Sleep Duration and Risk of High Blood Pressure in Thai Adolescents: The Thai National Health Examination Survey V, 2014 (NHES-V)

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Abstract

Background: Sleep duration has been proposed to be associated with high blood pressure. However, nationwide studies regarding the association between sleep duration and high blood pressure in adolescents are limited. This study aimed to explore the national prevalence of high blood pressure among Thai adolescents and to determine whether sleep duration is associated with high blood pressure.

Methods: Data of adolescents aged 10-19 years from the Thai National Health and Examination Survey V were included. Demographic data including age, gender, height, weight, waist circumference, blood pressure, fasting blood chemistries and data on the sleep duration were collected. High blood pressure was defined based on the cut-off values from the guidelines by the American Academy of Pediatrics. Risk factors for high blood pressure were analyzed using multivariate logistic regression.

Results: A total of 3539 (1803 female) adolescents were included. The prevalence of high blood pressure was 9.4% (95%CI 8.5, 10.4%). The high blood pressure group had higher BMI z-score, triglyceride, LDL-C and a lower HDL-C than those in the normotensive group. In multivariate analysis, BMI z-score was associated with high blood pressure. Interestingly, after adjusting for BMI z-score and lipid profile, an average sleep duration below 6 hours/day was associated with a 2-fold higher risk of high blood pressure compared to that of the group with an average sleep duration of more than 8 hours/day.

Conclusions: High blood pressure risk was increased in participants who had an average sleep duration below 6 hours/day. This study highlights the need for promoting an adequate sleep duration in Thai adolescents to alleviate the risk of high blood pressure.

Background

Over the past few decades, the prevalence of elevated blood pressure in children has been rising [(1)]. The prevalence of elevated blood pressure reported by the National Health and Nutrition Examination Survey (NHANES) in the US increased from 15.8–19.2% in boys and 8.2–12.6% in girls during the years 1999-2008 (compared with the years 1988-1994) [(2)]. A study of school aged-children in Thailand showed that 24.3% of boys and 21.4% of girls had elevated blood pressure [(3)]. Obesity plays an important role as one of the causes of an increase in the prevalence of elevated blood pressure among school-aged children. One of the school-based studies in Thailand revealed that 30.6% of boys and 12.8% of girls had obesity and it increased the risk of elevated blood pressure for 10.3-folds [(4)]. The positive association of the prevalence of obesity and hypertension in children was consistent across many countries in Asia [(5–8)].

Apart from obesity, sleep duration has been reported to be one of the factors associated with high blood pressure in adult studies. However, little is known about the association between sleep duration and hypertension in adolescents. Wells et al reported that short sleep duration was associated with increased systolic blood pressure in a cross-sectional survey of 4452 Brazilian adolescents [(9)]. Bal et al found that Turkish adolescents aged 11-17 years who slept ≤ 8 hours/day had a high prevalence of hypertension and pre-hypertension up to 35% [(10)]. Moreover, adolescents who slept ≤ 5 hours/day had two times higher risk of elevated blood pressure than that of adolescents who slept 8-9 hours/day in a national survey from Korea [(11)]. As the prevalence of hypertension is increasing in Thailand and most of the other countries, it is urgent and important to have more information about the risk factors of hypertension in adolescents and young adults to de-escalate the public health burden in the near future. In addition, there has been no study regarding the association between sleep duration and blood pressure in Thailand. By analyzing the data from the Thai National Health and Examination Survey V, this study aimed to find the prevalence of high blood pressure and determine whether sleep duration is associated with high blood pressure in adolescents.

Methods

This study was conducted with approval from the Ramathibodi Hospital ethics committee for human research (MURA 2019/917) and (MURA 2021/664). The participants included in this study were recruited from the database of the Thai National Health and Examination Survey V (NHES-V) conducted in the year 2014. The NHES-V was a national-wide, cross-sectional survey using a multistage, stratified sampling of the Thai population. The detailed method of sampling was described previously [(12)]. In brief, the survey included 32,400 participants of all ages starting from age 1-year-old in five regions including Bangkok, Central region, Northern region, North-eastern region, and Southern region. A total of 3559 adolescents aged 10-19 years were examined in the NHES-V survey. Twenty participants were excluded due to the lack of blood pressure data. In this study, a total of 3539 adolescents were included.

