LIFESTYLE AND HIGH BLOOD PRESSURE AMONG MEXICAN ADOLESCENTS

ESTILO DE VIDA Y PRESIÓN ARTERIAL ALTA EN ADOLESCENTES MEXICANOS

Cristian Manrique-Hernández
Licenciatura en enfermería
Escuela Superior de Tlahuelilpan, Universidad Autónoma del Estado de Hidalgo; Hidalgo, México
mahec2000@hotmail.com
https://orcid.org/0000-0002-8003-9727

Xóchitl Hernández-Espinoza
Licenciatura en enfermería
Maestría en Salud Pública
Escuela Superior de Tlahuelilpan, Universidad Autónoma del Estado de Hidalgo; Hidalgo, México
xochitlhernandez8494@gmail.com
https://orcid.org/0000-0003-2629-0862

José Ángel Hernández-Mariano
Licenciatura en enfermería
Maestría en Ciencias en Epidemiología y Doctorado en Ciencias en Epidemiología
División de investigación, Hospital Juárez de México. Ciudad de México, México
jose.hernandez@salud.gob.mx
https://orcid.org/0000-0003-0339-5610

Edith Araceli Cano-Estrada
Licenciatura en Bioquímica
Maestría en Ciencias Bioquímicas y Doctorado en Ciencias Bioquímicas
Escuela Superior de Tlahuelilpan, Universidad Autónoma del Estado de Hidalgo; Hidalgo, México
edith_cano@uaeh.edu.mx
https://orcid.org/0000-0002-8315-1087

Ana Cristina Castañeda-Márquez
Licenciatura en enfermería
Maestría en Ciencias en Nutrición y Doctorado en Ciencias en Epidemiología
Instituto de Investigación Científica, Universidad Juárez del Estado de Durango; Durango, México

cristy_acm@hotmail.com
https://orcid.org/0000-0001-6948-5892

Artículo recibido el 08 de agosto de 2023. Aceptado en versión corregida el 30 de julio de 2024.

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 ≥ percentil 95. La asociación de interés se evalúo 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.

http://dx.doi.org/10.7764/Horiz_Enferm.35.2.660-678

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 both[1]. Over the past three decades, the global prevalence of hypertension has increased substantially [2]. 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 countries [3]. 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 adulthood [10].

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 subject [11]. 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 develops [15].

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 obesity [18]. 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 adolescents [19]. 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 country [16], 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 municipality [20]. 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-l-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 applied [21]; HPLP-l 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 ≥95th 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 adolescents [24]. 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-l.

Potential confounding variables were identified in the existing literature. These variables were assessed as potential confounders using the estimate change method (*i.e*., OR ≥ 10% change), starting with all variables in the models and deletion them one by one in a stepwise manner [25]. 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-l 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-l (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	Total (n=200)	High BP		p-value[a]
		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

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

[a]Comparing 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

[b]American dollars

Source: Authors

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

HPLP-l	**Total n=200 (100%)**	**High BP**		
		No n=156 (78%)	**Yes n=44 (22%)**	
	n (%)	**n (%)**	**n (%)**	**p-value [a]**
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-l				
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. [a]Pearson'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

[a]Ajusted 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
[a]Ajusted 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 adults [28]. 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 stress [29]. 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-l, 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.

Acknowledgments: We thank the adolescents who gave their time and effort to participate in this study.

Funding: This work did not receive funding.

Disclosure statement: No potential conflict of interest was reported by the authors.

REFERENCES

(1) Rehman S, Hashmi MF. Blood Pressure Measurement. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK482189/ [Accessed 13th January 2024].

(2) Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, Chen J, He J. Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-based Studies from 90 Countries. Circulation [Internet] 2016 [cited 2020 Sep 16]; 134:441–50. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4979614/

(3) World Health Organization. Hypertension [Internet]. 2021; Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension

(4) Kuciene R, Dulskiene V. Associations between body mass index, waist circumference, waist-to-height ratio, and high blood pressure among adolescents: a cross-sectional study. Sci Rep [Internet] 2019 [cited 2022 Apr 7]; 9:9493. Available from: https://www.nature.com/articles/s41598-019-45956-9

(5) Nkeh-Chungag BN, Sekokotla AM, Sewani-Rusike C, Namugowa A, Iputo JE. Prevalence of Hypertension and Pre-hypertension in 13-17 Year Old Adolescents Living in Mthatha - South Africa: a Cross-Sectional Study. Cent Eur J Public Health [Internet] 2015 [cited 2022 Apr 7]; 23:59–64. Available from: http://cejph.szu.cz/doi/10.21101/cejph.a3922.html

