

LIFESTYLE AND HIGH BLOOD PRESSURE AMONG MEXICAN ADOLESCENTS

ESTILO DE VIDA Y PRESIÓN ARTERIAL ALTA EN ADOLESCENTES MEXICANOS

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ABSTRACT

BACKGROUND. High blood pressure (BP) is an important risk factor for cardiovascular disease. The relationship between lifestyle and high BP has been widely documented in adults; nevertheless, the evidence in adolescents is still scarce. **OBJECTIVE.** To assess the association between lifestyle and blood pressure among adolescents. **METHODOLOGY.** A cross-sectional analytical study was conducted on 200 adolescents aged 15 to 19 years. The lifestyle information was obtained with the Health-Promoting Lifestyle Profile questionnaire, made up of six dimensions: nutrition, exercise, health responsibility, stress management, interpersonal support, and self-actualization. In addition, regular consumption of tobacco, alcohol, and coffee was measured. Systolic and diastolic blood pressure was taken twice. High BP was defined when the average of Systolic BP or diastolic BP was ≥ 95 . The association between lifestyle and BP levels was evaluated using adjusted logistic regression models. **RESULTS.** Adolescents with a global unhealthy lifestyle, including ineffective stress management and interpersonal support factors, were more likely to present elevated BP compared to those with a healthy lifestyle. Similar associations were observed in those adolescents who regularly consumed tobacco, alcohol, and coffee. **CONCLUSIONS.** The unhealthy lifestyle, both globally and with respect to several specific factors, was associated with the presence of high BP in Mexican adolescents. Healthy lifestyles should be promoted to control BP from the early stages of life.

Keywords: Adolescent; Lifestyle; blood pressure; hypertension.

RESUMEN

INTRODUCCIÓN. La tensión arterial (TA) alta es un importante factor de riesgo de enfermedad cardiovascular. La relación entre el estilo de vida con la TA en población adulta ha sido ampliamente estudiada; no obstante, la evidencia en adolescentes continúa siendo escasa. **OBJETIVO.** Evaluar la asociación entre el estilo de vida con la presencia de TA alta en adolescentes mexicanos. **MÉTODOS.** Estudio transversal analítico en una muestra de 200 adolescentes de 15 a 19 años. El estilo de vida se determinó con el cuestionario PEPS-I conformado por seis factores: nutrición, ejercicio, responsabilidad en salud, manejo del estrés, soporte interpersonal y autoactualización. Asimismo, se obtuvo información sobre el consumo regular de tabaco, alcohol y café. La TA sistólica y diastólica se midieron por duplicado considerándose como TA alta cuando el promedio de alguna fue \geq percentil 95. La asociación de interés se evaluó con modelos de regresión logística. **RESULTADOS.** Los adolescentes con estilo de vida no saludable de forma global y en los factores manejo del

estrés y apoyo interpersonal tuvieron mayores posibilidades de presentar TA elevada en comparación con aquellos con un estilo de vida saludable. Asociaciones similares se observaron en aquellos adolescentes que consumían regularmente tabaco, alcohol y café. CONCLUSIONES. El estilo de vida no saludable tanto a nivel global como en varios de sus factores se asoció con la presencia de TA alta en adolescentes mexicanos. Se recomienda la promoción de estilos de estiva saludables y el control de la TA desde etapas tempranas de la vida.

Palabras clave: adolescente; estilo de vida; presión arterial; hipertensión.

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INTRODUCTION

When the heart pumps, it uses force to push oxygen-rich blood out to your arteries. The amount of force your blood uses to get through the arteries is known as blood pressure (BP). BP is measured in millimeters of mercury, within the major arterial system of the body. It is conventionally separated into systolic and diastolic determinations. Hypertension or high blood pressure is the sustained elevation of systolic or diastolic blood pressure or both¹. Over the past three decades, the global prevalence of hypertension has increased substantially². It is estimated that approximately more than 1,280 million adults worldwide live with this health problem, which is more frequent in low and middle-income countries³. However, high BP is not exclusive to the adult population, since recent studies have shown the presence of this health condition pressure in adolescents from different parts of the world, with proportions ranging from 10% to 23%^{4,5}. High blood pressure is a widely recognized cardiovascular risk factor due to its potential to favor the development of atheroma, mainly at the level of the

coronary arteries^{6,7}. Although Atherosclerotic disease manifests clinically until adulthood, studies have shown that it begins early in life^{8,9}. Thus, high BP since adolescence might produce changes in the arteries that contribute to the development of cardiovascular disease in adulthood¹⁰.

