frequencies and percentages for categorical variables. Differences between groups were assessed using Student's t-tests for independent samples and chi-square tests for categorical variables. Correlations between SBP and DBP with anthropometric and behavioral variables were analyzed using Spearman's correlation coefficient due to the nature of the data. Correlations with a p-value <0.05 were considered significant.

Ethical Aspects

The study was approved by the Research Ethics Committee of Hospital Centenario Miguel Hidalgo in Aguascalientes. Informed consent was obtained from parents and assent from adolescents. Confidentiality and anonymity of participants were ensured at all times.

RESULTS

The Mexican adolescents included in the study have a mean age of 13.12 years (±0.48). The average systolic blood pressure is 104.9 mmHg (±8.20) overall, with daytime and nighttime readings of 109.62 mmHg (±10.94) and 97.26 mmHg (±7.19), respectively. The average diastolic blood pressure is 59.07 mmHg (±7.06), with daytime readings of 64.60 mmHg (±9.58) and nighttime readings of 54.95 mmHg (±7.52). Regarding physical condition, 28.3% of adolescents are obese, 20.8% are overweight, and 50.9% have a normal weight. Additionally, 68.7% of participants are male and 31.3% are female. Other anthropometric measurements are shown in Table 1. It is important to highlight that the students did not present arterial hypertension; however, 23.8% of the sample presented prehypertension. Similarly, 35.7% were non-Dippers.

Table 1. Sociodemographic and clinical characteristics of the Mexican adolescents included in the study.

Characteristics of the Mexican adolescents		
	Age	
	Mean	**SD**
Average age	13.12*	±0.48
	Systolic Blood Pressure (SBP)	
Category	**Mean**	**SD**
Total	104.9	±8.20
Daytime measurement	109.62	±10.94
Nighttime measurement	97.26	±7.19
	Diastolic Blood Pressure (DBP)	
Category	**Mean**	**SD**
Total	59.07	±7.06
Daytime measurement	64.60	±9.58
Nighttime measurement	54.95	±7.52
	Condition Indicator	
Category	**Percentage**	**Quantity**
Obesity	28.3 % **	27
Overweight	20.8%	11
Normal	50.9%	15
	Gender	
Male	68.7%	
Female	31.3%	

*Mean
**Percentage

In Table 2, it can be observed that the anthropometric characteristics of the Mexican adolescent patients included in the study present an average waist circumference of 77.7 cm (±9.41), while the hip circumference has an average of 87.56 cm (±13.92). The triceps skinfold shows an average of 18.40 mm (±8.01) and the biceps skinfold of 10.67 mm (±5.34). Regarding muscle areas, the arm muscle area shows an average of 33.74 cm^2 (±8.64) and the total arm area has an average of 55.72 cm^2 (±15.91). The total muscle mass of the adolescents shows an average of 39.52 kg (±6.36).

Table 2. Anthropometric characteristics of Mexican adolescent patients included in the study.

Variable	Minimum	Maximum	Mean	SD
Waist circumference (cm)	61	103	77.7	±9.41
Hip circumference (cm)	20.5	120	87.56	±13.92
Triceps skinfold (mm)	6	35	18.40	±8.01
Biceps skinfold (mm)	4	28	10.67	±5.34
Subscapular skinfold (mm)	6	30	16.45	±7.32
Suprailiac skinfold (mm)	5	35	17.09	±8.23
Arm muscle area (cm^2)	21.1	62.9	33.74	±8.64
Total arm area (cm^2)	35.1	103.1	55.72	±15.91
% of arm fat area (cm^2)	6.2	53.4	21.98	±11.47
Total muscle mass (kg)	28.4	61.3	39.52	±6.36

SD: Standard Deviation.

The bivariate analysis identified a correlation between average SBP and BMI (Spearman's Rho: 0.390, p=0.013), triceps skinfold, biceps skinfold, suprailiac skinfold, hip circumference, body fat percentage, and hours of sports per week (Table 3).

Table 3. Bivariate correlation of systolic blood pressure with anthropometric measures of Mexican adolescents included in the study.

Variable	Spearman's Rho	p-value
Body Mass Index (BMI)	0.390	0.013
Hip circumference	0.332	0.032
Triceps skinfold	0.358	0.020
Biceps skinfold	0.385	0.012
Suprailiac skinfold	0.630	0.020
Total body fat % (BMI/sex)	0.368	0.018
Hours of TV per week	0.194	0.394
Hours of sports per week	0.420	0.002

Regarding average DBP, a direct proportional relationship was evidenced between it and BMI (Spearman's Rho: 0.382, p=0.015). Additionally, an association was found between average DBP and total body water percentage and hours of sports per week (Table 4).

Table 4. Bivariate correlation of Diastolic Blood Pressure (DBP) with anthropometric measures of Mexican adolescents included in the study.

Variable	Spearman's Rho	p-value
Body Mass Index (BMI)	0.382	0.015
Hip circumference	0.034	0.834
Triceps skinfold	0.040	0.621
Biceps skinfold	0.212	0.123
Suprailiac skinfold	0.123	0.234
Total body fat % (BMI/sex)	0.390	0.020
Hours of TV per week	0.116	0.231
Hours of sports per week	0.387	0.010

As additional results, it was found that prehypertensive group of students had an average weekly TV usage of 21 hours, compared to the normotensive group, which had 15.51 hours per week (p=0.016). On the other hand, the average weekly hours dedicated to sports for the prehypertensive group was 1.8 hours, while the normotensive group spent 6.1 hours per week.

