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Original Article

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Predictors of Childhood High Blood Pressure among Overweight and Obese Children and Adolescents according to the Lifestyle-Scoring Algorithm Using Data from Iranian Health Care Reform Plan

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ABSTRACT

In this study, the association between dietary pattern and lifestyle in predicting hypertension (HTN) among 425 overweight and obese children and adolescents aged 6 to 18 years was evaluated. In the current cross-sectional study, the lifestyle-scoring algorithm was developed considering the Iranian Health Reform Plan (HRP) criterion. HTN was defined according to standard protocols. Hierarchical linear regression models were used for the analysis. The prevalence of overweight/obesity was 5.82%. The results showed that systolic and diastolic blood pressure (SBP, DBP) had significant positive correlation with age ($p < 0.001$ and $p < 0.001$) and body mass index (BMI) ($p < 0.005$ and $p < 0.007$), respectively. Moreover, DBP had a significant correlation with fruit consumption of less than 2 servings per day versus no consumption ($p = 0.014$, B = 0.444), fruit consumption of more than 2 servings per day versus no consumption ($p = 0.014$, B = 0.480), and vegetable consumption less than 3 servings per day versus no consumption ($p = 0.045$, B = −0.374). Moreover, DBP had a significant correlation with fast foods/junk foods consumption of 1–2 items per week versus almost daily consumption ($p = 0.047$, B = −0.177). The final model could predict 32.1% of HTN by SBP and DBP ($R^2 = 0.32$). According to our findings, lower intake of vegetables and fruits, higher amounts of fast foods, higher age and BMI could be potent predictors of high blood pressure among Iranian children and adolescents.

Keywords: Hypertension; Children; Adolescents; Obesity

INTRODUCTION

Childhood obesity has been considered as one of the most serious public health problems in the world [1]. The increasing prevalence of childhood obesity with numerous obesity-related

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Conflict of Interest
The authors declare that they have no competing interests.

comorbidities not only menace the health of those affected but also put pressure on the health care system [2]. Hypertension (HTN) is one of the most important health problems among obese children and adolescents [3]. The prevalence of HTN in obese children ranges from 19% to 22%, compared to 4% to 6% in normal weight children [4]. The prevalence of HTN among Iranian children and adolescents was estimated to be 8.9% in overall [5]. Several other studies also reported higher prevalence of HTN among Iranian children and adolescents [6,7]. HTN in childhood is associated with cardiovascular disease in adulthood [5]. Studies showed that HTN is significantly associated with the combination of genetic, environment, behavioral, and dietary factors [8]. Menghetti et al. [9] demonstrated that obese children and adolescents had four times higher risk of developing HTN than normal weight children. Their cross-sectional study among 2,007 healthy children and adolescents revealed lower physical activity, higher hours spent for television and/or computer, higher rate of unhealthy diet eating behaviors, and lower fruit and salad consumption among obese hypertensive children [9]. The National Heart, Lung, and Blood Institute's (NHLBI) Growth and Health Study, which followed 2,185 females over 10 years of age, demonstrated that consuming more than two servings of dairy and more than 3 servings of fruits and vegetables daily is associated with lower blood pressure (BP) in childhood and a 36% lower risk of developing high BP by young adulthood [10]. Similar relationships in 2,440 youth aged 10 to 22 years with type 1 diabetes mellitus in the SEARCH for Diabetes in Youth Study demonstrated an inverse association between healthy diet and BP [11].

Since the 1970s, the NHLBI has recommended measurement of BP in healthy children as a part of their routine health maintenance [12]. Preventive programs combining dietary modifications alongside higher physical activity could serve beneficial effects against systolic blood pressure (SBP) [13]. The Iranian Health Reform Plan (HRP) aiming to improve Iranians' health systems with the responsibility of the Ministry of Health and Medical Education (MOHME) was launched on May 15, 2014, with three main approaches: financial protection of the people, creating justice in access to health care services, and improving the quality of health care services. Most studies on the HRP have focused on the effectiveness of the HRP and its effects on access to health services, as well as the economic impact of HRP [14,15]. Evaluation of the nutritional status was performed by obtaining anthropometric information, demographic factors, dietary intakes, and lifestyle patterns. These parameters constituted to a part of lifestyle-scoring algorithm including nutritional and lifestyle associated risk factors. In the current report, we assessed the predictors of childhood HTN according to the lifestyle-scoring algorithm using data from Iranian HRP among children and adolescents [16].