On the other hand, lifestyle has been defined as the way of life of people, which is based on the interaction between the living conditions and behavior patterns, as well as the sociocultural characteristics and personal factors of each subject¹¹. In adults, lifestyle factors such as diet (*i.e.*, excessive consumption of calories from foods high in saturated fat; excessive salt intake, and decreased consumption of fruits and vegetables), physical inactivity, high alcohol consumption, and tobacco, have been associated with an increase in blood pressure levels^{6,12}. Therefore, changes made to these factors could have an impact on blood pressure reduction.^{13,14}. Adolescence is a period in which important physical, psychological, and contextual changes occur for the

establishment of the lifestyle, being a critical moment where the habits acquired during childhood are consolidated and others transmitted through the social context are integrated into how the adolescent develops¹⁵.

Although there is no precise data on the prevalence of high BP in adolescents in Mexico, studies have reported rates between 10.4% and 14.1%^{16,17}; increasing by 20% in adolescents suffering from obesity¹⁸. Obesity among Mexican adolescents may be due to physical inactivity or an unhealthy diet; however, the evidence is still scarce. Only one study published to date has examined the relationship between lifestyle and blood pressure levels in Mexican adolescents. This study found that the joint presence of smoking, alcohol consumption, illegal drug use, and reduced physical activity was positively associated with high BP in a group of adolescents¹⁹. Considering that the risk factors present in the early stages of life are predictive of risk in adult life, the objective of our study was to evaluate the association between lifestyle with presence of high BP in a group of adolescents aged 15 to 19 years in Hidalgo, Mexico.

MATERIAL AND METHODS

Design and study population

An analytical cross-sectional study was carried out on a sample of 200 adolescents residing in the municipality of Mixquiahuala, Hidalgo, Mexico. Based on data previously reported in our country¹⁶, we calculated the sample size to estimate a percentage of high BP of at least 14.1% with a confidence level of 95%, taking into account that there were 3,973 adolescents

(15 to 19 years) in the municipality²⁰. During November and December 2021, a dissemination campaign was carried out to invite adolescents to participate in the study. Between January to February 2022, data collection was performed. The sample included men and women (not pregnant) between the ages of 15 and 19, with no previous diagnosis of hypertension, thyroid, and/or heart problems.

Ethical aspects

Before participation in the present study, informed consent was obtained from parents and assent from each adolescent. The study was carried out following the ethical standards of the Declaration of Helsinki. In addition, the protocol of the present research study was approved by the Ethics and Research Committee of the Superior School of Tlahuelilpan of the Autonomous University of the Hidalgo State (code assigned: 2021-I-XVIII-II).

Lifestyle

To identify the lifestyle of the participants, the Spanish language version of the Health-Promoting Lifestyle Profile questionnaire (HPLP-I) designed by Nola J. Pender was applied²¹; HPLP-I has been previously used in the Mexican population with acceptable internal consistency (Cronbach's alpha >0.70). This instrument is made up of 48 reagents that are subdivided into six dimensions: I) nutrition, which evaluates the selection and consumption of food for sustenance, well-being, and health; II) exercise, which measures constant participation in light, moderate or vigorous activities within daily life or leisure; III) responsibility in

health, which explores the participation of the individual to manage their well-being; IV) stress management, which assesses the degree to which a person can identify and mobilize the psychological and physical resources available to effectively control or reduce stress levels; V) interpersonal support; evaluates the individual's perception of the social support they receive and; VI) self-actualization, explores the individual's self-updating on the information necessary for self-care of health. The HPLP-I has a Likert-type response pattern of four criteria (1, never; 2, sometimes; 3, frequently; 4, routinely), depending on the frequency with which the subject experienced the situation described in each item. The values obtained in each reagent are added to obtain a total score that ranges from 48 to 192 points, the highest score refers to a healthy lifestyle. Based on previously suggested cut-off points, the participants with a score ≥ 121 were classified as having a global healthy lifestyle, while the rest as unhealthy^{22,23}. The cut-off points for each PEPS-I dimension are presented below: nutrition, ≥ 16 ; exercise ≥ 14 ; health responsibility ≥ 26 ; stress management, ≥ 18 ; interpersonal support ≥ 33 self-actualization^{22,23}.

