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The Risk of Hypertension in Adulthood as a Consequence of Adolescent Obesity

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Abstract

An increased population of overweight and obese adolescents currently exists. Without early intervention, these problems will result in an increasing prevalence of hypertension and risk of death in adults. This study aimed to explain the relationship between being overweight and/or obese in adolescence and having hypertension as adults. The study used the Indonesian Family Life Survey (IFLS) data with a retrospective cohort study. Adolescent body mass index (BMI) measurements were taken from 2007 and the risk of hypertension was then measured in 2014. The population was all adolescents aged 10–20 years in 2007. A random sample of 1,697 adolescents was taken from 2007 IFLS data using inclusion criteria, namely biological children and a single birth, children living with biological parents, and children remaining alive until adulthood in 2014. Multivariate analysis used logistic regression. The study found that 8.1% of women and 5.6% of men were overweight and obese. In adulthood, there was a 45.4% incidence of hypertension. Incidence of hypertension for men was higher (67.3%) than for women (26.8%). The multivariate model showed that adolescent BMI affected blood pressure and adult BMI after being controlled for adolescent blood pressure, residential area, and sex. Sex interacts with adolescent BMI. The risk of hypertension in adulthood based on being overweight and obese is three times higher for males and two times higher for females.

Keywords: Adolescent, adulthood, body mass index, hypertension, obesity

Introduction

Incorrect dietary habits and lifestyle in adolescence creates multiple nutritional problems. Children and adolescents today have more nutritional problems, and this is true in both developed country societies as well as globally. In the United States from 2007 to 2008, among children and adolescents aged 2 through 19 years, the prevalence of higher body mass index (BMI) measurements was as follows: 11.9% prevalence of BMI ≥ 97%; 16.9% prevalence of BMI ≥ 95%; and 31.7% prevalence of BMI ≥ 85%.[1] The results of a study in Bangladesh that observed children aged 6 to 15 years showed that 3.5% were obese and 9.5% were overweight. The prevalence of obesity in urban areas is higher (5.6%–10.6%) than in rural areas (1.2%–8.6%).[2] Like other developing countries, Indonesia also faces multiple nutritional problems in adolescent groups. National Basic Health Research (2013) reported that adolescents aged 13–15 years old are increasingly significantly overweight, with a prevalence increasing from 1.4% in 2010 to 7.3% in 2013 and consisting of 5.7% being overweight and 1.6% being obese.[3]

Adolescents' experience of being overweight and having obesity problems allegedly continues until adulthood and becomes a risk factor for non-communicable diseases whose prevalence is likely to increase. A systematic review of five studies on being overweight and obese being associated with premature mortality found that children or adolescents who are overweight or obese have an increased risk of premature mortality. A total of 11 studies indicated that being overweight or obese was

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significantly associated with a 1.1 to 5.1 times increased risk of cardiometabolic morbidity (diabetes, hypertension, coronary heart disease, and stroke) in adult life. Nine studies show that being overweight and obese in adolescence is associated with an increased risk of cancer morbidity, disability pension, asthma, and polycystic ovary syndrome in adult life.[4]

The main non-communicable disease is hypertension. Hypertension is a major cause of cardiovascular morbidity and mortality.[5] The World Health Organization (WHO) (2013) explains that 17,000 people die worldwide per year from cardiovascular disease, and 9,400 of those are caused by complications of hypertension. The prevalence of hypertension globally reached 29.2% in men and 24.8% in women.[6] WHO (2011) also reports that one billion people in the world suffer from hypertension and two-thirds of them are the low- and the middle-income living in developing countries. The prevalence of hypertension is expected to increase; by 2025, it is predicted to affect 29% of adults globally and that it will increase to 31.7% in Indonesia. In Indonesia, the prevalence trend of hypertension diagnosed by health workers increased from 7.6% in 2007 to 9.5% in 2013. Out of all patients suffering from hypertension in Indonesia, only 25% are diagnosed. This means that three out of four patients with hypertension do not know that they have the condition. Even more dangerous, fewer than 1% of patients with hypertension consume drugs to lower their blood pressure.[3] Patients with hypertension who do not get regular treatment and regular control experience various heart complications such as myocardial infarction, coronary heart disease, and congestive heart failure. Brain complications include stroke and hypertensive encephalopathy, while kidney complications include chronic kidney failure. While, complications with the eyes can occur as well in the form of hypertensive retinopathy. Based on these various complications, hypertension is considered a very serious disease and that it can affect sufferers psychologically as well because it decreases quality of life, especially in stroke, kidney failure, and heart failure cases.[7]