MATERIALS AND METHODS

Study and participant's characteristics

The present study is a cross-sectional evaluation of data from HRP. The preliminary data were obtained from the Integrated Health System, known as SIB System (https://sib.tbzmed.ac.ir/home/), from 2018 September 1 to 2019 January 30. Accordingly, anthropometric information, demographic factors, dietary intakes, and lifestyle-associated factors in 425 overweight and obese children and adolescents (246 males and 179 females) referred to Shahid Bakeri Health Center in Tabriz, Iran were collected. The center is a large primary and secondary health care referral system involving the population of four districts with different socioeconomic status and an acceptable representativeness of general population. The inclusion criteria were: aged 6 to 18 years and being overweight or obese. The exclusion criteria were any renal or liver disorders, diabetes, heart disease, thyroid dysfunctions, pregnancy, smoking, and taking steroid medications.

Demographic, anthropometric and BP measurements

Demographic information and detailed diet history were recorded by an expert dietitian via direct face-to-face interviews with the participants and their parents. Weight was measured to the nearest 100 g (Seca GmbH & Co., Hamburg, Germany). Height was measured using a stadiometer (with a precision of 0.1 cm) and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. SBP and diastolic blood pressure (DBP) were measured on left arm at the heart level after at least 5 minutes of resting in sitting position. The mean of two recordings was assigned as final BP value. High BP was defined according to the criteria presented by the fourth report on the diagnosis, evaluation, and treatment of high BP in American children and adolescents by gender-specific BP tables [17]. Accordingly, SBP and DBP < 90 percentile considered as normal, ≥ 90 percentile and < 95 percentile as prehypertension, and ≥ 95 percentile considered as hypertension. Since the childhood overweight and obesity criteria are different from adults, we used the World Health Organization (WHO) criteria for identifying overweight and obesity in people aged 5–18 years old. According to these criteria, BMI for age more than 2 standard deviations (SDs) from the middle of growth standards were considered as obese and more than 1 SD from the middle of growth standards were considered as overweight.

Lifestyle-scoring algorithm

In the lifestyle-scoring algorithm, the HRP criterion was used, which considers the usual dietary intake of different food groups, dietary habits, physical activity, as well as anthropometric measurements and BMI using a questionnaire. The lifestyle-scoring criteria of children and adolescents in the HRP are different from the adult criteria. The questionnaire included information about dietary consumption of fruits, vegetables, dairy products, the daily meals' frequency, fast food/junk food consumption, physical activity, and hours of TV/PC watching. Food intakes were measured based on serving size according to the food pyramid. Each serving of fruits is equal to a medium-sized fruit (e.g., apple, banana, orange, or pear), ½ cup of small fruits such as berries and grapes, or ½ cup of cooked fruit, or ¼ cup of dried fruit, or ½ cup of fresh and natural fruit juice, or their exchanges. Each serving of vegetables is equal to a cup of raw leafy vegetables (spinach and lettuce), or ½ cup of cooked vegetables, green peas, green beans and chopped carrots, or a medium tomato or carrot, or their exchanges. Each serving of dairy is equal to one glass (250 mL) of milk or yogurt or 45–60 g cheese or their exchanges [18]. The questionnaire contained seven questions with Likert scoring pattern. The total scores of all questions are summed up and the final score ranges between 0 to 14. The details of scoring procedure are presented in **Table 1**. We used a researcher-designed questionnaire, the validity of which was verified by the internal evaluation software presented by the MOHME. The questionnaire was sent to the experts to receive their opinions in classifying and scoring, which was finally approved [19].

Statistical analysis

The data were expressed as mean ± standard error (SE) and frequency (%) for quantitative and qualitative variables, respectively (nominal or ordinal). The BMI was categorized as quartile as follows: BMI < 22.20, 22.20–25.22, 25.22–28.79 and ≥ 28.79 kg/m^2. Normality of data was confirmed based on three criteria: SD less than half of the mean, Kurtosis in the range of ± 3, and skewness in the range of ± 1.5. Data analysis was performed using statistical software STATA (MP 4.2 Portable 2017; StataCorp LLC, College Station, TX, USA). Univariate