Blood pressure levels

Systolic and diastolic BP in mmHg were measured with a MICRO LIFE digital sphygmomanometer (BP3AG1) with a precision of 1 mmHg. The measurement was made on the left arm resting at heart level, with the participant seated and after a minimum rest period of 10 minutes. Measurements were made in

duplicate with a minimum difference of five minutes between both shots. For the analysis of this study, the average of the two measurements of systolic BP and diastolic BP, respectively, was calculated. The presence of high BP was defined from the ≥ 95 th percentile of the mean systolic BP or diastolic BP for the adolescent's age, sex, and height, according to the criteria of the national program for the prevention, diagnosis, evaluation, and control of hypertension. arterial hypertension for identification of high blood pressure in children and adolescents²⁴. Considering the criteria for the definition of high BP, the height of each participant was also measured in centimeters (cm) using a Seca 213© brand stadiometer with a capacity of up to 205 cm in length and a reading precision of 1 mm. For the measurement of height, each participant was asked to be barefoot, with the heels together, as well as the back and buttocks touching the vertical surface of the stadiometer and the head located in the Frankfort plane.

Covariates

Through a general data questionnaire, information was obtained on covariates of interest from the participants, such as age, sex, schooling, family history of hypertension, family monthly income, and father's and mother's education. Because the HPLP-I does not collect information on other lifestyle factors that are related to increased blood pressure levels, it was also asked about regular consumption of tobacco, coffee, and alcohol. For this study, adolescents who reported consuming these substances

at least once a week are considered regular users.

Statistical analysis

The sociodemographic characteristics, lifestyle, and BP levels were described with frequencies and percentages in the case of categorical variables. Since the age of the participants followed a normal distribution (p-value of the Shapiro-Wilk test = 0.70), it was described with mean and standard deviation (DE); but the monthly family income, height, levels of systolic and diastolic BP were presented with a median and interquartile range because they did not follow a normal distribution (p-value of the Shapiro-Wilk test <0.01). The comparisons between these characteristics with high BP status (yes vs. no) were carried out using Pearson's X^2 or Fisher's Exact for the difference in proportions; Student's t-test for the difference in means; and Mann-Whitney U test for the difference in medians. Using logistic regression models, we evaluated the association between lifestyle and blood pressure, so we estimated the Odds Ratio (OR) of presenting high BP in adolescents with an unhealthy lifestyle compared to those with a healthy lifestyle. Additionally, we evaluated this same association for each of the lifestyle dimensions evaluated with the HPLP-I. Also, using logistic regression models, we independently evaluated the association between tobacco, alcohol, and coffee consumption with the presence of high blood pressure, since they are lifestyle factors that have been associated with changes in blood pressure levels and these factors are not measured by the HPLP-I.

Potential confounding variables were identified in the existing literature. These variables were assessed as potential confounders using the estimate change method (*i.e.*, OR \geq 10% change), starting with all variables in the models and deletion them one by one in a stepwise manner²⁵. Finally, all models were adjusted for age, sex, schooling, family history of hypertension, family monthly income, father's education, and mother's education. Statistical significance for hypothesis tests and statistical models was based on a $p < 0.05$ value. All analyses were performed using the STATA statistical package, version 15.1 (Stata Corporation, College Station, TX).

RESULTS

The mean age of the participants was 16.9 years. 53% of the participants were women and, 85% were high school students. 17.5% and 38.5% of adolescents reported being regular consumers of tobacco and alcohol, respectively, while more than half were also regular coffee consumers. Almost 50% had a family history of high blood pressure. 22% of the adolescents in the study had high BP. The proportion of adolescents who consumed tobacco, alcohol, and coffee regularly was significantly higher in those with high BP compared to those with normal levels of BP. As expected, the mean levels of systolic and diastolic BP were higher in adolescents with high BP (table 1).

