ORIGINAL ARTICLE

Contribution of Snacks and Physical Activities to Elevated Blood Pressure of Adolescent Girls in West Java, Indonesia

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ABSTRACT

Introduction: The prevalence of hypertension in Indonesia has continued to increase over the last few years. An unhealthy diet and lack of physical activity can elevate blood pressure, particularly if an unhealthy lifestyle has been followed since adolescence. This study aimed to analyze the correlation between snack consumption and physical activity with blood pressure in adolescent girls. **Methods:** A cross-sectional study was conducted with 349 adolescent girls from seven Islamic boarding schools in West Java, Indonesia. Data on daily food and snack consumption were obtained by the 24-hour recall for 3 non-consecutive days. Blood pressure was measured using a digital blood pressure instrument, and the results were categorized by age, gender, and height. Linear regression analyses were performed to investigate determinants of blood pressure. **Results:** A total of 120 (34.4%) of the adolescent girls in the study had hypertension. A majority of girls had inadequate daily intake (energy, fat, carbohydrates, and sodium; only total protein intake met Indonesia's recommended dietary allowance). Snacks were found to be high in protein, fat, and carbohydrates, with consumption levels above 15%. More than half (61.9%) of the subjects' daily sodium intake came from snacks. Low-fat intake from snacks was associated with an increase in blood pressure in this study. Daily nutritional intake affecting blood pressure included sodium and total fat intake. Lack of physical activity in adolescent girls was not a risk factor for elevated blood pressure. **Conclusion:** Fat and sodium intake was associated with elevated blood pressure in adolescent girls.
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INTRODUCTION

Hypertension is a worldwide epidemic that can lead to stroke, myocardial infarction, cardiac failure, dementia, renal failure, or blindness if left uncontrolled. There are approximately 1.13 billion people worldwide with the condition, making it the leading risk factor for global deaths (1). In Indonesia, the prevalence of hypertension in the population ages 18 and older has increased from 25.8% in 2013 to 34.1% in 2018, with most cases occurring in women (36.85% in women vs. 31.34% in men) (2,3). Hypertension in adulthood often begins with an increase in blood pressure in adolescence (4). Elevated blood pressure in adolescents ages 12 to 18 also is associated with an increased risk of coronary heart disease in young adulthood (ages 33–39) (5).

Globalization has caused lifestyle changes, including changes in dietary habits and physical activity patterns (6). It leads to changes in disease patterns, from infectious diseases associated with undernutrition to chronic diseases, such as hypertension, caused by obesity (7). Adolescents have the highest prevalence of low physical activity when compared to other age groups, at 64.4% for ages 10 to 14 and 49.6% for ages 15 to 19 (3). Moreover, a study of students ages 13 to 15 found that 34.2% of the girls had sedentary behavior for 3 hours or more, which was slightly higher than boys (at 33.0%) (8). A sedentary lifestyle with little physical activity is associated with a high prevalence of hypertension in adolescents (9,10).

Another factor that increases the risk of hypertension is consuming snack foods while sitting still. Types of snack foods consumed are usually high-fat, high-sugar, and salty foods that can elevate blood pressure (11,12). In addition, snacks account for almost half of total daily sodium needs; this is associated with elevated blood pressure in adolescents (13). The frequency of snacking increases when the main meal frequency is less than 3 times a day, due to impaired appetite control (14).

In European countries, adolescents ages 10 to 17 have formed unhealthy snacking habits (15). In Spain, more than half of adolescents consume less than the recommended fruit and vegetables, whereas fried foods are consumed excessively (16). Meanwhile, in Indonesia, adolescents have a high consumption of fatty foods, instant foods, and soft drinks when compared to other age groups. In addition, the consumption of fruits and vegetables of 5 servings or more, according to World Health Organization (WHO) recommendations, is very low, at only 3.2% in the 10- to 12-year-old group and 3.6% in the 15- to 19-year-old group (3). In the following decades, this behavior might negatively affect Indonesia's health (17). The goal of this study was to analyze how nutritional intake, specifically from snacks, and physical activity of adolescent girls is associated with their blood pressure.