Table 1. The life style algorithm scoring details in the health care reform plan

Question	Food group		Score
1	Daily fruit consumption	No consumption or occasionally consumption	0
		< 2 serving	1
		≥ 2 serving	2
2	Daily vegetable	No consumption or occasionally consumption	0
		< 3 serving	1
		≥ 3 serving	2
3	Dairy product consumption	No consumption or occasionally consumption	0
		< 3 serving	1
		≥ 3 serving	2
4	Daily fast foods/junk foods consumption	Almost every day	0
		One or two such items a week	1
		Rarely (repetitively less than the weekly)	2
5	Frequency of daily meal consumption (e.g., main meals and snacks)	≤ 2	0
		3–4 meals	1
		≥ 5 meals	2
6	TV/PC using time	> 2 hours	0
		About 2 hours	1
		< 2 hours	2
7	Physical activity per week (defining as 60 minutes of moderate and severe physical activity every time and divided in different days of the week)	No targeted physical activity in the week	0
		< 420 minutes/week	1
		≥ 420 minutes/week	2

and multivariable hierarchical linear regression models were used for the association between parameters. In hierarchical multivariable linear regression analysis, three models were applied according to the R-squared value of each studied group. The group of food habits (daily consumption of dairy products, fruits, vegetables, fast food consumption, and the number of meals and snacks) had R^2 of 0.0348; the group considering demographic factors including gender, age, BMI, and obesity or overweight status had R^2 of 0.0277; and the group of physical activity and watching TV/PC had R^2 of 0.0281. Accordingly, the models' priority for entrance to the hierarchical multivariable linear regression analysis were as follows: the first model considered demographic factors; second model considered factors in the first model with additional adjustment for the food habits; and the third model considered first and second model with further adjustment for physical activity and TV/PC watching.

Ethical approval and consent to participate

Each participant was completely informed about the study protocol and provided a written informed consent form before taking part in the study. The study protocol was approved and registered by the ethics committee of Tabriz University of Medical Sciences, Iran (ethics number: IR.TBZMED.REC.1398.840). Written informed consent was obtained from all parents of the children before participation in the study. For participants above 16, written informed consent was obtained.

RESULTS

Demographic and anthropometric characteristics and the mean SBP and DBP in participants are presented in **Table 2**. The characteristics of the participants are presented in **Table 3**. Among 425 participants (246 boys and 179 girls), 86.12%, 9.41%, and 4.47% had normal BP, prehypertension, and HTN, respectively. Total prevalence of prehypertension and HTN was 19.88%.

Table 2. Demographic and anthropometric characteristics and the mean SBP and DBP in participants

Variable	Mean ± SD	Min–Max
Age	10.62 ± 3.46	5–16
Weight	59.77 ± 2.27	19–133
Height	148 ± 18.9	105–187
BMI	25.76 ± 4.53	17.23–41.05
DBP	62.31 ± 9.45	40–100
SBP	100.14 ± 13.0	70–160

BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure; SD, standard deviation.

Table 3. General characteristics of the participants

Variables	Subgroups	Total	Boys	Girls
Number of participants		425	246	179
BMI quartiles*	1st	106 (24.94)	64 (26.02)	42 (23.46)
	2nd	105 (24.71)	64 (26.02)	41 (22.91)
	3rd	105 (24.71)	54 (21.95)	51 (28.49)
	4th	106 (24.94)	62 (25.20)	43 (24.02)
Blood pressure	Normal	366 (86.12)	208 (84.55)	157 (87.71)
	Prehypertension	40 (9.41)	27 (10.98)	13 (7.26)
	Hypertension	19 (4.47)	10 (4.07)	9 (5.03)
Fruit	Rarely/never	5 (1.18)	3 (1.22)	2 (1.12)
	< 2 serving/day	70 (16.47)	37 (15.04)	32 (17.88)
	≥ 2 serving/day	350 (82.35)	205 (83.33)	145 (81.01)
Vegetable	Rarely/never	8 (1.88)	4 (1.63)	4 (2.23)
	< 3 serving/day	126 (29.65)	65 (26.42)	60 (33.52)
	≥ 3 serving/day	291 (68.47)	176 (71.54)	115 (64.25)
Dairy product	Rarely/never	6 (1.41)	2 (0.81)	3 (1.68)
	< 3 serving/day	104 (24.47)	49 (19.92)	55 (30.73)
	≥ 3 serving/day	315 (74.12)	194 (78.86)	121 (67.60)
Fast foods/junk foods	Almost every day	37 (8.71)	15 (6.10)	21 (11.73)
	1–2 items/week	103 (24.24)	67 (27.24)	36 (20.11)
	Rarely	285 (67.06)	163 (66.26)	122 (68.16)
Meals/snacks	≤ 2 meals/day	12 (2.82)	4 (1.63)	8 (4.47)
	3–4 meals/day	288 (67.76)	138 (56.10)	89 (49.72)
	≥ 5 meals/day	185 (43.53)	103 (41.87)	82 (45.81)
Watching TV/PC	> 2 hours/day	171 (40.24)	100 (40.65)	70 (39.11)
	2 hours/day	88 (20.71)	54 (21.95)	34 (18.99)
	< 2 hours/day	166 (39.06)	91 (36.99)	75 (41.90)
Physical activity	Without targeted physical activity	72 (16.94)	30 (12.20)	41 (22.91)
	< 420 minutes/week	182 (42.82)	105 (42.68)	77 (43.02)
	≥ 420 minutes/week	171 (40.24)	110 (44.72)	61 (34.08)

Values are presented as number of participants (%).
BMI, body mass index.
*BMI was categorized as quartile as follows: 1st quartile, < 22.20 kg/m^2; 2nd quartile, 22.20–25.22 kg/m^2; 3rd quartile, 25.22–28.79 kg/m^2; and 4th quartile, ≥ 28.79 kg/m^2.