According to the HPLP-I data, 80.5% of the participants had a global healthy lifestyle. When we analyze the lifestyle for each of the HPLP-I dimensions, we observe that more than 50% of the adolescents presented a healthy

lifestyle in almost all the dimensions except for the exercise dimension. Regarding the type of lifestyle according to high BP status, we observed a higher proportion of adolescents with a global healthy lifestyle in the normal BP group compared to those with high BP. We observed similar patterns in the HPLP-1 dimensions of stress management and interpersonal support HPLP-1 (table 2).

After adjusting for confounders, we observed that adolescents with an unhealthy global lifestyle had a higher OR of high blood pressure (adjusted [aOR]= 3.63; 95% CI= 1.57, 8.37) compared to adolescents with a healthy lifestyle. When we analyzed each lifestyle dimension, we observed that the aORs of high BP were higher among adolescents with an unhealthy lifestyle in the Stress

management dimension (aOR= 3.0; CI 95%=1.44, 6.25) and Interpersonal support dimension (ORa = 4.46; CI 95%= 1.68, 11.80). We also observed associations in the same direction for the dimensions of Nutrition (aOR= 1.82; 95% CI= 0.77, 4.33) and Exercise (OR= 1.34; 95% CI= 0.63, 4.33), however, in neither case there was statistical significance. In the rest of the dimensions, the associations were null (Table 3).

Adolescents who smoked regularly had a higher OR of high BP (aOR= 3.18; 95% CI= 1.27, 7.27) compared with non-smoking adolescents (Table 4). We observed increased aORs among adolescents with regular alcohol (aOR= 2.26; 95% CI= 1.08, 4.60) and coffee consumption (aOR= 2.13; 95% CI= 1.03, 4.38; Table 4).

Table 1. Characteristics of the study participants according to high blood pressure status

| Characteristics | High BP | | | p-value ^a |
|----------------------------|---------------|----------------|----------------|----------------------|
| | Total (n=200) | No n=156 (78%) | Yes n=44 (22%) | |
| Sex; n (%) | | | | |
| Female | 106 (53.0) | 83 (53.2) | 23 (52.3) | 0.91 |
| Male | 94 (47.0) | 73 (46.8) | 21 (47.7) | |
| Age (yr) | | | | |
| Mean (SD) | 16.9 (1.3) | 16.8 (1.3) | 17.2 (1.3) | 0.10 |
| Height (cm) | | | | |
| Median (IQR) | 162 (12.5) | 164 (10) | 166 (9) | 0.45 |
| Systolic BP (mmHg) | | | | |
| Median (IQR) | 122 (15) | 115 (14) | 120 (18) | 0.01 |
| Diastolic BP (mmHg) | | | | |
| Median (IQR) | 85 (10) | 78 (10) | 86 (8) | 0.01 |
| Education; n (%) | | | | |
| Middle school | 30 (15.0) | 20 (14.7) | 7 (15.9) | 0.84 |

Lifestyle and high blood pressure among mexican adolescents

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|---|------------|------------|-----------|-------|
| High school | 170 (85,0) | 133 (85.3) | 37 (84.1) | |
| Regular tobacco consumption; n (%) | | | | |
| Yes | 165 (82,5) | 135 (86.5) | 30 (68.2) | <0.01 |
| No | 35 (17,5) | 21 (13.5) | 14 (31.8) | |
| Regular alcohol consumption; n (%) | | | | |
| Yes | 123 (61.5) | 102 (65.4) | 21 (47,7) | 0.03 |
| No | 77 (38.5) | 54 (34.6) | 23 (52.3) | |
| Regular coffe consumption; n (%) | | | | |
| Yes | 136 (68,0) | 113 (72.4) | 23 (52,3) | 0.01 |
| No | 64 (32,0) | 43 (27.6) | 21 (47.7) | |
| Monthly household income^b | | | | |
| Median (IQR) | 350 (102) | 350 (58) | 350 (146) | 0.08 |
| Father's education; n (%) | | | | |
| ≤ Secondary school | 110 (55.0) | 89 (57.1) | 21 (47.3) | 0.27 |
| ≥ High school | 90 (45.0) | 67 (42.9) | 23 (52.7) | |
| Mother's education; n (%) | | | | |
| ≤ Secondary school | 98 (49.0) | 79 (50.6) | 19 (43.2) | 0.38 |
| ≥ High school | 102 (51.0) | 77 (49.4) | 25 (56.8) | |
| Familiar history of HTN; n (%) | | | | |
| Yes | 101 (50.5) | 81 (51.9) | 20 (45.5) | 0.91 |
| No | 99 (49.5) | 75 (48.1) | 24 (54.5) | |