MATERIALS AND METHODS

Study design

This cross-sectional study was conducted on school girls from seven traditional Islamic boarding schools in Tasikmalaya City, West Java, Indonesia. Inclusion criteria consisted of being a female student, aged 12 to 18, receiving main meals twice a day, residing in an Islamic boarding school, and getting parental consent. Using the calculation for the minimum of subjects needed for a cross-sectional study, the sample size was determined. Based on the results of basic health research, the prevalence of hypertension in Indonesia at the age of 18 is 34% (3), the corresponding level of confidence of 95%, the margin of error of 5%, and the possibility of nonresponse, the total sample size was 349 people.

Measurement

Through interviews, information on the characteristics of the subjects and the frequency of physical activity was collected. Data on daily consumption of main meals and snacks were obtained through a 24-hour recall method for three non-consecutive days. Food pictures and household measurements were used to help subjects define portion size. The data were then analyzed using Nutrisurvey software based on Indonesian Food Composition Data 2017 (18) to measure the intake of energy, protein, fat, carbohydrates, fiber, sodium, and potassium. The total nutritional intake was compared with the Indonesian recommended dietary allowance (RDA) and was classified into two groups, adequate if the RDA was met and inadequate if the nutritional intake was less than the RDA. Nutritional intake from snacks was high if the intake level was greater than 15% and low if the intake level was less than 15% (19). A standardized digital blood pressure instrument (the Omron Digital HEM-8712, Japan) was used to measure blood pressure. Measurements were carried out three times with the subject in a sitting position. Classification of hypertension in the present study was based on U.S. National Institutes of Health guidelines, as follows. Normal blood pressure (normotensive) is defined by systolic blood pressure (SBP) and diastolic blood pressure (DBP) that are less than the 90th percentile by sex, age, and height; prehypertensive indicates that SBP and DBP are greater than or equal to the 90th percentile but less than the 95th percentile; and hypertension is defined by a mean systolic and diastolic pressure equal to or above the 95th percentile for age, sex, and height (20). Body weight was measured using a digital scale (Omron, Japan) with a precision of 0.1 kg, and height was measured using a stadiometer with a precision of 0.1 cm. Measurements were repeated three times. Body mass index (BMI) was calculated by dividing body weight (kg) by height squared (m2). The nutritional status parameter used was the BMI for age z-score (BAZ) categorized according to the Indonesian Child Anthropometry Standard for ages 5 to 15, namely: thin (–3 SD to less than -2 SD), normal (-2 SD to +1 SD), overweight (+1 SD to +2 SD), and obese (greater than +2 SD) (21). This study has received ethical approval (no. 178/EA/KEPK-FKM/2021) from the Health Research Ethics Committee, Faculty of Public Health, Diponegoro University, Semarang, Indonesia.

Statistical analysis

Data were analyzed using SPSS software version 23. Descriptive analyses were reported as means plus or minus standard deviation (SD) for quantitative variables and frequency and percentage for categorical variables. Prior to statistical analysis, all variables with numerical data were tested for normality of the data distribution using the Kolmogorov-Smirnov test. Statistical tests were carried out with a 95% confidence level, or α of 5%. Bivariate analysis used Pearson's product moment if the data were normally distributed and Spearman's rank if the data was not normally distributed. To investigate determinants of blood pressure, we used a linear logistic analysis. The independent variables included in the multivariate modeling were those with a p of less than 0.25 in bivariate analysis. We use multiple linear regression (MLR) to determine the direction and how much influence the independent variables have on the dependent variable. The variables that will be included in the model are those that have a p value <0.25 from the results of the bivariate analysis. Both for Systolic Blood Pressure and Diastolic Blood Pressure variables, we use backward stepwise regression to find a stepwise regression approach starting with the full model and at each step gradually removing variables from the regression model to find the reduced model that best describes the data.

RESULTS

The mean age of the included subjects was around 15 years, and the mean weight and height were 46.67 kg ± 9.43, and 149.60 cm ± 5.45, respectively. Of the 349 subjects, most (76.5%) had a normal BAZ, and 13.5% were in the overweight category. The mean SBP was

113.36 mmHg ± 12.21 and the mean DBP was 78.39 mmHg ± 9.19. A total of 53.6% of the subjects had normal blood pressure and one-third had hypertension (34.4%). Most (75.4%) of the subjects rarely did physical activity, with a frequency of only 1.3 times per week (Table I).