Demographic data including age, weight, height, waist circumference and blood pressure were obtained. Body mass index (BMI) was calculated using the formula as follows: weight (kg)/height (m)^2. BMI was categorized into BMI z-score based on the World Health Organization growth reference for age and gender [(13)]. Overweight is defined as a BMI z-score > 1 but < 2. Obesity is defined as a BMI z-score ≥ 2. Waist circumference (WC) to height ratio (WHR) was calculated using: waist circumference (cm)/height (cm). Weight was measured in kilograms (kg) with the closest one decimal point. Height was measured in centimeters (cm) with the closest to one decimal point. Waist circumference was measured at the midpoint between the lower rib and the top of the iliac crest in centimeter with the closest to one decimal point.

The standardized blood pressure measurement was used as recommended by the guidelines from the American Academy of Pediatrics (AAP) [14]. The blood pressure monitor used in this study was Microlife BP 3AG1 (Widnau, Switzerland) which has been validated according to the British Society of Hypertension guidelines. Blood pressure was measured on the right arm in a sitting position after resting for 5 minutes. The cuff size with the width at least 40% and the length at least 80% of the mid-arm circumference of each participant. Each participant had three blood pressure measurements with the 5 minute-interval between measurements. The first measurement was discarded and the average of the last two measurements was defined as the blood pressure for each participant. Adolescents with either systolic blood pressure (SBP) or diastolic blood pressure (DBP) ≥ the 95th percentile based on age, gender and height in those aged 10-12 years or ≥ 130/80 mmHg in those aged ≥ 13 years were defined as having high blood pressure [14]. The term “hypertension” was not used in this study as the blood pressure measurement was performed in only a single visit for each participant.

Data regarding the sleep-wake times for weekdays (WD) and weekends (WE) were also collected using direct interviews by the trained researchers. Average sleep duration was calculated as [(WD x 5) + (WE x 2)] / 7. Based on the recommendation from the National Sleep Foundation, adolescents should have a sleep duration of 8-10 hours/day [15]. Therefore, the sleep duration was categorized into 3 groups as follows: Group A, < 6 hours/day as a very short sleep duration group; Group B, 6-8 hours/day as a short duration group; and Group C, > 8 hours/day as a control group.

Fasting blood samples were taken for chemistry analysis including plasma glucose, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and triglyceride (TG). Abnormal lipid profile for adolescents defines as LDL-C ≥ 130 mg/dl, TG ≥ 130 mg/dl or HDL-C < 40 mg/dl according to a recommendation from the National Heart, Lung, and Blood Institute [16].

Demographic data were presented as frequency and median (inter-quartile range). The Mann-Whitney U test was used to detect the difference of continuous data between the two groups. The Chi-square test was used to detect the difference of categorical data between the two or three groups. Multivariate logistic regression analysis was used to evaluate the parameters associated with high blood pressure in 2 models. Independent variables in model 1 included BMI category (BMI z-score <2 vs each 1 z-score increase), HDL-C (>40 vs each 5 mg/dl decrease), LDL-C (<130 vs each 10 mg/dl increase), TG (<130 vs each 10 mg/dl increase) and the model was further added with the variables of an average sleep duration as the model 2. A *p*-value of ≤ 0.05 was considered statistically significant. Institutional licensed SPSS version 22 software was used for statistical analysis.

Results

Demographic data and fasting blood chemistries

A total of 3539 adolescents (1803 females) aged 10-19 years were included in this study. The overall prevalence of high blood pressure was 9.4% (95%CI 8.5, 10.4%). Demographic data and the other parameters between the high blood pressure and normotensive groups for the whole population and separated by gender are presented in Table 1. For the whole population, the high blood pressure group had a significantly greater BMI z-score, WHR and more proportions of obesity than those of the normotensive groups. Moreover, the high blood pressure group had significantly greater plasma glucose, TC, LDL-C and TG and a lower HDL-C than those of the normotensive group.