Table 4 presents the mean SBP and DBP values according to the lifestyle-scoring algorithm. In males, elevated SBP and DBP were associated with increased consumption of fruits and vegetables, while reduced SBP and DBP were in parallel of reduced consumption of fast foods. Accordingly, reduced SBP values were associated with reduced TV/PC watching. In females, reduced SBP and DBP values were associated with reduced consumption of fast foods and TV/PC watching, and increased physical activity. Moreover, reduced SBP was associated with increased vegetables consumption. **Table 5** shows the correlation between SBP and DBP with underlying variables, lifestyle, and dietary intake using the Pearson and Spearman correlation analysis. The results showed that, by examining each of the predictors separately, SBP and DBP had a positive correlation with BMI and physical activity and an inverse correlation with watching TV/PC ($p < 0.05$). Also, DBP had a positive correlation with consumption of fruits ($p < 0.05$).

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Table 4. The mean SBP and DBP in participants according to lifestyle-related factors

Lifestyle factors	Boys (n = 246)			Girls (n = 179)		
	No.	SBP	DBP	No.	SBP	DBP
Fruit						
Rarely/never	3	86.66 ± 5.77	46.66 ± 5.77	2	100 ± 0	60 ± 0
< 2 serving/day	38	97.36 ± 13.54	60 ± 10.06	32	101.56 ± 11.46	63.87 ± 10.31
≥ 2 serving/day	205	100.78 ± 14.35	63.12 ± 9.65	145	99.77 ± 10.88	61.79 ± 8.47
Vegetable						
Rarely/never	4	97.5 ± 17.07	60.25 ± 15	4	103.75 ± 7.5	62.5 ± 5
< 3 serving/day	66	97.57 ± 15.22	60.30 ± 1.14	60	103.41 ± 12.02	64.4 ± 9.40
≥ 3 serving/day	176	101.19 ± 13.78	63.23 ± 9.59	115	98.23 ± 10	60.95 ± 8.37
Dairy product						
Rarely/never	3	90 ± 0	56.66 ± 5.77	3	103.33 ± 5.77	63.33 ± 5.77
< 3 serving/day	49	103.16 ± 13.52	64.38 ± 9.1	55	102.38 ± 11.02	64.07 ± 8.29
≥ 3 serving/day	194	99.56 ± 14.43	62.03 ± 10.05	121	99.06 ± 10.79	61.32 ± 8.97
Fast foods/junk foods						
Almost every day	16	101.25 ± 14.88	60.53 ± 11.57	21	102.38 ± 11.02	64.28 ± 11.64
1–2 items/week	67	100.52 ± 12.09	62.66 ± 60.71	36	101.44 ± 13.55	62.88 ± 9.37
Rarely	163	99.90 ± 15.07	62.48 ± 1018	122	99.30 ± 10	61.55 ± 8.03
Meals/snacks						
≤ 2 meals/day	4	105 ± 17.32	65 ± 17.32	8	105 ± 9.25	65 ± 9.25
3–4 meals/day	139	100.39 ± 14.07	62.19 ± 9.70	89	99.74 ± 10.83	61.11 ± 8.97
≥ 5 meals/day	103	99.66 ± 14.50	62.66 ± 9.87	82	100 ± 11.16	62.98 ± 8.49
Watching TV/PC						
> 2 hours/day	101	102.02 ± 13.08	62.97 ± 9.62	70	101.25 ± 11.53	63.57 ± 9.33
2 hours/day	54	97.03 ± 12.42	60.37 ± 9.85	34	100.29 ± 10.51	61.32 ± 6.43
< 2 hours/day	91	99.94 ± 16.31	63.07 ± 10.10	75	99.13 ± 10.57	61.18 ± 9.11
Physical activity						
Without targeted physical activity	31	93.06 ± 13.27	57.58 ± 10.15	41	101.70 ± 9.19	63.29 ± 9.32
< 420 minutes/week	105	102.38 ± 15.56	64.38 ± 11.41	77	101.58 ± 12.41	62.85 ± 8.71
≥ 420 minutes/week	110	100.04 ± 12.54	62 ± 7.48	61	97.13 ± 9.41	60.47 ± 7.40