The correlation between being overweight or obese with the incidence of hypertension has been proven many times, but studies in Indonesia are very limited to prove the correlation with a cohort approach. Most studies use a cross-sectional approach, so that exactly how the mechanisms of hypertension are associated with obesity has remained unclear until now. There are some factors suspected of playing a role in the pathogenesis of hypertension as related to obesity. Most subjects had a high blood pressure accompanied by being overweight or obese.[5] This study aimed to determine correlation of being overweight and obese as measured by BMI during adolescence with the incidence of hypertension in adults.

Method

This study used the Indonesian Family Life Survey (IFLS) data published by the RAND Corporation. The study design used a retrospective cohort approach. Adolescent BMI was based on 2007 IFLS data and hypertension disease data was based on 2014 IFLS data. Various other risk factors were also identified from 2007 data. The population in this study included all adolescents in Indonesia aged 10 to 20 years old in 2007. The samples were adolescents randomly enrolled in the 2007 survey. The sample consisted of 1,697 adolescents who fulfilled the criteria that were biological and single born children, children who lived with their biological parents, children who were aged 10–20 years old at the implementation of the 2007 survey, and children who were alive until adulthood at the time of the 2014 survey. The independent variable was adolescents. BMI was based on BMI for age Z score (BAZ) measurements from the 2007 IFLS. The dependent variable was the risk of hypertension in adulthood measurements from the 2014 IFLS. Variables to be controlled were the characteristics of adolescents (consumption patterns, physical activity, blood pressure, and smoking behavior based on sex), characteristics of adolescents' families (residential area, socio-economic status, and the number of family members by sex), nutritional status (adult age and BMI, parental BMI), hypertension (hypertension during adolescence, parents' record of hypertension). IFLS data was obtained by the interviewer filling out questionnaires. The questionnaire was available in the question books (Book 1-5, Book K, Book T). Question information from the books was obtained from individuals based on characteristics of age, sex, and marital status. In this survey, anthropometric measurements were also performed for all family members (Book US1). Univariate analysis was performed to examine the frequency distribution of each nominal or ordinal scale variable, and to describe the variation of interval and ratio data by looking at the mean value, standard deviation, variance, and the existence of outlier data. Bivariate analysis was performed to identify the relationship of each independent variable to the dependent variable using chi-square test to see whether there was difference of proportion and simple logistic regression test for multivariate candidate variable selection. Multivariate analysis used multivariate logistic regression by controlling for confounding variable after interaction and confounding test. This study was reviewed and had received ethical approval from the Health Research Ethics Commission at the Bengkulu Health Polytechnic of Health Ministry No. DM.01.04/054/3/V/2016.

Results

Table 1 shows that more than half of girls and boys have unbalanced consumption patterns. No female adolescents smoke, but 31.1% of male adolescents smoke. Based on physical activity, both female adolescents (78.8%) and male adolescents (75.5%) have less activity. Female adolescents mostly (74.6%) have normal blood pressure, but for male adolescents, more than half (56.4%) have hypertension. More than half of adolescents lived in rural environments. Most of the female adolescents (80.1%) and male adolescents (82.3%) lived with big families (more than four family members). Based on the family's socio-economic status, both female adolescents (73.5%) and male adolescents (63.7%) lived mostly with non-poor families.