Table 1
Demographic data of adolescents participating in this survey

Parameters	Both genders (N=3539)		*P*-value	Male (N=1736)		*P*-value	Female (N=1803)		*P*-value
	Normotension (N=3206)	High blood pressure (N=333)		Normotension (N=1503)	High blood pressure (N=233)		Normotension (N=1703)	High blood pressure (N=100)	
Age (years), median (IQR)	14 (12,16.4)	13.7 (11.5,16.8)	0.431	13.9 (12.1,16.4)	13.7 (11.6,17.1)	0.414	14.1 (11.9,16.6)	13.8 (11.4,0.8715.9)	0.76
Height (cm), median (IQR)	156 (148,163)	157 (147,167)	0.24	161 (141,168)	160 (147,170)	0.989	154 (148,159)	154 (147,160)	0.749
Weight (kg), median (IQR)	47 (39,56)	57 (43,77)	**<0.001**	50 (39,59)	59 (44,78)	**<0.001**	46 (39,53)	53 (42,69)	**0.003**
WC (cm), median (IQR)	67 (61,75)	77 (64,92)	**<0.001**	68 (61,76)	79 (64,93)	**<0.001**	67 (61,74)	75 (63,88)	**<0.001**
BMI (kg/m^2), median (IQR)	19 (16.7,21.9)	27.8 (18,28.8)	**<0.001**	18.8 (16.6,22)	23.3 (18.2,28.5)	**<0.001**	19.1 (16.9,21.9)	22.2 (18.2,29.4)	**0.003**
BMI z-score, median (IQR)	-0.16 (-0.8,0.87)	1.1 (-0.2,3.52)	**<0.001**	-0.17 (-0.88,1.0)	1.16 (-0.23,3.7)	**<0.001**	-0.16 (-0.77,0.8)	0.72 (0.27,3.06)	**<0.001**
WHR (cm/cm), median (IQR)	0.43 (0.4,0.48)	0.48 (0.42,0.57)	**<0.001**	0.42 (0.4,0.47)	0.49 (0.42,0.58)	**<0.001**	0.43 (0.4,0.48)	0.47 (0.42,0.57)	**<0.001**
SBP (mmHg), median (IQR)	105 (98,113)	127 (121,134)	**<0.001**	109 (101,115)	129 (122,135)	**<0.001**	103 (97,110)	125 (119,131)	**<0.001**
DBP (mmHg), median (IQR)	63 (58,68)	77 (68,82)	**<0.001**	63 (58,68)	76 (68,81)	**<0.001**	63 (58,67)	79 (70,82)	**<0.001**
Prevalence of obesity (%)	11.76	39.64	**<0.001**	14.9	41.2	**<0.001**	8.9	26	**<0.001**
[%]Glucose (mg/dl), median (IQR)	87 (83,93)	89 (83,94)	**0.018**	88 (83,93)	89 (84,95)	**0.012**	87 (82,93)	87 (82,92)	0.859
[#]TC (mg/dl), median (IQR)	169 (147,191)	174 (151,195)	**0.034**	163 (141,186)	176 (151,198)	**0.001**	174 (152,190)	172 (170,192)	0.463
[@]HDL-C (mg/dl), median (IQR)	50 (43,59)	46 (39,54)	**<0.001**	48 (41,57)	46 (38,53)	**0.004**	52 (44,60)	48 (40,58)	**0.02**

SD, standard deviation; WC, waist circumference; BMI, body mass index; WHR, waist to height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; WD, weekdays; WE, weekends

[@]N=2877, [#]N=2878, [$]N=2879, [%]N=3509, **Bold text**, statistical significance (p-value ≤ 0.05)