Table I: Characteristics of Adolescent Girls at Islamic Boarding Schools in West Java, Indonesia (N = 349)

Characteristic	Values
Age (years)	14.92 ± 1.73
Weight (kg)	46.67 ± 9.43
Height (cm)	149.60 ± 5.45
BAZ status, n (%)	
Thin	17 (4.9)
Normal	267 (76.5)
Overweight	47 (13.5)
Obese	18 (5.2)
Systolic blood pressure (mmHg)	113.36 ±12.21
Diastolic blood pressure (mmHg)	78.39 ± 9.19
Hypertension status, n (%)	
Hypertensive	120 (34.4)
Prehypertensive	42 (12.0)
Normotensive	187 (53.6)
Physical activity frequency (time/week)	1.30 ± 1.40
Physical activity level, n (%)	
Inadequate (0-1 times/week)	263 (75.4)
Adequate (2-7 times/week)	86 (24.6)

Data are mean ± standard deviation for quantitative variables and frequency (percent) for categorical variables.
BAZ, body mass index for age z-score.

Table II shows that the total daily nutritional intake level of the subjects (energy, fat, carbohydrates, and sodium) was inadequate, and only protein intake met the participants' daily needs based on Indonesia's RDA. Nutritional intake from snacks was often high in energy, protein, fat, and carbohydrates, with consumption above the cut-off point of 15%. The average daily fiber intake was 3.57 g/day, of which 2.46 g/day came from snacks. Average sodium intake was 506.63 g/day, and average snacking accounted for about 61.9% (313.95 g/day) of total daily sodium intake. More than one-third of potassium intake came from snacks (157.71 mg/day).

The results of the bivariate analysis in Table III show that there was a correlation between SBP and BAZ, total energy, total fat, total sodium, and total potassium intake, whereas DBP was associated with total nutritional intake (energy, protein, fat, carbohydrates, sodium, and potassium). Nutritional intake from snacks and physical activity frequency was not correlated with SBP and DBP.

To conduct multiple regression analysis and identify risk factors influencing blood pressure, we selected 7 models for Tables IV and V.

Multiple regression analysis was conducted for systolic and diastolic blood pressure to determine the relevance

Table II: Average Daily Nutritional Intake and Categories of Nutritional Intake Level Based on RDA for Adolescent Girls in West Java, Indonesia (N = 349)

Variables	Values
Nutritional intake	
Energy (kcal/day)	1501.29 ± 721.41
Protein (g/day)	33.53 ± 16.19
Fat (g/day)	44.54 ± 28.73
Carbohydrate (g/day)	235.67 ± 116.36
Dietary fibre (g/day)	3.57 ± 3.13
Sodium (g/day)	506.63 ± 607.00
Potassium (mg/day)	367.49 ± 308.14
Energy intake level, n (%)	
Adequate	73 (20.9)
Inadequate	276 (79.1)
Protein intake level, n (%)	
Adequate	333 (95.4)
Inadequate	16 (4.6)
Fat intake level, n (%)	
Adequate	61 (17.5)
Inadequate	288 (82.5)
Carbohydrate intake level, n (%)	
Adequate	100 (28.7)
Inadequate	249 (71.3)
Sodium intake level, n (%)	
Adequate	29 (8.3)
Inadequate	320 (91.7)
Nutritional intake from snacks	
Energy (kcal/day)	829.75 ± 716.88
Protein (g/day)	12.89 ± 12.10
Fat (g/day)	29.64 ± 28.44
Carbohydrate (g/day)	125.31 ± 112.52
Dietary fibre (g/day)	2.46 ± 3.05
Sodium (g/day)	313. 95 ± 486.35
Potassium (mg/day)	157.71 ± 250.28
Energy intake level from snacks, n (%)	
>15%	249 (71.3)
≤15%	100 (28.7)
Protein intake level from snacks, n (%)	
>15%	176 (50.4)
≤15%	173 (49.6)
Fat intake level from snacks, n (%)	
>15%	233 (66.8)
≤15%	116 (33.2)
Carbohydrate intake level from snacks, n (%)	
>15%	245 (70.2)
≤15%	104 (29.8)