Table 2 shows that 11.8% of female adolescents and 11.3% of male adolescents have a skinny BMI; at the same time, 5.3% of female adolescents are overweight and 2.8% are obese. For boys, 3.9% are overweight and 1.7% are obese. As adults, 14.3% of women and 19.9% of men have a skinny BMI. Nutritional problems are more prevalent in women, 15% of whom are obese; 19.9% obesity degree I and 8.1% obesity degree II. Men have 10% obesity, 11.8% obesity degree I and 3.1% obesity degree II. Table 2 also shows the characteristics of parental BMI. Based on female BMI, more than half of female adolescents have more mothers with good nutrition, at a rate of 17.2% obesity, 33.5% obesity degree I and 11.1% obesity degree 2. The same trend was also found in male adolescents. There are more than half of mothers with good nutrition that have higher than 16% obesity, 35.7% obesity degree I, and 13.2 obesity degree II. Based on fathers' BMI, women have fathers who are 16.8% overweight, 22.5% obesity degree I and 5.4% obesity degree II. Meanwhile, fathers have more nutritional problems, where 15.7% are overweight; 21.3% obesity degree I and 5.8% obesity degree II.

Table 3 describes blood pressure for adolescents, adults, and parents. The results show that blood pressure in adolescent women is most normal (74.6%), but in males, most have hypertension: 50.6% have pre-hypertension and 5.7% have hypertension degree I. Adults show the same trend. Blood pressure in female adults is most normal (73.2%), but in males, 57.5% experienced pre-hypertension, 9.2% have hypertension degree I and 0.5% have hypertension degree II. Based on mothers' blood pressure, in female adults, only 34.4% of mothers have normal blood pressure, and only 33.4% of adult men have normal mother's blood pressure. Based on the father's blood pressure, only 21.8% of adult females have normal blood pressure and only 19.8% of adult males come from fathers with normal blood pressure.

Table 4 shows that the problem of high blood pressure continues into adulthood; the prevalence of hypertension in adulthood is 45.4%. The results showed that of adolescents with normal blood pressure, 33% have hypertension as adults, while 70.1% of adolescents with hypertensive blood pressure continue to experience hypertension as adults. The results in Table 4 also show variables that are candidates for confounding variables in multivariate analysis (p-value < 0.25).

Table 5 is the result of bivariate analysis with simple logistic regression to show the proportion of hypertension incidence based on characteristics of adolescents, parents, and family socio-economic status.

The final model results of multivariate analysis are presented in Table 6. Table 6 shows the study results that BMI during adolescence is correlated with blood pressure during adulthood that interacts with sex. This means that sex is preconceived with the BMI effect and adult blood pressure during adolescence. The statistical model showed that BMI for adult age, blood pressure of adolescents, residence area, and sex were confounding variables, so that they were controlled in proving BMI relationship during adolescence with adult blood pressure. Male adolescents who were overweight and/or obese had a risk three times higher of having hypertension when adult (OR = $e^{0.656 + 1.924 - 1.447} = 3.1$),

Table 1. Characteristics of Adolescent and Family According to Sex

Characteristic of Adolescent and Family	Category	Female (n=918)	Male (n=779)	Total	p-Value
Consumption pattern	Balanced	42.2	41.4	41.7	0.739
	Imbalanced	57.8	58.9	58.3	
Smoking behaviour	Not smoking	100	68.9	85.7	0.001
	Smoking	0	31.1	14.3	
Physical activity	Enough	21.2	24.5	22.7	0.105
	Not enough	78.8	75.5	77.3	
Blood pressure of adolescent	Normal	74.6	43.6	60.5	0.001
	Hypertension	25.4	56.4	39.5	
Residential area of family	Urban	46.7	47.5	47.1	0.753
	Rural	53.3	52.5	52.9	
Total of family member	Nuclear family	19.9	17.7	18.9	0.245
	Extended family	80.1	82.3	81.1	
Socio-economic status of family	Non-poor family	73.5	63.7	69.1	0.001
	Poor family	26.5	36.3	30.9	