Values are presented as mean ± standard error.
SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 6 presents the predictors of BP among overweight and obese children and adolescents according to their lifestyle-associated factors in three models with hierarchical analysis. In the first model containing gender, age, BMI, and obesity status, SBP and DBP had significant correlations with age and BMI directly, and this model could predict 28.1% of HTN by increased SBP ($R^2 = 0.281$) and 27.5% of HTN by increased DBP ($R^2 = 0.275$). The second model included the consumption of fruits, vegetables, dairy products, fast foods/junk foods, meals or snacks, and nutritional screening score in addition to the variables included in the first model. The results showed that SBP and DBP had significant associations with age and BMI. Moreover, DBP had a direct association with fruits consumption. This model could predict 30.7% of HTN by increased SBP ($R^2 = 0.307$) and 30.3% of HTN by increased DBP ($R^2 = 0.303$). In the third model, which included watching TV/PC and doing physical activity in addition to the variables included in the second model, SBP had a significant positive correlation with age ($p < 0.001$, B = 0.344) and BMI ($p = 0.005$, B = 0.212). Also, DBP had a significant association with age ($p < 0.001$, B = 0.327), BMI ($p = 0.007$, B = 0.207), fruits consumption < 2 servings per day versus no consumption ($p = 0.014$, B = 0.444), fruits ≥ 2 servings versus no consumption ($p = 0.014$, B = 0.480), vegetables consumption < 3 servings versus no consumption ($p = 0.045$, B = −0.374), vegetables consumption ≥ 3 servings versus no consumption ($p = 0.038$, B = 0.439), respectively. DBP had also significant correlations with fast foods/junk foods consumption of 1-2 items per week versus almost daily consumption ($p = 0.047$, B = −0.177). This final model could predict 32.1% of HTN ($R^2 = 0.321$). The results of the present study generally showed that although SBP and DBP levels

Table 5. Univariate correlations between SBP and DBP with life style related factors in obese children and adolescents

Predictor variables	SBP (mmHg)				DBP (mmHg)			
	Coefficient	p	95% CI	R^2	Coefficient	p	95% CI	R^2
BMI*								
BMI quartile 1	Referent							
BMI quartile 2	3.93	**0.014**	0.79, 7.06	0.2080	1.50	0.197	−0.78, 3.78	0.2040
BMI quartile 3	9.50	**< 0.001**	6.81, 13.08		7.07	**< 0.001**	4.79, 9.35	
BMI quartile 4	15.51	**< 0.001**	12.39, 18.64		10.55	**< 0.001**	8.28, 12.83	
Overweight/obesity								
Overweight	Referent							
Obesity	1.24	0.430	−1.84, 4.32	0.0015	0.54	0.636	−1.70, 2.78	0.0005
Nutrition screening pattern	3.61	0.066	−0.24, 7.46	0.0080	0.54	0.706	−2.27, 3.35	0.0003
Fruit consumption								
Rarely or never/day	Referent							
< 2 serving/day	7.28	0.225	−4.84, 19.05	0.0058	9.77	**0.025**	1.24, 18.29	0.0153
≥ 2 serving/day	8.42	0.149	−3.03, 19.87		10.57	**0.013**	2.27, 18.86	
Vegetable consumption								
Rarely or never/day	Referent							
Vegetable < 3 serving/day	−0.26	0.955	−9.56, 9.03	0.0002	−0.24	0.943	−7.01, 6.52	0.0000
Vegetable ≥ 3 serving/day	−0.60	0.897	−9.74, 8.54		−0.16	0.962	−6.81, 6.49	
Dairy consumption								
Rarely or never/day	Referent							
< 3 serving/day	5.97	0.227	−4.66, 16.61	0.0128	4.22	0.284	−3.51, 11.96	0.0138
≥ 3 serving/day	2.70	0.611	−7.74, 13.14		1.73	0.655	−5.86, 9.32	
Fast foods/junk foods consumption								
Almost every day	Referent							
1–2 items/week	−1.04	0.673	−5.92, 3.83	0.0033	−0.08	0.965	−3.63, 3.47	0.0012
Rarely	−2.24	0.322	−6.69, 2.20		−0.75	0.650	−3.99, 2.49	
Meals/snacks								
≤ 2 meals or snacks/day	Referent							
3–4 meals or snacks/day	−4.85	0.206	−12.39, 2.67	0.0043	−3.22	0.248	−8.71, 2.25	0.0053
≥ 5 meals or snacks/day	−5.18	0.179	−12.77, 2.39		−2.18	0.436	−7.70, 3.32	
Nutritional pattern rating	−2.90	0.268	−0.80, 0.24	0.0029	−0.06	0.740	−0.43, 0.31	0.0003
Watching TV/PC								
> 2 hours/day	Referent							
About 2 hours/day	−3.32	**0.050**	6.65, 0.004	0.0120	−2.47	**0.045**	−4.90, −0.05	0.0095
< 2 hours/day	−2.04	0.147	−4.80, 0.72		−0.99	0.333	−3.00, 0.01	
Physical activity								
No physical activity	Referent							
< 420 minutes/week	4.05	**0.024**	0.53, 7.75	0.0171	2.87	**0.028**	0.31, 5.43	0.0169
≥ 420 minutes/week	1.01	0.573	−2.53, 4.57		0.622	0.636	−1.96, 3.20	

