ROLE OF AGE, SEX, AND BODY MASS INDEX ON BLOOD PRESSURE AMONG STUDENTS OF ST. HENDRIKUS HIGH SCHOOL, SURABAYA, INDONESIA

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ABSTRACT

The purpose of this study was to analyze the influence of age, sex, Body Mass Index (BMI), and nutritional status on blood pressure in class X and XI students, SMAK St. Hendrikus, Surabaya, Indonesia. The sample of students in class X and XI of SMAK St. Hendrikus Surabaya in 2013. The sample size was 150 students. The sampling technique was consecutive sampling. The independent variables were age, sex, BMI, and nutritional status, while the dependent variable was blood pressure. Data were analyzed by Pearson correlation test, Spearman, and Chi Square statistical test with ?=0.05. The level of risk was calculated by epi info program. Most students (40.7%) were 16 years old, those with pre-hypertension (systolic) 26.7%, grade 1 systolic hypertension by 1.3%, diastolic pre-hypertension 25.3% and grade 1 diastolic hypertension by 6.7%. Age did not have significant influence (p=0.623) on systolic blood pressure, but had a significant influence (p=0.002) on diastolic blood pressure. Male sex significantly influenced systolic (p=0.002, RR 5.36 95% CI 2.2320-12.8649) and diastolic (p <0.001, RR 1.95 95% CI 1.1272-3 , 3719) blood pressure. BMI had significant influence (p <0.001) on blood pressure. Nutritional status had significant influence on systolic blood pressure (p=0.002), with overnutrition status with RR 2.28, 95% CI 1.3983-3.7104. Nutritional status had significant influence on diastolic blood pressure (p <0.001), and with overnutrition status with RR 2.73, 95% CI 1.8143-4.1179. In conclusion, the trend for pre-hypertension to grade 1 diastolic hypertension increases with age and age has an influence on diastolic blood pressure. The risk of males to have pre-hypertension to grade 1 systolic hypertension is 5.36 times that of females, and the risk to have pre-hypertension to grade 1 diastolic hypertension is 1.95 times that of women. The higher the BMI, the higher the systolic and/or diastolic blood pressure.

Keywords: Age; sex; BMI; nutritional status; blood pressure; students of St. Hendrikus

ABSTRAK

Tujuan dari penelitian ini adalah untuk menganalisis pengaruh usia, jenis kelamin, Indeks Massa Tubuh (BMI), dan status gizi terhadap tekanan darah pada siswa kelas X dan XI, SMAK St. Hendrikus, Surabaya, Indonesia. Sampel siswa di kelas X dan XI SMAK St. Hendrikus Surabaya pada 2013. Ukuran sampel adalah 150 siswa. Teknik pengambilan sampel adalah consecutive sampling. Variabel independen adalah usia, jenis kelamin, IMT, dan status gizi, sedangkan variabel dependen adalah tekanan darah. Data dianalisis dengan uji korelasi Pearson, Spearman, dan uji statistik Chi Square dengan? = 0,05. Tingkat risiko dihitung oleh program epi info. Sebagian besar siswa (40,7%) berusia 16 tahun, mereka yang pra-hipertensi (sistolik) 26,7%, hipertensi sistolik grade 1 sebesar 1,3%, pra-hipertensi diastolik 25,3% dan hipertensi diastolik grade 1 sebesar 6,7%. Usia tidak memiliki pengaruh yang signifikan (p = 0,623) pada tekanan darah sistolik, tetapi memiliki pengaruh yang signifikan (p = 0,002) pada tekanan darah diastolik. Jenis kelamin laki-laki secara signifikan mempengaruhi tekanan darah sistolik (p = 0,002, RR 5,36 95% 2,2320-12,8649) dan diastolik (p <0,001, RR 1,95 95% CI 1,1272-3,3719) tekanan darah. BMI memiliki pengaruh signifikan (p <0,001) pada tekanan darah. Status gizi berpengaruh signifikan terhadap tekanan darah sistolik (p = 0,002), dengan status kelebihan gizi dengan RR 2,28, 95% CI 1,3983-3,7104. Status gizi memiliki pengaruh signifikan terhadap tekanan darah diastolik (p <0,001), dan dengan status kelebihan gizi dengan RR 2,73, 95% CI 1,8143-4,1179. Kesimpulannya, tren untuk pra-hipertensi untuk hipertensi diastolik grade 1 meningkat dengan usia dan usia memiliki pengaruh pada tekanan darah diastolik. Risiko laki-laki untuk memiliki pra-hipertensi untuk hipertensi sistolik grade 1 adalah 5,36 kali dari wanita, dan risiko untuk memiliki pra-hipertensi untuk hipertensi diastolik grade 1 adalah 1,95 kali dari wanita. Semakin tinggi BMI, semakin tinggi tekanan darah sistolik dan/atau diastolik.