Table 2. Body Mass Index of Adolescent and Adult According to Sex

Category	Body Mass Index	Female (n=918)	Male (n=779)	Total	p-Value
Adolescent	Thin	11.8	11.3	11.5	0.167
	Normal	80.1	83.2	81.5	
	Overweight	5.3	3.9	4.7	
	Obesity	2.8	1.7	2.3	
Adult	Thin	14.3	19.9	16.9	0.001
	Normal	42.7	55.2	48.4	
	Overweight	15.0	10.0	12.7	
	Obesity degree I	19.9	11.8	16.2	
	Obesity degree II	8.1	3.1	5.8	
Mother	Thin	9.9	7.7	8.9	0.298
	Normal	28.4	27.3	27.9	
	Overweight	17.2	16.0	16.7	
	Obesity degree I	33.5	35.7	34.5	
	Obesity degree II	11.1	13.2	12.1	
Father	Thin	12.9	11.3	12.1	0.705
	Normal	42.4	45.9	44.1	
	Overweight	16.8	15.7	16.2	
	Obesity degree I	22.5	21.3	21.9	
	Obesity degree II	5.4	5.8	5.6	

**p-value to chi-square Test*

Table 3. Blood Pressure of Adolescent and Parents According to Sex

Category	Blood Pressure	Female (n=777)	Male (n=652)	Total	p-value
Adolescent	Normal	74.6	43.6	60.5	0.001
	Pre-hypertension	24.1	50.6	36.2	
	Hypertension degree I	1.3	5.7	3.3	
	Hypertension degree II	0	0.2	0.1	
Adult	Normal	73.2	32.7	54.6	0.001
	Pre-hypertension	24.5	57.5	39.7	
	Hypertension degree I	2.3	9.2	5.5	
	Hypertension degree II	0	0.5	0.2	
Mother	Normal	34.4	33.4	33.9	0.831
	Pre-hypertension	33.0	32.2	32.6	
	Hypertension degree I	18.3	20.0	19.1	
	Hypertension degree II	14.3	14.4	14.3	
Father	Normal	21.8	19.8	20.8	0.315
	Pre-hypertension	36.8	41.8	39.2	
	Hypertension degree I	22.1	22.0	22.1	
	Hypertension degree II	19.3	16.4	17.9	

Table 4. Changes of Blood Pressure from Adolescence to Adulthood

Blood Pressure of Adolescent	Blood Pressure of Adult		p-Value
	Normal n=771	Hypertension n=658	
Normal	67.0	33.0	
Hypertension	29.9	70.1	0.0001
Total	54.6	45.4	

whereas female adolescents with BAZ overweight/obesity risk had two times likelihood of hypertension when adult (OR = e $^{0.656}$ = 1.92) compared to adolescents with normal BMI. Results showed that the confounding variables were adult BMI, adolescent blood pressure, residential area, maternal blood pressure, and sex. Other factors affecting the incidence of hypertension in adults were adult BMI and blood pressure as adolescent. A person with a skinny BMI was twice as likely and an overweight/obese person was four times as likely to have hypertension than normal BMI. Someone with hypertension in adolescence was three times at risk of experiencing hypertension in adulthood than those who did not have hypertension in adolescence.

Discussion

The study results of adolescents' nutritional status for BAZ found a prevalence of being overweight and obesity in adolescents became a public health problem. Female adolescents are as much as 5.3% overweight and 2.8% obese. There were 3.9% overweight and 1.7% obese adolescent males. The findings of this study were in line with the report by the National Basic Health Research in Indonesia. The prevalence of obesity and being overweight in Indonesia was high and is likely to increase based on the National Basic Health Research data report from 2007. The obesity prevalence among the 15-year-old population based on BMI was 10.3% and 13.9% (male) and 23.8% (female).