Parameters	Both genders (N=3539)		*P*-value	Male (N=1736)		*P*-value	Female (N=1803)		*P*-value
	Normotension (N=3206)	High blood pressure (N=333)		Normotension (N=1503)	High blood pressure (N=233)		Normotension (N=1703)	High blood pressure (N=100)	
$LDL-C (mg/dl), median (IQR)	107 (88,126)	117 (93,137)	**0.009**	104 (85,124)	117 (95,138)	**<0.001**	111 (92,130)	112 (90,133)	0.917
#TG (mg/dl), median (IQR)	83 (62,111)	98 (68,132)	**<0.001**	81 (60,111)	93 (67,135)	**0.002**	84 (65,111)	102 (71,127)	**0.009**
$WD sleep duration (hours), median (IQR)	9 (8,10)	9 (8,10)	0.858	9 (8,10)	9 (8,10)	0.488	9 (8,10)	9 (8,9.5)	0.934
$WE sleep duration (hours), median (IQR)	9.5 (8.5,10.2)	9.5 (8.5,10)	0.652	9.5 (8.5,10.5)	9.5 (8.5,10)	0.43	9.5 (8.5,10)	9.5 (9,10)	0.805
$Average sleep duration (hours), median (IQR)	9 (8.1,10)	9 (8.3,9.9)	0.968	9 (8.29,10)	9 (8.2,9.9)	0.425	9 (8,9.9)	9 (8.5,9.8)	0.566

SD, standard deviation; WC, waist circumference; BMI, body mass index; WHR, waist to height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; WD, weekdays; WE, weekends

@N=2877, #N=2878, $N=2879, %N=3509, **Bold text**, statistical significance (p-value ≤ 0.05)

Sleep Duration And Blood Pressure

Data regarding sleep duration were available in 3509 participants. Overall, there were no differences in weekdays, weekends and average sleep durations between the high blood pressure and normotensive groups as demonstrated in Table 1. However, in males, a higher proportion with sleep duration < 6 hours/day (group A) on weekdays was found in the high blood pressure group compared to the normotensive group. Moreover, for both genders, the group with high blood pressure had a significantly higher proportion of sleep duration <6 hours/day (group A) on average and weekdays than those of the normotensive group as shown in Table 2. There were no significant differences of proportions with different sleep durations in females.

Table 2
Proportion of participants with and without high blood pressure categorized by groups of different sleep duration

Periods	Sleep duration	Both genders		*P*-value	Males		*P*-value	Females		*P*-value
		Normal N = 3178	**High blood pressure** N = 331		**Normal** N = 1491	**High blood pressure** N = 230		**Normal** N = 1688	**High blood pressure** N = 100	
Weekdays	C: >8 hours, N (%)	2059 (64.8)	230 (69.4)	**0.002**	1020 (68.4)	160 (69.6)	**0.01**	1040 (61.6)	69 (69)	0.292
	B: 6-8 hours, N (%)	1049 (33)	86 (26)		436 (29.2)	57 (24.8)		613 (37.3)	29 (29)	
	A: <6 hours, N (%)	70 (2.2)	15 (4.5)		35 (2.3)	13 (5.7)		35 (2.1)	2 (2)	
Weekends	C: >8 hours, N (%)	2440 (76.8)	256 (77.3)	0.836	1135 (76.1)	175 (76.1)	0.676	1306 (77.4)	80 (80)	0.789
	B: 6-8 hours, N (%)	675 (21.2)	70 (21.1)		316 (21.2)	51 (22.2)		359 (21.3)	19 (19)	
	A: <6 hours, N (%)	63 (2)	5 (1.5)		40 (2.7)	4 (1.7)		23 (1.4)	1 (1)	
Average	C: >8 hours, N (%)	2411 (75.9)	262 (79.2)	**0.048**	1160 (77.8)	180 (78.3)	0.276	1252 (74.2)	80 (80)	0.324
	B: 6-8 hours, N (%)	707 (22.3)	59 (17.8)		297 (19.9)	41 (17.8)		410 (24.3)	18 (18)	
	A: <6 hours, N (%)	60 (1.9)	10 (3.0)		34 (2.3)	9 (3.9)		26 (1.5)	2 (2)	

Bold text, statistical significance (*p*-value ≤ 0.05)

Focusing on participants with overweight or obesity (BMI z-score >1), male participants with high blood pressure had a more proportion of sleep duration on weekdays < 6 hours/day (group A) compared with that of the male normotensive group (supplemental Table S1). However, no difference was observed in female participants.