Bold styled values indicate the statistically significnace.
BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.
*BMI was categorized as quartile as follows: quartile 1, <22.20 kg/m²; quartile 2, 22.20–25.22 kg/m²; quartile 3, 25.22–28.79 kg/m²; and quartile 4, ≥ 28.79 kg/m².

in children and adolescents were associated with dietary intake and lifestyle, increased age and BMI can significantly increase SBP and DBP in the analysis based on three hierarchical multivariable linear regression model.

DISCUSSION

Pediatric HTN is undergoing a major shift from secondary HTN (mostly caused by renal disease) to essential HTN (as the main cause of HTN in childhood and adolescence) [20]. The factors related to primary HTN in children were different for increased SBP and DBP. In the current report, we evaluated the important predictors of HTN in children and adolescents and found that age and BMI were the main predictors of SBP, while age, BMI, higher intakes of fruits, vegetables, and fast foods were in positive and significant association with DBP.

Table 6. Blood pressure predictors of obesity and overweight children and adolescents according to lifestyle (food intake and physical activity)

Model	Predictor variable	SBP (mmHg)			DBP (mmHg)		
		p	B	R^2	p	B	R^2
1	Sex	0.754	−0.130	0.281	0.537	−0.025	0.275
	Age	**< 0.001**	0.354		**< 0.001**	0.356	
	BMI	**0.005**	0.213		**0.007**	0.205	
	Overweight	Referent					
	Obesity	0.747	−0.016		0.547	−0.031	
2	Sex	0.538	−0.026	0.307	0.286	−0.045	0.303
	Age	**< 0.001**	0.356		**< 0.001**	0.342	
	BMI	**0.005**	0.215		**0.007**	0.208	
	Overweight	Referent					
	Obesity	0.761	−0.015		0.545	−0.013	
	Fruit consumption rarely or never/day	Referent					
	Fruit < 2 serving/day	0.142	0.259		**0.009**	0.465	
	Fruit ≥ 2 serving/day	0.059	0.334		**0.003**	0.533	
	Vegetable consumption rarely or never/day	Referent					
	Vegetable < 3 serving/day	0.404	−0.147		0.159	−2.250	
	Vegetable ≥ 3 serving/day	0.345	−0.168		0.149	−0.258	
	Dairy consumption rarely or never/day	Referent					
	Dairy < 3 serving/day	0.549	0.145		0.463	0.144	
	Dairy ≥ 3 serving/day	0.692	0.079		0.828	0.043	
	Fast foods/junk foods consumption almost every day	Referent					
	Fast foods/junk foods 1–2 items/week	0.085	−0.135		0.090	−0.134	
	Fast foods/junk foods rarely	0.055	−0.174		0.081	−0.159	
	≤ 2 meals or snacks/day	Referent					
	3–4 meals/day	0.659	−0.058		0.597	−0.070	
	≥ 5 meals/day	0.306	−0.144		0.424	−0.089	
	Nutritional pattern rating	0.796	0.022		0.656	0.038	
3	Sex	0.537	−0.026	0.321	0.248	−0.049	0.321
	Age	**< 0.001**	0.344		**< 0.001**	0.327	
	BMI	**0.005**	0.2121		**0.007**	0.207	
	Overweight	Referent					
	Obesity	0.723	−0.018		0.459	−0.039	
	Fruit consumption rarely or never/day						
	Fruit < 2 serving/day	0.154	0.256		**0.014**	0.444	
	Fruit ≥ 2 serving/day	0.096	−0.324		**0.014**	0.480	
	Vegetable consumption rarely or never/day	Referent					
	Vegetable < 3 serving/day	0.217	−0.229		**0.045**	−0.374	
	Vegetable ≥ 3 serving/day	0.189	−0.277		**0.038**	−0.439	
	Dairy consumption rarely or never/day	Referent					
	Dairy < 3 serving/day	0.432	0.169		0.525	0.130	
	Dairy ≥ 3 serving/day	0.719	0.081		0.972	−0.007	
	Fast foods/junk foods consumption almost every day	Referent					
	Fast foods/junk foods 1–2 items/week	0.080	−0.156		**0.047**	−0.177	
	Fast foods/junk foods rarely	0.118	−0.212		0.060	−0.255	
	≤ 2 meals or snacks/day	Referent					
	3–4 meals/day	0.423	−0.118		0.262	−0.165	
	≥ 5 meals/day	0.237	−0.217		0.204	−0.233	
	Nutritional pattern rating	0.724	0.103		0.344	0.277	
	Watching TV/PC > 2 hours/day	Referent					
	Watching TV/PC about 2 hours/day	0.169	−0.093		0.059	−0.128	
	Watching TV/PC < 2 hours/day	0.786	0.034		0.479	−0.089	
	Does not any targeted physical activity	Referent					
	Physical activity < 420 minutes/week	0.169	0.116		0.329	0.081	
	Physical activity ≥ 420 minutes/week	0.880	0.020		0.622	−0.066	