The prevalence of overweight children aged 6–14 years was 9.5% in males and 6.4% in females. Meanwhile, if compared with the results from the National Basic Health Research data in 2013, the prevalence of obesity in Indonesia has increased significantly. The rate of obese men was 15% in 2010 and now at 20%. In women, the percentage increased from 26% to 35% in 2010. Incidence of obesity was found at all young ages. The National Basic Health Research data from the Health Ministry of the Republic of Indonesia is from 2013. The obesity problem in children aged 5–12 years old was still high nationally; e.g., 18.8%, composed of 10.8% fat and 8.8% obesity. While, the prevalence of obese adolescents aged 13–15 years old amounted to 10.8%, consisting of 8.3% fat and 2.5% obese.[3]

The prevalence of being overweight and obese in Indonesia is not found to be much different than in the United States. In the United States, the prevalence of being overweight and obese in children and adolescents from 2011 to 2012 was as high as 8.1%. In children under 20 years old, obesity rates were as high as 16.9%, and in adults, as much as 34.9%. The data showed that there was no difference in obesity rates between the 2003–2004 and 2011–2012 periods.[8] The cases of childhood obesity are rapidly increasing in the world. In just two decades, the prevalence of obesity doubled in American children aged 6 to 11 years old and even tripled in adolescents.

The Examination Survey of Health Nutrition National Yearly by the Centers of Disease Control and Prevention found that one in three American children were overweight or at risk of becoming obese. In total, approximately, 25 million American children and adolescents were overweight or close to obesity. As much as

Table 5. Proportion of Hypertension Incidence Based on Characteristics of Adolescent, Parents, and Family's Socio-economic Status

Study Variable	Category	Blood Pressure		Total	p-Value
		Normal	Hypertension		
Body mass index of adolescent	Thin	12.4	10.5	11.5	0.414
	Normal	81.0	82.1	81.5	
	Overweight/obesity	6.6	7.4	7.0	
Body mass index of adult	Thin	20.9	11.9	16.9	0.001
	Normal	49.1	47.7	48.4	
	Overweight/obesity	30.0	40.4	34.7	
Body mass index of mother	Thin	9.0	8.7	8.9	0.581
	Normal	28.9	26.8	27.9	
	Overweight/obesity	62.1	64.5	63.2	
Body mass index of father	Thin	13.0	11.1	12.1	0.574
	Normal	43.6	44.6	44.1	
	Overweight/obesity	43.4	44.3	43.8	
Blood pressure of adolescent	Hypertension	78.1	39.8	60.5	0.001*
	Not hypertension	21.9	60.2	39.5	
Blood pressure of mother	Hypertension	36.4	31.0	33.9	0.021*
	Not hypertension	63.6	69.0	66.1	
Blood pressure of father	Hypertension	22.3	19.2	20.8	0.2*
	Not hypertension	77.7	80.8	79.2	
Residential area	Urban	51.5	54.7	52.9	0.186*
	Rural	48.5	45.3	47.1	
Total of family member	Nuclear family	17.0	21.2	18.9	0.031*
	Extended family	83.0	78.8	81.1	
Socio-economic status of family	Non-poor family	72.8	64.4	69.0	0.001*
	Poor family	27.2	35.6	31.0	
Sex	Female	72.5	31.9	54.1	0.001*
	Male	27.5	68.1	45.9	
Consumption pattern	Balanced	22.0	17.0	19.7	0.010*
	Imbalanced	78.0	83.0	80.3	
Physical activity	Enough	22.0	23.6	22.7	0.425
	Less	78.0	76.4	77.3	
Smoking behavior	Smoking	91.2	79.2	85.7	0.001*
	Not Smoking	8.8	20.8	14.3	

**Multivariate candidate variable p-value based on simple logistic regression test < 0.25*

Table 6. Final Model Influence of Adolescent Body Mass Index with Blood Pressure in Adulthood