Parameters Associated With High Blood Pressure

The multivariate logistic regression revealed that an increase in BMI z-score > 2, a decrease in HDL-C < 40 mg/dl and an increase in LDL-C > 130 mg/dl were the three factors associated with high blood pressure in males and only BMI z-score > 2 was associated with high blood pressure in females (Model 1). In Model 2, an average sleep duration < 6 hours/day (group A) showed a significant association with high blood pressure after adjusting for BMI z-score and lipid profile in males. There was no association of average sleep duration and high blood pressure in females.

For the whole population, an average sleep duration < 6 hours/day (group A) was also associated with an increased risk of high blood pressure by 2-fold compared with that of group C as demonstrated in Table 3. By analyzing the association between sleep duration on weekdays and high blood pressure among participants with overweight or obesity, male participants with a sleep duration < 6 hours/day (group A) had an 8-fold higher risk of high blood pressure compared with that of group C as shown in supplemental Table S2. A higher risk of high blood pressure was not observed in the subgroup analysis of male participants without overweight or obesity.

Table 3
Univariate and multivariate analyses of factors associated with high blood pressure

Factors	Both genders			Male participants			Female participants		
	Univariate model	Multivariate model 1	Multivariate model 2	Univariate model	Multivariate model 1	Multivariate model 2	Univariate model	Multivariate model 1	Multivariate model 2
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
BMI z-score ≤ 2	1	1	1	1	1	1	1	1	1
BMI z-score 2 - <3	**2.5 (1.4-4.4)**	**2.6 (1.33-5.2)**	**2.6 (1.34-5.21)**	**2.2 (1.4-3.5)**	**1.9 (1.1-1-3.3)**	**2 (1.17-3.47)**	**2.92 (1.45-5.89)**	2.4 (0.97-5.94)	**2.6 (1.3-5.1)**
BMI z-score 3 - <4	**3.9 (2.6-6.2)**	**4.8 (2.8-8.2)**	**4.7 (2.74-7.9)**	**3.7 (2.2-6.2)**	**2.9 (1.6-5.2)**	**3 (1.66-5.3)**	**3.38 (1.39-8.23)**	**4.63 (1.8-12.1)**	**3.4 (1.6-6.2)**
BMI z-score 4 - <5	**7.3 (4.3-12.6)**	**7.5 (3.9-14.4)**	**7.52 (3.9-14.5)**	**4.3 (2.3-7.9)**	**4.2 (2-8.5)**	**4.3 (2.1-8.7)**	**14.9 (5.97-37.23)**	**14.7 (5.7-37.8)**	**5.1 (1.97-13.1)**
BMI z-score 5 - <6	**22 (12.3-39)**	**12.3 (6.3-24.2)**	**11 (5.9-23.3)**	**6 (2.8-13.2)**	**7.4 (2.8-19.2)**	**7.5 (2.8-19.6)**	**6.61 (1.8-24.26)**	**5.72 (1.17-27.9)**	**7.1 (2.4-21.4)**
BMI z-score ≥ 6	**25.2 (10.7-59.6)**	**24.6 (12.5-49)**	**24.7 (12.5-49)**	**18.6 (8.9-39.3)**	**17.2 (6.6-44)**	**17.7 (6.8-46.2)**	**64.6 (16.7-249)**	**57 (13.4-246.6)**	**29 (12.7-66)**
HDL-C ≥ 40 mg/dl	1	1	1	1	1	1	1	1	1
HDL < 40 (each 5 mg/dl decrease)	**1.36 (1.17-1.57)**	**1.19 (1.0-1.4)**	1.17(0.98-1.38)	**1.3 (1.1-1.57)**	**1.24 (1.02-1.52)**	**1.23 (1.01-1.51)**	**1.40 (1.09-1.82)**	1.14 (0.83-1.57)	1.1 (0.78-1.48)
LDL-C ≤ 130 mg/dl	1	1	1	1	1	1	1	1	1
LDL<130 (each 10 mg/dl increase)	**1.12 (1.02-1.22)**	**1.11 (1.0-1.22)**	**1.11 (1.01-1.23)**	**1.24 (1.1-1.37)**	**1.22 (1.1-1.37)**	**1.22 (1.09-1.37)**	0.97 (0.81-1.16)	0.91 (0.75-1.12)	0.92 (0.76-1.12)
TG ≤ 130 mg/dl	1	1	1	1	1	1	1	1	1
TG >130 (each 10 mg/dl increase)	**1.2 (1.11-1.28)**	0.99 (0.9-1.08)	0.99 (0.9-1.08)	**1.2 (1.1-1.31)**	0.98 (0.85-1.1)	0.98 (0.88-1.1)	1.15 (1.00-1.32)	1.04 (0.88-1.24)	1.01 (0.85-.12)
WD group C	1			1			1		
WD group B	0.73 (0.6-0.95)			0.83 (0.6-1.15)			0.70 (0.45-1.10)		
WD group A	**1.92 (1.08-3.41)**			**2.37 (1.2-4.57)**			0.85 (0.20-3.60)		
WE group C	1			1			1		
WE group B	0.99 (0.75-1.31)			0.8 (0.31-2.04)			0.38 (0.05-2.79)		