(6) Oparil S, Acelajado MC, Bakris GL, Berlowitz DR, Cífková R, Dominiczak AF, Grassi G, Jordan J, Poulter NR, Rodgers A, et al. Hypertension. Nat Rev Dis Primer [Internet] 2018 [cited 2021 Feb 10]; 4:18014. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6477925/

(7) Tune JD, Goodwill AG, Sassoon DJ, Mather KJ. Cardiovascular Consequences of Metabolic Syndrome. Transl Res J Lab Clin Med [Internet] 2017 [cited 2020 Nov 28]; 183:57–70. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5393930/

(8) Berenson GS, Srinivasan SR, Bao W, Newman WP, Tracy RE, Wattigney WA. Association between Multiple Cardiovascular Risk Factors and Atherosclerosis in Children and Young Adults. http://dx.doi.org/101056/NEJM199806043382302 [Internet] 2009 [cited 2020 Mar 1]; Available from: https://www.nejm.org/doi/10.1056/NEJM199806043382302?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub%3Dwww.ncbi.nlm.nih.gov

(9) Daniels SR, Pratt CA, Hayman LL. Reduction of Risk for Cardiovascular Disease in Children and Adolescents. Circulation [Internet] 2011 [cited 2020 Mar 1]; 124:1673–86. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3751579/

(10) Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood: a systematic review and meta-regression analysis. Circulation 2008; 117:3171–80.

(11) de Moraes ACF, Fernández-Alvira JM, Rendo-Urteaga T, Julián-Almárcegui C, Beghin L, Kafatos A, Molnar D, De Henauw S, Manios Y, Widhalm K, et al. Effects of clustering of multiple lifestyle-related behaviors on blood pressure in adolescents from two observational studies. Prev Med [Internet] 2016 [cited 2022 Jun 9]; 82:111–7. Available from: https://www.sciencedirect.com/science/article/pii/S0091743515003461

(12) Kornitzer M, Dramaix M, De Backer G. Epidemiology of risk factors for hypertension: implications for prevention and therapy. Drugs 1999; 57:695–712.

(13) Barone Gibbs B, Hivert M-F, Jerome GJ, Kraus WE, Rosenkranz SK, Schorr EN, Spartano NL, Lobelo F, null null. Physical Activity as a Critical Component of First-Line Treatment for Elevated Blood Pressure or Cholesterol: Who, What, and How?: A Scientific Statement From the American Heart Association. Hypertension [Internet] 2021 [cited 2022 Jun 9]; 78:e26–37. Available from: https://www.ahajournals.org/doi/10.1161/HYP.0000000000000196

(14) Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in blood pressure among children and adolescents. JAMA 2004; 291:2107–13.

(15) Hernando Á, Oliva A, Pertegal M. Diferencias de género en los estilos de vida de los adolescentes. Psychosoc Interv [Internet] 2013 [cited 2022 Jun 9]; 22:15–23. Available from: https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1132-05592013000100003

(16) Dyson PA, Anthony D, Fenton B, Matthews DR, Stevens DE, Community Interventions for Health Collaboration. High rates of child hypertension associated with obesity: a community survey in China, India and Mexico. Paediatr Int Child Health 2014; 34:43–9.

(17) Salcedo-Rocha AL, García de Alba JE, Contreras-Marmolejo M. Presión arterial en adolescentes mexicanos:

clasificación, factores de riesgo e importancia. Rev Salud Pública [Internet] 2010 [cited 2022 Jun 9]; 12:612–22. Available from: https://www.scielosp.org/article/rsap/2010.v12n4/612-622/

(18) Acosta-Berrelleza N, Guerrero-Lara T, Murrieta-Miramontes E, Alvarez-Bastidas L, Valle-Leal J. Niveles de presión arterial en niños y adolescentes con sobrepeso y obesidad en el noroeste de México. Enferm Univ [Internet] 2017 [cited 2020 Mar 2]; 14:170–5. Available from: http://www.scielo.org.mx/scielo.php?script=sci_abstract&pid=S1665-70632017000300170&lng=es&nrm=iso&tlng=es

(19) Sánchez-Zamorano LM, Burguete-García AI, Flores-Sánchez G, Salmerón-Castro J, Lazcano-Ponce EC, Diaz-Benitez CE. Conducta no saludable asociada con el desarrollo de presión arterial elevada en adolescentes. Cad Saúde Pública [Internet] 2017 [cited 2022 Sep 26]; 33. Available from: http://www.scielo.br/j/csp/a/zrg5jVXJssWh7MgwtXcLxFh/?lang=es

(20) Secretaría de Economía. Data México. Mixquiahuala de Juárez [Internet]. Data México2022 [cited 2021 Oct 10]; Available from: https://datamexico.org/es/profile/geo/mixquiahuala-de-juarez

(21) Walker S, Kerr M, Pender N. A spanish language version of the health-promoting lifestyle profile. Nurs Res 1990; 39:268–73.