Variable	Category	B	RR (95% CI)	p-Value
BMI* of adolescent	Normal		1	0.045
	Thin	-0.015	0.985 (0.587-1.653)	0.955
	Overweight/obesity	0.656	1.928 (1.144-3.249)	0.014
BMI* of adult	Normal		1	0.001
	Thin	0.675	1.964 (1.1413-2.731)	0.001
	Overweight/obesity	1.437	4.208 (2.924 – 6.055)	0.001
Blood pressure of adolescent	Not hypertension		1	
	Hypertension	1.199	3.318 (2.606-4.223)	0.001
Blood pressure of mother	Not hypertension		1	
	Hypertension	0.113	1.119 (0.994-1.260)	0.063
Residential Area	Urban		1	
	Rural	-0.196	1.216 (0.976 -1.523)	0.089
Sex	Female		1	
	Male	1.924	6.85 (5.245 – 8.946)	0.001
BMI of Adolescent*Sex	Normal		1	0.003
	Thin *Sex	0.141	1.151 (0.56 – 2.368)	0.700
	Overweight/obesity*Sex	-1.447	0.235 (0.1 – 0.554)	0.001
Constant		-2.412		

Notes: BMI= Body Mass Index, RR= Relative Risk, CI= Confidence Interval

18% of adolescents and 25% of adults in Indonesia were obese.[9] According to the WHO, approximately 35 million out of 45 million children worldwide who were overweight came from developing countries.[10]

This showed that adolescents comprised the age groups with a high risk of obesity. Then the high risk of

obesity in adolescents is worse if infants and toddlers were also overweight and obese. Children and adolescents who were overweight and obese will continue to be overweight as mature adults.[11] The results of the study found that as an adult, there was an increase in the prevalence of obesity and obesity, from 7% in adolescence to 34.7% in adulthood. This is an important concern because obesity in children and adolescents was correlated with an increased risk of cardiovascular disease, such as hypertension, dyslipidemia, and other diseases.[12] Being overweight and obese were also correlated with increased morbidity and mortality rates. The results of study in the British Virgin Islands found that the increase in the prevalence of being overweight and obese was positively associated with an increased risk of four cardiovascular diseases, including hypertension.[5]

Based on the study results, Indonesia needs to begin immediate treatment to overcome obesity problems, especially in adolescents. Most nutritional problems in adolescence were caused by incorrect lifestyle and consumption patterns. This study found that more than half of female and male adolescents had imbalanced consumption patterns. Regarding smoking behavior, no female adolescent smoked, but 31.1% of male adolescents smoked. Regarding physical activity, both sexes reported less activity, with 78.8% of female adolescents and 75.5% of male adolescents. Regarding the prevalence of hypertension, there was an 83% incidence of hypertension in adult age. As much as 83% had imbalanced diets; 76.4% had less physical activity, and 20.8% had smoking behaviors. Study results showed that the blood pressure of male adolescents was higher than for female adolescents. The incidence of hypertension was also higher for adult men than for female adults, with an average incidence rate of as much as 39.6%. The incidence of higher hypertension rates for adolescents contributed to a higher incidence rate for adults. Study results also found that the incidence of hypertension in adolescence was 39.6% and it increased to 45.5% by adulthood. This showed that blood pressure problems continued into adulthood (Table 4). Blood pressure problems for adolescents (pre-hypertension and hypertension degree II) contributed 65.8% to pre-hypertension problems in adulthood. Blood pressure problems in adolescents (pre-hypertension. Hypertension degree I and hypertension degree II) contributed 81.6% to hypertension degree II in adulthood. Blood pressure problems in adolescents (pre-hypertension and hypertension degree I) contributed 100% to hypertension degree II problems in adulthood. This showed how important it is to prevent hypertension in adolescence to prevent stimulating other diseases such as stroke, coronary heart disease, heart failure, and kidney disease. Handling hypertension problems before complications and the resulting decreased life expectancy is vital.