Abbreviations: yr, years; IQR, interquartile range; cm, centimeters; BP, blood pressure; mmHg, millimeter of mercury; HTN, hypertension

^aComparing subjects by lifestyle using Pearson's chi-squared or Fisher's exact tests for categorical variables; Student's t-test for the difference in means; and Mann-Whitney U test for the difference in medians

^bAmerican dollars

Source: Authors

Table 2. Global lifestyle and for each HPLP-I dimension according to high blood pressure status.

| <i>HPLP-I</i> | High BP | | | p-value^a |
|------------------------------|---|-------------------------------------|-------------------------------------|----------------------------|
| | Total n=200 (100%) n (%) | No n=156 (78%) n (%) | Yes n=44 (22%) n (%) | |
| Global | | | | |
| Healthy | 161 (80,5) | 134 (85.9) | 27 (61.4) | <0.01 |
| Unhealthy | 39 (19.5) | 22 (14.1) | 17 (38.6) | |
| Dimensions of HPLP-I | | | | |
| Nutrition | | | | |
| Healthy | 166 (75.0) | 133 (85.3) | 33 (75.0) | 0.11 |
| Unhealthy | 34 (25.0) | 22 (14.7) | 11 (25.0) | |
| Exercise | | | | |
| Healthy | 98 (49.0) | 79 (50.6) | 20 (43.2) | 0.38 |
| Unhealthy | 102 (51.0) | 77 (49.4) | 24 (56.8) | |
| Health responsibility | | | | |
| Healthy | 108 (54.0) | 83 (53.2) | 25 (56.8) | 0.67 |
| Unhealthy | 92 (46.0) | 73 (46.8) | 19 (43,2) | |
| Stress management | | | | |
| Healthy | 121 (60.5) | 102 (65.4) | 19 (43.2) | <0.01 |
| Unhealthy | 79 (39.5) | 54 (34,6) | 25 (56.8) | |
| interpersonal support | | | | |
| Healthy | 178 (89,0) | 146 (93.6) | 32 (72.7) | 0.02 |
| Unhealthy | 22 (11.0) | 10 (6.4) | 12 (27.3) | |
| Self-actualization | | | | |
| Healthy | 166 (83.0) | 130 (83.3) | 36 (81.2) | 0.81 |
| Unhealthy | 34 (17.0) | 26 (16.7) | 8 (18.2) | |

Abbreviations: HPLP-I, Health-Promoting Lifestyle Profile questionnaire.
^aPearson's chi-squared or Fisher's exact tests.
 Source: Authors.

Table 3. Adjusted odds ratio (OR) of high blood pressure according to global lifestyle and for each HPLP-l dimension.

| HPLP-l | OR (IC 95%) | p-value | OR (IC 95%) ^a | p-value |
|------------------------------|---------------------|---------|--------------------------|---------|
| Global | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 3.85 (1.80, 8.16) | <0.01 | 3.63 (1.57, 8.37) | <0.01 |
| Dimensions of HPLP-l | | | | |
| Nutrition | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 1.92 (0.85, 4,34) | <0.11 | 1.82 (0.77, 4.33) | 0.17 |
| Exercise | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 1.35 (0.68, 2.64) | <0.38 | 1,34 (0.63, 2.73) | 0.43 |
| Health responsibility | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 0.86 (0,44, 2.69) | 0.67 | 1.06 (0.51, 2.16) | 0.88 |
| Stress management | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 2.48 (1.25, 4.91) | <0.01 | 3.00 (1.44, 6.25) | <0.01 |
| interpersonal support | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 5.47 (2.17 – 13.76) | <0.01 | 4,46 (1,68, 11.80) | <0.01 |
| Self-actualization | | | | |
| Healthy | Ref. | - | - | - |
| Unhealthy | 1.11 (0.46, 2.66) | 0.81 | 1.00 (0.39. 2.57) | 0.99 |

Abbreviations: Ref, reference; Confidence interval

^aAdjusted for sex, age, monthly household income, familiar history of hypertension, father’s education, and mother’s education.