It was also noted that the average systolic blood pressure (SBP) in obese patients was significantly higher compared to patients with normal weight (p=0.035). The average atherogenic index in patients with cardiometabolic risk was 0.36, significantly higher than in patients without risk, who had an average of 0.17 (p=0.030). Additionally, the metabolic age was statistically higher in obese patients compared to those with overweight or normal weight (p=0.016).

DISCUSSION

Childhood obesity and overweight are global concerns, showing high rates and health risks. The World Health Organization [14] recently indicated that around 340 million children and adolescents aged 5 to 19 are overweight or obese, rising from 4% in 1975 to 18% in 2016. However, Ecuador has demonstrated the prevalence of overweight and obesity in children aged 5 to 11 through the National Health and Nutrition Survey (ENSANUT-ECU 2012), being higher in urban areas. This report also highlights that around 32.2% and 26% of children suffer from obesity in urban and rural Sierra regions, respectively [15].

In Mexico, the 2018-ENSANUT survey focused on representing physical activity in children aged 5 to 11 years, reporting overweight and obesity rates of 18.1% and 17.5%, respectively[16]. In 2020, ENSANUT identified that residents aged 12 to 19 years had 21% obesity and 27% overweight [16]. These data are concerning as they indicate an increase in chronic diseases such as obesity, diabetes, hypertension, and others that affect public health and society. Mexico has also shown the prevalence of malnutrition in children, evidencing both undernutrition and increased weight and obesity[17].

This highlights imbalances in nutrient-rich food intake, either by deficit or excess, generating an imbalance between intake and caloric expenditure [18]. The 2006 National Health and Nutrition Survey showed an increase in overweight and obesity levels, reaching 26.5% in children, 33% in adolescents, and 71.9% in adults[19]. Additionally, the Mexican diet is based on high energy density, low fiber, and sugary drinks, along with scarce physical activity[20].

Adolescents have modified their habits to adapt to the situation since the pandemic began, including light physical activities such as watching TV, listening to music, using social media, or sleeping. Family influence motivates adolescents to engage in physical activities, as they receive support and confidence from their relatives[21].

However, the WHO reports that physical activities play an important role in improving the quality of life, especially for those suffering from obesity, hypertension, diabetes, where low levels of activity will benefit their health and reduce the risk of acute respiratory diseases[22]. Moreover, Vergara-Castañeda et al.[23] indicate that physical activity is any bodily movement produced by skeletal muscles, causing energy consumption. Some of these activities are related to cardiovascular work, muscle strength and endurance, flexibility, and coordination. Therefore, moderate physical activities should be performed repetitively, with intervals of 30 to 60 minutes, allowing for adequate weight maintenance, improving defenses against pathogens, thus reducing morbidity and mortality from acute respiratory diseases[24].

Exercise is the main treatment for overweight and obesity, generating greater benefits such as regulating metabolic, muscular, and cardiovascular functions [25]. Guevara et al.[26] evaluated the nutritional status of adolescents in a Mexican public academy and identified that students aged 15 to 17 have BMI ranges of 23.7 kg/m^2 to 24.57 kg/m^2 for boys and girls, respectively. Adolescents reported regular consumption of addictive foods such as chocolates, potato chips, ice cream, flour, and pastries, which may lead to continued obesity into adulthood.

Additionally, the average weekly hours of sports practice for the prehypertensive group is 1.8 hours per week, while for the normotensive group it was 6.1 hours per week. This is different by approximately 4.3 hours per week dedicated to physical recreation. However, Mario et al.[27] indicate that 20.8% of adolescents engage in 1 to 5 hours of physical activity per week. This research has shown that the hours of physical activity in adolescents aged 13 to 15 have decreased over the years. Regarding the average TV usage hours, the prehypertensive group of students had 21 hours per week, compared to the normotensive group, which had 15.51 hours per week.

That is, the high-risk group dedicates more time to leisure using this device. According to Pérez Herrera & Cruz [7], the time children spend watching TV is concerning due to evidence related to childhood obesity as it is one of the most sedentary activities performed by children. This is also related to internet advertising, as most advertisements correspond to sugars and calorie-rich products, influencing the diet of Mexican children[28].

An important limitation of the study is the small sample size, which may affect the generalization of the results. Additionally, as a cross-sectional study, causal relationships between body mass index and blood pressure cannot be established. The research focused on a single urban school, which may not represent all urban adolescents in Mexico. Also, reliance on self-reporting for some variables, such as hours of sports and screen time, could introduce information biases.

CONCLUSION

The present study evidences a significant correlation between BMI and systemic blood pressure in secondary school adolescents. The data indicate that, of the 42 participants evaluated, approximately 28.5% were obese and 21.45% were overweight, highlighting not only the prevalence of weight problems in this population but also its link to elevated blood pressure levels. In particular, it was found that both SBP and DBP are directly related to BMI, with Spearman correlation coefficients of 0.390 and 0.382, respectively. Additionally, although no participant presented systemic arterial hypertension, a considerable 23.8% of adolescents were classified with prehypertension, underscoring the importance of implementing preventive interventions focused on modifying lifestyle habits from an early age. Significant differences were also observed in metabolic age, where obese adolescents recorded statistically higher values

compared to those with overweight or normal weight, highlighting the prolonged metabolic impact that obesity can have from adolescence. These findings underline the urgent need for public health policies and educational programs that promote healthy eating habits and regular physical activity in this age group. This approach would not only help control weight but also prevent the development of hypertension and other cardiovascular complications in the future. Furthermore, these results reinforce the importance of routine blood pressure screenings and BMI assessments in schools to identify and intervene early in at-risk populations.

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