The high incidence of hypertension in adults was influenced by various risk factors such as genetics, obesity, sex, stress, lack of exercise, high salt intake, and smoking. Butler[13] explained that genetic factors include a very important element of the value of measuring blood pressure. For example, if a father or mother in a family suffers from hypertension then their offspring have the tendency to have hypertension.[13] Genetic factors are 30–50% likely to contribute to the occurrence of hypertension, while environmental factors are about 50% likely to contribute to the occurrence of hypertension. This study found high incidences of hypertension in both parents. In men, 80.2% of fathers were hypertensive patients; in women, 79.2% were hypertensive patients. The prevalence of maternal hypertension was slightly lower for both men (66.6%) and women (65.6%). Other than genetic factors, increased sympathetic nervous activity might also intermittently increase the blood pressure value. This condition is common in people who experience stress, so if someone was experiencing prolonged stress, then blood pressure could increase.[14]

Smoking is a cardiovascular risk factor. The impact of smoking results in impaired endothelial function, arterial stiffness, inflammation, lipid modification, changes in antithrombotic and prothrombotic factors, and accelerated atherothrombotic processes, which lead to cardiovascular events. Acute smoking has the effect of hypertension, especially through stimulation of the sympathetic nervous system. Cigarettes affect arterial stiffness and wave reflection, creating greater pressure on central blood pressure. People with hypertension who smoke tend to suffer from severe hypertension, including malignant hypertension and renovascular due to atherosclerosis.[15] The results of this study found a high proportion of male adolescents smoking. Less physical activity and an unbalanced diet were shown to be risk factors for hypertension in adults as well.

The findings of this study proved that adolescent BMI influenced adult blood pressure where the influence was modified by sex. Cornier, *et al.*[16] developed a theory that obesity in children and adolescents would impact glucose intolerance, hypertension, dyslipidemia, inflammation, and continued obesity through adolescence. This situation would then affect the occurrence of cardiovascular disease in adults.[16] Systematic review of 11 studies provided evidence of cardiometabolic disease in adulthood such as diabetes, stroke, coronary heart disease, and hypertension. Increased risk of other diseases caused in overweight and/or obese children or adolescents are cancer, disability, asthma, and symptoms of polycystic ovary syndrome in adult life.[4] The mechanisms involved in the pathophysiology of hypertension involve activation of the sympathetic nervous system and rennin-an-

giotensin-aldosterone. In addition, the occurrence of endothelial dysfunction and abnormalities of renal function were also an important factor in the development of hypertension in obese people. More body mass means more blood is needed to supply oxygen and food to the body tissues. When the volume of blood circulating through the blood vessels increases, it puts greater pressure on artery walls.[5]

Hypertension and obesity are closely related to abnormalities, although the exact mechanism of the correlation remains unclear. Hypertension correlated with obesity generally has characteristics of plasma volume expansion and cardiac output, hyperinsulinemia and insulin resistance, increased sympathetic nervous system activity, sodium retention and salt-regulating hormone regulation.[5] The relationship mechanism between obesity and hypertension through activation of the sympathetic nervous system has been considered to have an important function in the pathogenesis of obesity-related hypertension. According to the principle of infinite feedback gain, the arterial-pressure control mechanism of diuresis and natriuresis seems to be shifted toward higher blood pressure levels in obese individuals. During the early phases of obesity, primary sodium retention exists as a result of an increase in renal tubular reabsorption. Extracellular-fluid volume is expanded, and the kidney-fluid apparatus resets to a hypertensive level, consistent with a model of hypertension due to volume overload. Plasma renin activity, angiotensinogen, angiotensin II and aldosterone values display a significant increase during obesity. Insulin resistance and inflammation may promote an altered profile of vascular function and consequently hypertension. Leptin and other neuropeptides are possible links between obesity and the development of hypertension as well. Obesity should be considered a chronic medical condition that is likely to require long-term treatment. Understanding the mechanisms associated with obesity-related hypertension is essential for successful treatment strategies.[17] The right intervention for hypertensive patients to control their blood pressure is to adopt a healthy lifestyle by regulating their eating patterns and participating in sufficient physical activity.[18]