Kata kunci: Usia; jenis kelamin; BMI; status nutrisi; tekanan darah; siswa St. Hendrikus

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INTRODUCTION

High blood pressure (hypertension) is one of the highest causes of death in the world. Complications of hypertension are estimated to cause 9.4 million deaths worldwide each year (WHO 2015). The Institute for Health Metrics and Evaluation (IHME) in 2017 stated that 53.3 million deaths in the world were mainly caused by cardiovascular disease, which was 33.1% (IHME, 2017). Hypertension is called the silent killer because it is often without complaints, so the patient does not know he is suffering from hypertension and only becomes known after complications occur. Data from the World Health Organization (WHO) in 2015 showed that around 1.13 billion people worldwide suffer from hypertension. This means that 1 in 3 people in the world is diagnosed with hypertension. The number of people with hypertension continues to increase every year along with an increase in the population, both in developing and developed countries. In 2025 it is estimated that there will be 1.5 billion people affected by hypertension (WHO, 2015).

In Indonesia in 2016 total deaths was 1.5 million with the most cause of death was cardiovascular disease (36.9%). In 2017, out of a total of 1.7 million deaths in Indonesia, 23.7% were caused by complications of hypertension (the highest was stroke followed by ischemic heart disease) (IHME, 2017). The prevalence of hypertension in Indonesia in the population aged 18 years and older was 25.8% (Riskesdas 2013), rose to 34.1%, the highest in South Kalimantan (44.1%), and lowest in Papua (22.2%). The proportion of hypertensive patients in 31-44 age group was 31.6%, 45-54 years was 45.3%, and 55-64 years was 55.2%. The increase in the prevalence of non-communicable diseases is related to lifestyle, including smoking, consumption of alcoholic beverages, lack of physical activity, and less consumption of fruits and vegetables.

From the prevalence of hypertension of 34.1%, it is known that of 8.8% are diagnosed with hypertension and 13.3% of those diagnosed with hypertension do not take medication, and 32.3% do not take medication regularly. This shows that most hypertensive patients do not know that they suffer from the disease so they do not get treatment. Reasons for hypertension patients not taking medication are because they feel healthy (59.8%), irregular visits to health care facilities (31.3%), taking traditional medicine (14.5%), using other therapies (12.5%), forgetting to take medicine (11.5%), not being able to buy drugs (8.1%), the presence of side effects of drugs (4.5%), and hypertensive drugs not available in health care facilities (2%). Uncontrolled hypertension and lack of treatment for a long time can cause complications in the form of heart, cerebral,

kidney and vascular diseases. In addition, it is also influenced by several factors including age, body weight, gender, and so on (Jacob 2006).

Research by the Indonesian Ministry of Health in 2009 showed that the proportion of hypertension in age group 45-54 years and older was always higher than normal with a percentage of 27.7%. The age group of 25-34 years had a risk of hypertension 1.56 times compared to the age of 18-24 years. The risk of hypertension increased significantly with age and >75 years age group had 11.53 times higher risk.

Body Mass Index (BMI) is a risk factor for hypertension. The higher the BMI, the higher the risk of developing hypertension. According to Riskesdas (2013), an increase in one BMI unit can be associated with an increase of 0.56 mmHg systolic and diastolic blood pressure. The results of Leni's research (2012) in Bojonegoro, East Java, also showed an association between overweight and obesity with hypertension.

At present, overweight and obese has become a global health problem. In the world, the incidence of obesity has more than doubled since 1980. In 2014, there were 41 million children who were overweight and obese. In adults, obesity is a risk factor for non-communicable diseases. Non-communicable diseases are now known as the top 10 main killers. As many as 2.8 million people of the world population died due to suffering from non-communicable diseases related to obesity. Usually obesity is found among people in high-income countries, now the same case is also found in low and middle income people in urban areas. This is caused by unhealthy lifestyles and the lack of sports activities. Even though it does not cause sudden death, obesity can be very dangerous if it is let unnoticed.