BMI, body mass index; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triglyceride; WD, weekdays; WE, weekends

Bold text, statistical significance (*p*-value ≤ 0.05)

Factors	Both genders			Male participants			Female participants		
	Univariate model	Multivariate model 1	Multivariate model 2	Univariate model	Multivariate model 1	Multivariate model 2	Univariate model	Multivariate model 1	Multivariate model 2
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
WE group A	0.76 (0.3-1.9)			0.61 (0.14-2.61)			0.72 (0.09-5.3)		
Average group C	1		1	1		1	1		1
Average group B	0.77 (0.57-1.04)		0.82 (0.58-1.16)	0.89 (0.62-1.28)		0.83 (0.54-1.28)	0.23 (0.03-1.64)		0.3 (0.4-2.3)
Average group A	1.7 (0.88-3.26)		**2.16 (1.04-4.52)**	1.7 (0.81-3.62)		**2.38 (1.02-5.56)**	1.25 (0.29-5.56)		1.46 (0.3-6.8)

BMI, body mass index; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triglyceride; WD, weekdays; WE, weekends

Bold text, statistical significance (*p*-value ≤ 0.05)

Discussion

The present study demonstrated that the prevalence of high blood pressure in adolescents aged 10-19 years in Thailand was 9.4% based on the cutoff values from the year 2017 guidelines by the AAP [1]. BMI z-score was independently associated with hypertension in a dose-response relationship in both genders. Moreover, an average sleep duration < 6 hours/day was an independent factor associated with high blood pressure after adjusting for BMI z-score and lipid profile.

This is the first study to represent the national prevalence of high blood pressure in Thai adolescents. Compared to the previous national studies conducted before the year 2017 from Iran, Australia and China which reported the prevalence at 6.8%, 5.8% and 6%, respectively [17–19], the prevalence of high blood pressure in the present study was higher. This finding could be partly explained by the fact that the cutoff values for diagnosis of hypertension of the year 2017 AAP guidelines used in the present study were lower than those of the year 2004 AAP guidelines [20] used in the studies from those countries. The year 2017 normative blood pressure tables were derived from the year 2004 normative blood pressure tables that did not include children and adolescents with overweight and obesity. Therefore, the cutoff values in the year 2017 guidelines were 2-3 mmHg lower than those of the year 2004 normative tables. The increase in the prevalence of hypertension by using these new cutoff values had been reported in an international cohort and a study from Thailand [21, 22]. The prevalence of high blood pressure increased from 7–16.2% and 6.9 to 10.8% in the international cohort and Thai studies, respectively.

The present study showed that, in male participants, TC, LDL-C and TG levels were significantly higher and HDL-C levels were significantly lower in the high blood pressure group than the normotensive group. In female participants, TG levels were significantly higher and HDL-C levels were significantly lower in the high blood pressure group than in the normotensive group. These results were consistent with the study reported by Garí-Llanes M et al [23]. Among 373 children aged 8-11 years in Cuba, the high blood pressure group had higher levels of TC, LDL-C, TG and lower levels of HDL-C than those in the normotensive group [23]. In the present study, the higher BMI and more proportion of obesity in the high blood pressure group could explain why they had higher levels of TC, LDL-C and TG and lower levels of HDL-C than those in the normotensive group. In contrast, the other reports from Serbia and Italy did not show a significant difference in those lipid profiles between high blood pressure and normotensive children [24, 25]. Since BMI and lipid profile in children and adolescents are correlated [26], the comparable BMI between the high blood pressure and normotensive groups in those reports from Italy and Serbia may explain the reason why there was no difference in lipid profiles between the two groups.