Data are mean ± standard deviation for quantitative variables and frequency (percent) for categorical variables.

of blood pressure and dietary factors. As shown in Table IV, the variable included for each model (1, 2, 3, 4, 5, 6, and 7) accounted for between 0.080 and 0.088 R2 of the variability in SBP. Sodium total, fat total, and fat from snacks were significantly associated with SBP. Fat from snacks was inversely associated with SBP in 3, 4, 5, 6, and 7 models, whereas total sodium was

Table III: Correlation between Body Mass Index for Age z Score, Physical Activity Frequency, and Nutritional Intake with Systolic and Diastolic Blood Pressure in Adolescent Girls in West Java, Indonesia (N = 349)

Nutritional Intake	Systolic blood pressure		Diastolic blood pressure	
	r	*p*	*r*	*p*
Physical activity frequency	-0.081	0.130	-0.091	0.090
Nutritional intake				
Energy (kcal/day)	0.113	0.035	0.125	0.019
Protein (g/day)	0.102	0.057	0.141	0.008
Fat (g/day)	0.128	0.017	0.134	0.012
Carbohydrate (g/day)	0.101	0.059	0.108	0.044
Dietary fibre (g/day)	0.040	0.454	0.063	0.241
Sodium (g/day)	0.210	0.001	0.123	0.022
Potassium (mg/day)	0.111	0,038	0.130	0.015
Nutritional intake from snacks				
Energy (kcal/day)	0.044	0.413	0.045	0.401
Protein (g/day)	0.029	0.586	0.015	0.783
Fat (g/day)	0.080	0.137	0.069	0.199
Carbohydrate (g/day)	0.037	0.486	0.030	0.572
Dietary fibre (g/day)	-0.007	0.903	0.019	0.726
Sodium (g/day)	0.098	0.067	0.038	0.480
Potassium (mg/day)	0.001	0.991	0.003	0.953

positively associated with SBP in all seven models. The fat total was positively associated with SBP in 2, 3, 4, 5, 6, and 7 models. Other risk factors such as energy intake, carbohydrate intake, physical activity frequency, potassium total, and protein total did not affect the SBP (Table IV). The variables included for models 1, 2, 3, 4, 5, 6, and 7 accounted for between 0.066 and 0.074 R2 of the variability in DBP. Sodium total, fat from snacks, and fat total were significantly associated with DBP. Fat from snacks was inversely associated with DBP in 4, 5, 6, and 7 models, and total sodium also was positively associated with DBP in all models. Total fat was associated with an increase in DBP in models 5, 6, and 7 ($p < 0.05$) (Table V).

DISCUSSION

The prevalence of hypertension in adolescent girls was 34.4% in Tasikmalaya, West Java, higher than in high school students in the western part of Indonesia, such as Pekanbaru (22.1%) (22) and Palembang (8%) (23). The prevalence of adolescent hypertension in Indonesia in this study was higher than in other Asian countries, such as Vietnam (26.5%) (24), Turkey (14.8%) (25), China (13.1%) (26), and India (6.4%) (27).

In this study, we analyze the effects of sodium, potassium, energy, protein, carbohydrate, fat, dietary fiber intake, physical activity frequency, and snack consumption on blood pressure in adolescent girls. The study indicated that total sodium was positively associated with SBP and DBP in multiple regression models in this population, supported by the results of descriptive analysis which showed the average total sodium intake was 506 g/day. The Indonesian Ministry of Health recommends that adolescent girls between 13 – 15 years old should have only about 1500 mg of sodium each day (28). Even though the average sodium consumption of young women is still below the RDA, which is 506 mg, research on adolescents in Italy showed the results of a significant direct association was found between total sodium intake and the highest SBP and DBP quartile (13). Fat from snacks was inversely associated with both SBP and DBP.