(22) Palmeros MB, Hernández CBE, Contreras EC, Terán MEF, Mendoza JS. Estilos de vida en estudiantes de posgrado de una universidad pública. Rev Biológico Agropecu Tuxpan [Internet] 2019 [cited 2022 Apr 3]; 7:19–26. Available from: https://revistabioagro.mx/index.php/revista/article/view/140

(23) Reyna PLL, Loza MGL, Vega JR. Relación entre estilo de vida y estrés laboral en el personal de enfermería en tiempos de COVID-19. Rev Cuba Enferm [Internet] 2021 [cited 2022 Oct 7]; 37. Available from: http://www.revenfermeria.sld.cu/index.php/enf/article/view/4043

(24) National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics 2004; 114:555–76.

(25) Greenland S. Modeling and variable selection in epidemiologic analysis. Am J Public Health 1989; 79:340–9.

(26) Cairella G, Menghetti E, Scanu A, Bevilacqua N, Censi L, Martone D, Sonni L, Rosano A, Spagnolo A, D'Addesa D. Elevated blood pressure in adolescents from Rome, Italy. Nutritional risk factors and physical activity. Ann Ig Med Prev E Comunita [Internet] 2007 [cited 2022 Jul 2]; 19:203–14. Available from: https://pubmed.ncbi.nlm.nih.gov/17658108/

(27) Çam HH, Ustuner Top F. Prevalence of Hypertension and Its Association with Body Mass Index and Waist Circumference Among Adolescents in Turkey: A Cross-Sectional Study. J Pediatr Nurs 2021; 57:e29–33.

(28) Liu M-Y, Li N, Li WA, Khan H. Association between psychosocial stress and hypertension: a systematic review and meta-analysis. Neurol Res [Internet] 2017 [cited 2022 Jun 12]; 39:573–80. Available from: https://doi.org/10.1080/01616412.2017.1317904

(29) Kurnianto A, Kurniadi Sunjaya D, Ruluwedrata Rinawan F, Hilmanto D. Prevalence of Hypertension and Its Associated Factors among Indonesian Adolescents. Int J Hypertens [Internet] 2020; 2020:4262034. Available from: https://doi.org/10.1155/2020/4262034

(30) Ayada C, Toru Ü, Korkut Y. The relationship of stress and blood pressure effectors. Hippokratia [Internet] 2015 [cited 2022 Jun 12]; 19:99–108. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4938117/

(31) Hsieh H-F, Heinze JE, Caruso E, Scott BA, West BT, Mistry R, Eisman AB, Assari S, Buu A, Zimmerman MA. The Protective Effects of Social Support on Hypertension Among African American Adolescents Exposed to Violence. J Interpers Violence [Internet] 2022 [cited 2022 Jun 12]; 37:NP7202–24. Available from: https://doi.org/10.1177/0886260520969390

(32) Harding BN, Hawley CN, Kalinowski J, Sims M, Muntner P, Young BA, Heckbert SR, Floyd JS. Relationship between social support and incident hypertension in the Jackson Heart Study: a cohort study. BMJ Open [Internet] 2022 [cited 2022 Jun 12]; 12:e054812. Available from: https://bmjopen.bmj.com/content/12/3/e054812

(33) Yang YC, Boen C, Harris KM. Social Relationships and Hypertension in Late Life: Evidence from a Nationally Representative Longitudinal Study of Older Adults. J Aging Health [Internet] 2015 [cited 2022 Jun 12]; 27:403–31. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4368483/

(34) Harandi TF, Taghinasab MM, Nayeri TD. The correlation of social support with mental health: A meta-analysis. Electron Physician [Internet] 2017 [cited 2022 Jun 14]; 9:5212–22. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5633215/

(35) Ewald DR, Haldeman LA. Risk Factors in Adolescent Hypertension. Glob Pediatr Health [Internet] 2016 [cited 2022 Jun 13]; 3:2333794X15625159. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4784559/