Source: Authors.

Table 4. Adjusted Odds ratio (OR) of high blood pressure according to other lifestyle factors.

| Other lifestyle factors | OR ^a | 95% IC | p-valor |
|------------------------------------|-------------------|--------|-------------------|
| Regular tobacco consumption | | | |
| No | Ref. | | Ref. |
| Yes | 3.00 (1,36, 4.56) | <0.01 | 3.18 (1.27, 7,27) |
| Regular alcohol consumption | | | |
| No | Ref. | | Ref. |
| Yes | 2.06 (1.05, 4.07) | 0.03 | 2.26 (1,08, 4.60) |
| Regular coffe consumption | | | |
| No | Ref. | | Ref. |
| Yes | 2.39 (1.03, 4.38) | 0.01 | 2.13 (1,03, 4.38) |

Abbreviations: ref, reference; Confidence interval

^aAdjusted for sex, age, monthly household income, familiar history of hypertension, father's education, and mother's education.

Source: Authors.

DISCUSSION

In our study, the rate of high BP was slightly higher, compared to the proportions reported in studies from other parts of the world. For example, in South African adolescents aged 13 to 17 years (hypertension, 10.1%)⁵; in Italian adolescents between 13 and 17 years old (hypertension, 18.2%)²⁶; and Turkish adolescents aged 14 to 19 years (hypertension, 14.8%)²⁷. The differences observed between the frequencies of hypertension in previous studies may be due to aspects such as the sample size, the age of the adolescents, and the ethnic and socioeconomic differences between the different countries. Furthermore, the criteria for defining the presence of hypertension may vary from one country to another, which could also explain the different results of previous studies.

In general, in our study population, we observed that an unhealthy global lifestyle was significantly associated with the presence of high BP. When we analyzed each lifestyle dimension, we observed that high BP was higher in adolescents with an unhealthy lifestyle in the Stress management dimension, which suggests that stress acts as a predictor of increased BP levels as in the case of adults²⁸. These findings are consistent with the results reported in a group of adolescents aged 13 to 18 years in Indonesia, in which the presence of hypertension was observed to be 5 times higher in adolescents with high levels of perceived stress²⁹. Although the underlying mechanism between stress and high blood pressure has not been fully elucidated, there is evidence to suggest that high levels of stress might produce

increased sympathetic nervous system activity, glucocorticoid overload, and altered oxide bioavailability nitric, which might lead to increased BP levels ³⁰.

In our study, we observed that an unhealthy lifestyle in the Interpersonal support dimension was associated with high BP, which suggests that the lack of social support might be related to alterations in BP. Although to date there are no other published studies in this regard, a previous investigation in which the effect of violence on hypertension in African-American adolescents was evaluated, showed that those who had social support had a lower risk of presenting hypertension ³¹. In addition, longitudinal studies have suggested the potential protective role of social support in the risk of hypertension in adults ^{32,33}. It has been suggested that social support reduces stress levels, which could explain the possible protective role that this has in the increase in BP levels ³⁴.

In our analyses, we observed that an unhealthy lifestyle in the Nutrition and Exercise dimension was associated with high BP. These findings, although they did not reach statistical significance, suggest that an inadequate diet and lack of physical activity could be related to alterations in BP levels given the direction of the associations. The relationship between diet and physical activity with BP has been widely documented in adolescents ^{29,35,36}. It has been suggested that a diet high in sodium favors water retention, alters endothelial function, and produces changes in the structure of the large elastic arteries, which is related to changes in BP levels ³⁷. On the other hand, diets rich in fats and a sedentary lifestyle ³⁵, lead to an

increase in adipose tissue, which is related to vascular resistance and activation of the sympathetic nervous system, particularly at the level of the renal sympathetic nerve, which leads to over-activation of the renin-angiotensin-aldosterone system, which in turn leads to a sustained increase in BP levels ^{38,39}.