The test of Hierarchical regression was performed. Bold styled values indicate the statistically significance.
BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.

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The univariate analysis showed a significant correlation between adiposity indicators and sedentary lifestyle (lower physical activity and spent much time for TV/PC watching) with SBP and DBP, whereas higher intake of fruits was also associated with DBP.

In this study, we used a hierarchical linear multivariable regression model to examine the effect of each of the predictors in a model on other variables. Several other reports also confirmed the main determinant role of BMI in HTN development. Falkner et al. [21] examined electronic medical record data from primary care practices on 18,618 children aged 2 to 19 years and showed that 16.7% of children and adolescents were at risk of overweight and 20.2% were overweight. They also demonstrated that there was a significant association between increasing BMI with SBP and DBP in children and adolescents [21]. Dong et al. [22] also reported that increased prevalence of HTN was associated with higher BMI among 943,128 participants aged 7 to 17 years. Similar results were also observed in the Zeberio et al. study, indicating a positive association between SBP and BMI in school-aged children [23]. Several mechanisms have been suggested for the association between increasing BMI with HTN development. Sorof et al. [24] showed that increased carotid artery intima-media thickness (C-IMT) is associated with HTN in children. Studies show that there is a significant independent predicting role of CRP in C-IMT and flow-mediated vasodilation in children [25]. Ogawa et al. [26] also showed that higher concentrations of circulating inflammatory cytokines associated with the atherosclerotic process and C-reactive protein (CRP) was one of the most susceptible indicators of HTN in obese Japanese children.

Similar to our results, several studies have also demonstrated that a rise in the BP is associated with increased age in children and adolescents [23,27]. Several reports also indicated the possible role of puberty as an important determinant in the association between obesity and HTN among adolescents, especially females. This might also explain the increased prevalence of HTN with increased age [28]. Barba et al. [27] reported that in the period close to the completion of puberty, the association between age and BP becomes more evident among females. In the study by Oliveros et al. [29], the prevalence of HTN and stage 2 of HTN was higher among younger children compared with older ones, while stage 1 HTN was more prevalent among older children. It seems that the age range and the presence of puberty hormones in girls and boys is one of the reasons for conflicting results in different studies.

Among the dietary factors influencing the nutritional pattern score in the current study, a positive correlation between HTN and increased consumption of fruits groups and fast food/junk food consumption, and an inverse correlation between HTN and vegetables groups was observed. Increased fast food consumption containing high amounts of salt, sugar, and fat [30] is associated with increased obesity state [31,32]. Studies showed that high levels of fats, sugar, and salt intake in fast foods are one of the possible reasons of increased BP in children and adolescents [33-35]. The possible role of increased salt and sodium consumption in the pathogenesis of HTN has been clarified. Recently, the role of other dietary factors, food patterns, and lifestyle habits in increasing BP has also been a focus of interest. Stamler et al. [36] showed that in addition to sodium, several other nutrients, including calcium, magnesium, potassium, and fiber are also involved in the pathogenesis of HTN. One meta-analysis of 56 studies on the effect of sodium restriction on BP showed that sodium restriction could be beneficial among elderly individuals with HTN; however, its beneficial effects were low among people with normal BP [37]. The higher sodium and energy contents of fast/junk foods are possibly an underlying reason of the association between fast food consumption and HTN.