Apart from the BMI z-score and lipid profile, a sleep duration was found to be another independent factor associated with high blood pressure in male participants. The increases in sympathetic activity and appetite hormones such as ghrelin in individuals with short sleep duration were proposed to be the mechanisms underlying the association between sleep duration and blood pressure [27]. There have been many studies reporting the association between sleep duration and blood pressure. Wells JCK et al found that short sleep duration was associated with increased systolic blood pressure for both genders in 4452 Brazilian adolescents aged 10-12 years [9]. Bal C et al reported a study of 2860 Turkish adolescents aged 11-17 years and found that each hour of increase in sleep duration decreased the risk of hypertension by 12% [10]. The effect of an increase in sleep duration on a decrease in the risk of high blood pressure seemed to exist for both genders. For the whole population,

compared to the group with average sleep duration of > 8 hours/day (group C), an average sleep duration < 6 hours/day (group A) increased the risk of high blood pressure by 2-fold after adjusting for BMI z-score and lipid profile. This result was concordant with the data from Korea.[11]

When analyzing the data between male participants with overweight or obesity and the sleep duration on weekdays, the risk of high blood pressure in group A was even greater (8-fold) compared with that in group C. Nonetheless, the effect of short sleep duration on high blood pressure was attenuated in the male participants with BMI z-score <1. This finding enlightened the fact that short sleep duration increased the risk of high blood pressure particularly in male adolescents with overweight or obesity. The author also did not observe the associations of short sleep duration and high blood pressure in females. This could be due to a small number of female participants with high blood pressure compared to the number in males.

The present study represented the first national prevalence of high blood pressure in Thai adolescents. This study also demonstrated that not only BMI z-score but also was a sleep duration associated with high blood pressure after adjusting for the other parameters. However, this study has some limitations. Firstly, the cause and effect between the risk factors and high blood pressure could not be drawn from this cross-sectional survey. Secondly, high blood pressure was diagnosed based on just a single visit of BP measurement, not three occasions as recommended by the current guidelines, therefore the diagnosis of hypertension could not be made from this study. The data regarding awareness of hypertension and co-morbidities among these participants were not available. Moreover, the sleep duration was not measured using a validated self-reported tool specifically designed to measure adolescents' sleep such as the Adolescent Sleep-Wake Scale [28]. Lastly, the number of female participants with high blood pressure was limited, so it might not have enough power to detect any significant association with the sleep duration. Therefore, the more researches on the association of sleep duration and risk of high blood pressure in adolescents are needed.

Conclusions

The overall prevalence of high blood pressure was 9.4%. BMI z-score was an important factor associated with high blood pressure. Moreover, an average sleep duration of < 6 hours/day had an increased risk of high blood pressure especially in males. This finding highlighted the importance of adequate sleep duration in adolescents to alleviate the risk of high blood pressure especially in male adolescents.

Abbreviations

CI, confidence interval; SD, standard deviation; WC, waist circumference; BMI, body mass index; WHR, waist to height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; WD, weekdays; WE, weekends

Declarations

Ethics approval and consent to participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the ethics committee for human research (MURA 2019/917 and MURA 2021/664) Faculty of Medicine Ramathibodi Hospital, Mahidol University. We received the permission to access and use the 5th Thai National Health Examination Survey database from the Department of Community Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University; e-mail: headracm@mahidol.ac.th

Consent to publish

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the Department of Community Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University on reasonable request.

Completing interests

The authors declare no conflict of interest relevant to this study.

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Authors' contribution

KP, WA, SS, WP, PK, NN, SC, SA and ST had substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; KP, WA and SS had substantial contributions to drafting the article and revising it critically for important intellectual content; KP, WA, SS, WP, PK, NN, SC, SA and ST had approved the manuscript of the version to be published.

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