Numerous studies have shown a direct link between sodium intake and blood pressure (29–33). Sodium intake increased hypertension by 1.479 times in both the

Table IV: Multiple Regression Models of Systolic Blood Pressure and Effect of Related Variables among Adolescent Girls in West Java, Indonesia (N = 349)

	Model 1 R^2 = 0.088		Model 2 R^2 = 0.088		Model 3 R^2 = 0.088		Model 4 R^2 = 0.088		Model 5 R^2 = 0.087		Model 6 R^2 = 0.084		Model 7 R^2 = 0.080	
	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value
Physical activity frequency	-0.058 (0.468)	0.283	-0.057 (0.460)	0.279	-0.057 (0.459)	0.276	-0.058 (0.456)	0.269	-0.060 (0.455)	0.252	-0.060 (0.455)	0.249		
Protein total	- 0.090 (0.067)	0.314	-0.088 (0.059)	0.264	-0.088 (0.059)	0.257	-0.085 (0.052)	0.221	-0.075 (0.051)	0.266				
Sodium total	0.233 (0.002)	0.013	0.233 (0.002)	0.013	0.229 (0.001)	0.000	0.230 (0.001	0.000	0.230 (0.001)	0.000	0.214 (0.001)	0.000	0.213 (0.001)	0.000
Fat from snack	-0.306 (0.073)	0.074	-0.307 (0.073)	0.073	-0.310 (0.067)	0.048	-0.304 (0.062)	0.035	-0.322 (0.061)	0.023	-0.258 (0.055)	0.047	-0.277 (0.055)	0.032
Potassium total	0.039 (0.002)	0.525	0.039 (0.002)	0.525	0.038 (0.002)	0.526	0.040 (0.002)	0.492						
Carbohydrate total	-0.017 (0.037)	0.961												
Fat total	0.397 (0.101)	0.096	0.405 (0.072)	0.018	0.408 (0.069)	0.012	0.412 (0.067)	0.010	0.437 (0.065)	0.005	0.344 (0.055)	0.008	0.356 (0.055	0.006
Energy total	0.038 (0.009)	0.943	0.013 (0.002)	0.924	0.014 (0.002	0.917								
Sodium from snack	-0.006 (0.002)	0.953	-0.005 (0.002)	0.959										

Table V: Multiple Regression Models of Diastolic Blood Pressure and Effect of Related Variables among Adolescent Girls in West Java, Indonesia (N = 349)

	Model 1 R^2 = 0.074		Model 2 R^2 = 0.074		Model 3 R^2 = 0.073		Model 4 R^2 = 0.072		Model 5 R^2 = 0.070		Model 6 R^2 = 0.070		Model 7 R^2 = 0.066	
	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value	β(SE)	*p* value
Physical activity frequency	-0.025 (0.355)	0.645	-0.024 (0.355)	0.650										
Energy total	0.513 (0.007	0.334	0.426 (0.006)	0.328	0.395 (0.005)	0.358	0.383 (0.005)	0.372	0.037 (0.001)	0.750				
Protein Total	-0.026 (0.051)	0.774												
Carbohydrate total	-0.319 (0.028)	0.369	-0.270 (0.025	0.385	-0.244 (0.024)	0.425	-0.255 (0.024)	0.402						
Dietary fiber	-0.049 (0.230)	0.535	-0.047 (0.229)	0.546	-0.049 (0.229)	0.533								
Sodium total	0.127 (0.001)	0.032	0.127 (0.001)	0.032	0.128 (0.001)	0.030	0.131 (0.001)	0.025	0.148 (0.001)	0.007	0.152 (0.001)	0.005	0.154 (0.001)	0.004
Potassium total	0.082 (0.002)	0.232	0.081 (0.002)	0.239	0.082 (0.002)	0.232	0.063 (0.002)	0.303	0.063 (0.002)	0.302	0.069 (0.002)	0.229	-)	
Fat from snack	-0.271 (0.052)	0.090	-0.253 (0.047)	0.084	-0.262 (0.047)	0.069	-0.280 (0.046)	0.048	-0.306 (0.045)	0.027	-0.296 (0.043)	0.028	0.341 (0.042	0.009
Fat total	0.174 (0.073)	0.448	0.184 (0.072)	0.417	0.198 (0.072)	0.375	0.213 (0.071)	0.337	0.346 (0.050)	0.026	0.368 (0.045)	0.009	0.431 (0.042	0.001