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Numerous studies have shown that higher intakes of fruits, vegetables, and dairy products could have an effective role in prevention of childhood HTN due to several nutrients, including potassium, magnesium, calcium, and fiber [38,39]. The positive association between fruits intake and HTN in our study, in contrast with several previous studies, could be attributed to the difference in study design, target group characteristics such as age or gender distribution [38], or possibly because of considering fruits and vegetables as a group with no separation [39]; however, we analyzed fruits and vegetables separately in 2 independent groups. Additionally, in the current study, 100% fruit juices were considered as fruit groups, in the foods groups pyramid, and were likely to increase BP by increasing consumption of fructose-rich fruit juice. Auerbach et al. [40] showed that consumption of more than 24 ounce per day of 100% fruit juice was associated with increased HTN risk. Also, 100% fruit juices might be associated with HTN through several possible biological mechanisms, including increased energy intake, weight gain, and uric acid production, which is also associated with elevated BP [41]. Moreover, consuming whole fruits in high amounts can increase weight due to increased energy intake. Considering that fiber is one of the most important factors in whole fruits that plays a role in BP, in our study, fruit juices and fruits were not separated. Therefore, further studies could study the effects of whole fruits and fruit juices separately.

No significant correlation was found between BP and dairy products in the current study. Yuan et al. indicated that high intake of dairy (≥ 2 servings per day) has antihypertensive effects on BP among children aged 8 to 10 years [42]. In a study by DellaValle et al. [43], greater intakes of dairy products were associated with lower SBP in white but not black children and teens, suggesting the possible role of demographic factors including race in beneficial role of dairy products. Given that, the type of dairy products in terms of low- or high-fat, as well as different types of dairy products such as milk, yogurt, cheese was not identified in our study; this may justify the discrepancy in the results, because studies show that specific types of dairy products such as low-fat milk and milk products have inverse association with hypertension and there were no association with high-fat dairy or cheese [44].

In the current report, 43.53% of participants consumed more than five meals per day; however, there was no significant relationship between frequency of meals' and HTN. Several studies showed that the prevalence of obesity declined by increased number of meals [45]. Donin et al. [46] presented that more snacks and meal consumption lead to obesity and cardiovascular problems in children. Toschke et al. [45] studied 4,370 children aged 5–6 years and found that the prevalence of obesity declines by increasing the number of meals.

In the final regression model, we did not observe any significant correlation between BP and physical activity or TV/PC watching. Torrance et al. [47] demonstrated that 40 minutes of moderate to vigorous aerobic-based physical activity 3–5 days/week is required to reduce BP in obese children. TV commercials influence the food choices of children in different ways. Using their highfalutin and vivid messages, they encourage people to buy the advertised products [48]. A program comprising screening, early detection, and health promotion through school health programs may help to prevent future complications of HTN [49]. In another study, de Moraes et al. [50] showed that maintaining sedentary behaviors during childhood increases the risk of developing HTN after 2 years of follow-up among 16,228 children 2–9 year. There is strong evidence that physical activity has a strong effect on the release of vasodilator factors produced by the vascular endothelium [51], such as nitric oxide and endothelium derived hyperpolarizing factor (EDHF) [52], and children with a physical activity of less than 60/min/d have lower vasodilation capacity of the endothelium, which could be the biological mechanism by which they develop HTN. There are multiple possible physiological mechanisms by which sedentary behaviors contribute to increased BP. Pedersen and Febbraio [53] suggested that sedentary behaviors change the myokine response in the skeletal muscle that leads to promoting the endothelial dysfunction in the cardiovascular system by increasing the pro-inflammatory adipokines. Consequently, this increment could be the start of atherosclerosis processes, and progressively develop into hypertension [53]. Although in the current study we observed a correlation between BP and TV watching and physical activity in the univariate regression, these associations had been disappeared by including several moderators into the model. It is suggested that more studies be conducted through considering the moderator's variables in this field.

Several limitations of the current study should be addressed. First, the family history of HTN among study participants was not considered. Second, the effects of other food items, including the amount of salt and fat intake were not evaluated. Finally, the socio-economic status of household, educational level for parents, and the presence of care-givers were not evaluate in this study.

CONCLUSION

According to our findings, it can be concluded that in the children and adolescent populations, pathogenesis of higher BP is influenced by age, higher BMI, and lifestyle factors like dietary intake. Therefore, by increasing the age of children, especially in overweight and obese ones, controlling their weight, encouraging the consumption of more vegetables, and recommending less fast food consumption could be a preventive strategy against HTN.

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