In this study, sex influenced adolescent BMI and was a precondition for higher adult blood pressure. The model obtained showed that adult BMI was correlated with the individual's blood pressure as an adolescent and residence area, with sex as the confounding variable. This suggests that these variables should be controlled in explaining the relationship of adolescent BMI to adult blood pressure. In adolescence, overweight/obese men were three times more likely to risk experiencing hypertension as an adult, while adolescent overweight/obese women had two times the risk of experiencing hypertension as an adult compared with adolescents with a normal BMI. Risk estimates from the Framingham Heart study showed that 78% of hypertension in men and 65% of hypertension in women are directly correlated to obesity.[5] The risk of incidence of hypertension increased to 2.6 times in obese male subjects and increased 2.2 times in obese female subjects as compared to subjects of normal weight.[19]

The results of this analysis are in line with Rahajeng's findings, which found men to have the highest risk and the highest likelihood of having hypertension.[20] This is often triggered by unhealthy behaviors, such as smoking and alcohol consumption, as well as by depression, low occupational status, and feelings of discomfort regarding work and unemployment. Similarly, education and work factors are an influence. It is thought that lifestyle is correlated with social status. Those with low education correlated with a low awareness for healthy behaviors and low access to health care facilities. While, job problems are thought to be correlated with psychological problems associated with the work environment. High alcohol consumption in both men and women is also a risk factor for hypertension.[21]

Women have a lower prevalence of hypertension because women who have not yet experienced menopause are protected by the effects of estrogen. This protection is considered an explanation of women's immunity at the pre-menopause age. In pre-menopause, women gradually begin to lose the estrogen hormone that protects blood vessels from damage. As this process continues, the estrogen hormone changes in quantity naturally according to a woman's age; pre-menopause and menopause generally begin in women aged 45–55 years old.[22] In women, estrogen acts as protection against the development of hypertension.[24]

Premenopausal women have a lower risk of hypertension compared to men of the same age, but at menopause and after age 65, women's risk of hypertension is higher than in men.[22] Sex differences in the risk of hypertension are multifactorial and still need more investigation. There are several factors that influence it, including sex hormones, the renin-angiotensin system, oxidative stress, endothelin, weight gain, and sympathetic activation.[23]

Conclusion

The statistical model shows a relationship between BMI during adolescence and adult blood pressure after controlling for adult BMI factors, with blood pressure during adolescence, residential area, and sex as confounding variables. Sex is a precondition factor of the effect of BMI with hypertension. In adolescence, overweight/obese boys have three times the risk of experiencing hypertension in adulthood, while adoles-

cent overweight/obese girls have two times the risk of experiencing hypertension in adulthood compared with normal adolescent BMI. Confounding factors that affect the incidence of hypertension in adults were adult BMI and blood pressure during adolescence. A person with a skinny BMI has two times the risk, while someone with an overweight/obese BMI has four times the risk of having hypertension compared to someone with a normal BMI. Someone with hypertension in adolescence had three times the risk of experiencing hypertension in adulthood than those who do not have hypertension during adolescence.

The large contribution of overweight and obesity adolescents to the incidence of hypertension in adults is an important reason for early and ongoing prevention to overcome overweight and obesity problems starting from within the family and in school. Families need to understand and regulate the dietary habits and physical activity of adolescents. A supporting policy is also needed from the Ministry of Education and Culture and from school teachers to perform routine physical activities and regular weight monitoring every month prevent becoming overweight or obese. Health promotion should also be done to prevent and overcome weight problems and obesity.

Health workers can work with school teachers to routinely assess the nutritional status of school children and to perform routine blood pressure monitoring to prevent complications of hypertension. This predicted model can provide important information in preparation to promote anti-hypertension and preventive activities through the Health Ministry of the Republic of Indonesia's health facilities in the provinces, districts, and villages. The Health Ministry should activate the integrated program, improve monitoring of nutritional status, and work to prevent and control hypertension.

Conflict of Interest

Author Demsa Simbolon declares that she has no conflict of interest. Authors Epti Yorita and Ruzita ABD Talib declare that they have no conflicts of interest.

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