Guangxi Bai Ku Yao and Han populations, ages 15 to 89, according to a cross-sectional study in China (34). In a Mediterranean population, sodium intake raised DBP in normotensive and untreated hypertension subjects (35). According to an analysis of data from The Third National Health and Nutrition Examination Survey (NHANES III), those with high sodium intake were more likely to have high DBP (30). SBP and DBP increased by 0.8 mmHg and 0.7 mm Hg, respectively, for each additional gram of sodium consumed per day (36). In contrast to the common eating habits of Indonesians, which is three main meals a day, the traditional Islamic boarding schools only provided meals twice a day: breakfast at 7 a.m. and dinner at 5 p.m. Female students might have consumed snacks between these times, leading to a high contribution of sodium from snacks to total daily nutrition intake. However, sodium intake from snacks was less than a quarter of the recommended maximum intake value of 1400–1600 mg/day for young women, meaning that the level of sodium intake from snacks was safe and did not cause adverse effects on health (28). Elevated blood pressure in children ages 8 to 17 years may occur if sodium intake is equal to or greater than 3450 mg/day (37). The low intake of sodium from snacks showed that adolescent girls rarely consume high-sodium snacks, as a single snack item may supply an average of 6% to 14% of the recommended daily intake of sodium (38).

Our study found that total fat intake was one of the factors associated with blood pressure. This is consistent with a study in China that reported that SBP increased by 1.08 mmHg per 50 grams of fat intake per day in those with low fruit and vegetable consumption (178 ± 49 g/day) (39). On the other hand, reducing fat intake, particularly saturated fatty acids (SFA), may reduce the risk of high blood pressure in adolescents (40). The inverse relationship between fat from snacks and blood pressure or hypertension was maintained even after daily sodium intake was adjusted. A Korean study discovered that snacking frequency was inversely associated with blood pressure and hypertension (41). Previous studies have found that dietary fat from different sources is negatively associated with the incidence of hypertension. The fat referred to here is a fat derived from eggs, milk, dairy products, and seafood that has a protective effect against prehypertension and hypertension (42). According to a cross-sectional study conducted on 39,252 adult males in Shanghai, China, those who consume "fruit and milk" as part of their diet have lower SBP and DBP (43). The Indonesian Nutrition Adequacy Rate for fat at the age of 13-15 years is 80 grams (28). The results of this study show that the average consumption of fat from snacks is 29.64 g. This figure can be categorized as low. A study modifying the diet of respondents to reach 30 g of total fat showed that there was a decrease in systolic and diastolic blood pressure (44).

Adolescent girls in Islamic boarding schools rarely experienced physical activity (only about once a week), although this was not significantly associated with blood pressure. The frequency of physical activity was less than the WHO recommendation of 3 days a week for children ages 5 to 17 (45). However, adolescent girls may experience misinformation regarding the definition of physical activity and limit reports of physical activity to exercises. Physical activity includes any body movement produced by skeletal muscles that require energy expenditure. Therefore, the daily activities that are usually carried out by adolescent girls, such as washing clothes and sweeping and mopping floors, should be included in the category of physical activity. This likely increases the frequency of physical activity to more than once a week. The limitation of this study was

that the method of measuring physical activity; 24-hour physical activity recall was not used. This may provide a detailed description of the type and intensity of physical activity for each full day (46). In addition, the 24-hour recall method can also cause bias because it depends on the memory of the participants, several types of food may not be recorded because the participants forgot and only gives an overview of one day, which may not truly depict participants' normal diet. Two or more non-consecutive recalls are needed to estimate the distributions of typical dietary intake to account for day-to-day variance. In this study, the 24-hour food recall was conducted over 3 non-consecutive days. The multiple administrations in order to minimize bias (47).

CONCLUSION

In adolescent girls, elevated SBP and DBP were associated with high total sodium and total fat intake. Fat from snacks was found to be inversely associated with blood pressure and this warrant further evaluation of the different type of fats in the regular snacks consumed by the girls. Physical activity was not associated with elevated SBP or DBP. Further research is needed on the effects of various types of snacks and types of fat on the blood pressure of adolescent girls.

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