In our study population, regular tobacco consumption was associated with the presence of high BP. Our findings are consistent with the results of a recent study of US children and adolescents aged 8 to 19 years, which found that both active and passive tobacco use, both independently and together, were associated with a higher possibility of present high BP ⁴⁰. There is evidence suggesting that tobacco consumption accelerates heart rate and induces vasoconstriction, which would lead to an acute elevation of BP; in addition, the nicotine in cigarettes might act as an adrenergic agonist and stimulate the release of vasopressin ⁴¹.

Regular alcohol consumption was a lifestyle factor that was also associated with BP among the adolescents in our study. Through our results, it has been shown in Argentine adolescents aged 13 to 18 years that the amount and frequency of alcohol consumed correlated with the increase in diastolic BP levels ⁴². Likewise, a study showed that excessive alcohol consumption in adolescence (12 to 18 years) was associated with an increased risk of developing high BP in young adulthood in the US population ⁴³. It has been suggested that alcohol might stimulate the adrenal glands to release adrenaline, which in turn increases heart rate, cardiac output, and systolic blood pressure ⁴⁴. Results from animal models

also suggest that exposure to high alcohol consumption might cause endothelial cell dysfunction and affect the availability of nitric oxide, which would explain the increase in BP levels ⁴⁵.

Finally, in our study, regular coffee consumption was significantly associated with high BP. Our findings are consistent with the results reported by a recent meta-analysis, which reported that regular coffee consumption was associated with increased systolic BP levels in adolescents ⁴⁶. The biological mechanisms underlying the association of coffee consumption with high BP have not been elucidated yet. However, experimental evidence suggests that coffee consumption could produce sympathetic overactivation, act as an antagonist of adenosine receptors, increase the release of norepinephrine through direct effects on the adrenal medulla, as well as induce the activation of the renin-angiotensin system ⁴⁷, however, more epidemiological and experimental evidence is still required to help clarify these data.

To adequate interpretation of our results, it is necessary to take into account some considerations. The cross-sectional approach of this analysis does not allow to establish a temporal sequence between lifestyle with the BP levels of adolescents, therefore, the associations that we estimate are not causal and should be interpreted with caution, although these associations are known, especially in the adult population, and have been consistently reported in previous cohort studies ^{32,40,43,48}. Although important confounders were controlled for in the present study, there were no environmental

measurements of toxic pollutants that may affect BP levels, so we were not able to discard the existence of some degree of residual confusion. On the other hand, the Nutrition dimension of the HPLP-1, although it evaluates the healthy daily diet based on the FAO guidelines, does not allow the identification of eating patterns. Although in the present study, we asked about the regularity of tobacco, alcohol, and coffee consumption, we did not ask about the intensity of their consumption (*i.e.*, the number of cigarettes consumed per day), a factor that could be associated with changes in BP. The application of the questionnaires and the measurement of height and BP were carried out by trained and standardized personnel. In addition, the BP measurement was performed in duplicate, so it is unlikely that the findings obtained are the result of a misclassification bias.

CONCLUSIONS

The results of this study suggest the presence of high BP in Mexican adolescents aged 15 to 19 years is associated with an unhealthy global lifestyle, as well as with specific factors such as stress management, interpersonal support, and regular consumption of tobacco, alcohol, and coffee. The etiology of hypertension is multifactorial; however, unhealthy lifestyles seem to play an important role in its development. Hence, it is important for primary care staff to actively participate in BP monitoring and develop strategies aimed at generating healthy lifestyle habits in adolescents and their families and making them aware of the importance of physical activity, eating

a balanced diet, carrying out activities that reduce stress, for which the involvement of schools and other social agents is necessary. Alcohol and tobacco use usually begins during adolescence in Mexico ⁴⁹, therefore, it is necessary to develop interventions that also have an impact on this, either through an individual approach in consultation or through support groups, in which they share their experiences.

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