(36) Soudarssanane MB, Karthigeyan M, Stephen S, Sahai A. Key Predictors of High Blood Pressure and Hypertension among Adolescents : A Simple Prescription for Prevention. Indian J Community Med [Internet] 2006 [cited 2022 Jun 13]; 31:164. Available from: https://www.ijcm.org.in/article.asp?issn=0970-0218;year=2006;volume=31;issue=3;spage=164;epage=164;aulast=soudarssanane;type=0

(37) Grillo A, Salvi L, Coruzzi P, Salvi P, Parati G. Sodium Intake and Hypertension. Nutrients [Internet] 2019

[cited 2022 Jun 14]; 11:1970. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6770596/

(38) DeMarco VG, Aroor AR, Sowers JR. The pathophysiology of hypertension in patients with obesity. Nat Rev Endocrinol [Internet] 2014 [cited 2022 Apr 9]; 10:364–76. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4308954/

(39) Kotchen TA. Obesity-Related Hypertension: Epidemiology, Pathophysiology, and Clinical Management. Am J Hypertens [Internet] 2010 [cited 2022 Apr 9]; 23:1170–8. Available from: https://doi.org/10.1038/ajh.2010.172

(40) Levy RV, Brathwaite KE, Sarathy H, Reidy K, Kaskel FJ, Melamed ML. Analysis of Active and Passive Tobacco Exposures and Blood Pressure in US Children and Adolescents. JAMA Netw Open [Internet] 2021 [cited 2022 Jun 13]; 4:e2037936. Available from: https://doi.org/10.1001/jamanetworkopen.2020.37936

(41) Freitas SRS, Alvim RO. Smoking and Blood Pressure Phenotypes: New Perspective for an Old Problem. Am J Hypertens [Internet] 2017 [cited 2022 Jun 13]; 30:554–5. Available from: https://doi.org/10.1093/ajh/hpx039

(42) Jerez SJ, Coviello A. Alcohol Drinking and Blood Pressure Among Adolescents. Alcohol [Internet] 1998 [cited 2022 Jun 13]; 16:1–5. Available from: https://www.sciencedirect.com/science/article/pii/S0741832997001523

(43) Hayibor LA, Zhang J, Duncan A. Association of binge drinking in adolescence and early adulthood with high blood pressure: findings from the National Longitudinal Study of Adolescent to Adult Health (1994–2008). J Epidemiol Community Health [Internet] 2019; 73:652. Available from: http://jech.bmj.com/content/73/7/652.abstract

(44) Husain K, Ansari RA, Ferder L. Alcohol-induced hypertension: Mechanism and prevention. World J Cardiol [Internet] 2014 [cited 2022 Jun 13]; 6:245–52. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4038773/

(45) Piano MR. Alcohol's Effects on the Cardiovascular System. Alcohol Res Curr Rev [Internet] 2017 [cited 2022 Jun 13]; 38:219–41. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5513687/

(46) Xu Z, Meng Q, Ge X, Zhuang R, Liu J, Liang X, Fan H, Yu P, Zheng L, Zhou X. A short-term effect of caffeinated beverages on blood pressure: A meta-analysis of randomized controlled trails. J Funct Foods [Internet] 2021 [cited 2022 Jun 13]; 81:104482. Available from: https://www.sciencedirect.com/science/article/pii/S1756464621001316

(47) Geleijnse JM. Habitual coffee consumption and blood pressure: An epidemiological perspective. Vasc Health Risk Manag [Internet] 2008 [cited 2022 Jun 13]; 4:963–70. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2605331/

(48) Genovesi S, Orlando A, Rebora P, Giussani M, Antolini L, Nava E, Parati G, Valsecchi MG. Effects of Lifestyle Modifications on Elevated Blood Pressure and Excess Weight in a Population of Italian Children and Adolescents. Am J Hypertens [Internet] 2018 [cited 2022 Jun 14]; 31:1147–55. Available from: https://doi.org/10.1093/ajh/hpy096

(49) Reséndiz Escobar E, Bustos Gamiño MN, Mujica Salazar R, Soto Hernández IS, Cañas Martínez V, Fleiz Bautista C, Gutiérrez López M de L, Amador Buenabad N, Medina-Mora ME, Villatoro Velázquez JA, et al. National trends in alcohol consumption in Mexico: results of the National Survey on Drug, Alcohol and Tobacco Consumption 2016-2017. Salud Ment [Internet] 2018 [cited 2022 Jun 14]; 41:7–15. Available from: http://www.scielo.org.mx/scielo.php?script=sci_abstract&pid=S0185-33252018000100007&lng=es&nrm=iso&tlng=en