Obesity is a health problem that needs to be considered as a risk factor for hypertension. In Indonesia, the number of overweight and obesity at the age of 21 years is 21.7% of the population (Rikesdas, 2010). Overweight and obesity in Indonesia have become major problems that require serious treatment (Roche 2008). Riskesdas data (2013) shows that there are 18.8% of children aged 5-12 years have overweight. As many as 10.8% suffer from obesity. The same data also shows the prevalence of obesity in children with comorbidity is closely related to the incidence of obesity in the elderly. Seeing the danger of this disease, obesity is now included in the national medium and long term development plan and the Republic of Indonesia's Ministry of Health strategic plan 2015-2019.

Rahajeng and Tuminah's research in 2009 showed that risk factors significantly related to hypertension were

old age (OR 11.5 with CI 9.01-9.98), male (OR 1.3 with 95% CI 1.21-1, 29), low education (OR 1.6 with 95% CI 1.51-1.71), obesity (OR 2.8 with 95% CI 2.67-2.91), and abdominal obesity (OR 1.4 with 95% CI 1.36-1.44). Therefore, research needs to be carried out on the role of age, sex, and BMI on blood pressure.

MATERIALS AND METHODS

This study was a cross-sectional observational analytic study in which age, sex, BMI, and blood pressure were determined at the same time. The research sample comprised students of class X and XI of SMAK St. Hendrikus Surabaya in 2013 who were willing to participate in this study. The sample size was 150 students. Based on the formula of Lameshow (1997) the minimum sample size was 73 students. The sampling technique used was consecutive sampling. The independent variables were age, sex, BMI, and nutritional status, while the dependent variable was blood pressure.

Weight (BW) was measured using a spring scale where the respondent stood upright on the scale. Height (BH) was is measured by microtoice where the respondent's head, back, buttocks, and heels were pressed against the wall and parallel line was drawn from the floor to the tip of the head. Based on the measurement results, body mass index (BMI) was calculated as BW (kg)/BH2 (m). Nutritional status was underweight if the BMI was <18.5, normal if the BMI between 18.5-24.9, and over if > 25.

Blood pressure was checked using mercury tensimeter in three times measurements. Intially, the respondents were rested for 10 minutes in a sitting position and the tensimeter was placed at the height of the heart. Blood pressure measurements were carried out three times with a 5 minute break. An average value of three measurements was taken if there were differences in blood pressure values of more than 10 mmHg. The measurement results were regarded to be normal if blood pressure <120/80 mmHg, pre-hypertension if systolic blood pressure 120-139 mmHg or diastolic blood pressure 80-89 mmHg, grade 1 hypertension if systolic blood pressure 140-159 mmHg or diastolic blood pressure 90 -99 mmHg, and grade 2 hypertension if cystolic blood pressure >160 mmHg or diastolic blood pressure >100 mmHg (JNC VII, 2007). Data were analyzed with Pearson's correlation (?=0.05), Spearman (?=0.05) and Chi Square (?=0.05) tests. The level of risk was calculated using epi info program.

RESULTS

Data processing showed that students with undernutrition status were 31 (20.7%), and overnutrition were 27 students (18%). The distribution of nutritional status of the students by age showed that most students (54.8%) with undernutrition were 16 years old, and students with overnutrition mostly (44.4%) aged 16 years (Table 1).

Table 1. Distribution of respondents by age and nutritional status

Age (yrs)	Nutritional Status			Total
	Under	Normal	Over	
15	8 (25.8%)	18 (19.6%)	5 (18.5%)	31 (20.7%)
16	17 (54.8%)	44 (47.8%)	12 (44.4%)	73 (48.7%)
17	6 (19.4%)	26 (28.3%)	8 (29.6%)	40 (26.7%)
18	0 (0%)	3 (3.3%)	2 (7.4%)	5 (3.3%)
19	0 (0%)	1 (1.1%)	0 (0%)	1 (0.7%)
Total	31 (20.7%)	92 (61.3%)	27 (18%)	150 (100%)

Table 2. Distribution of students by age and systolic blood pressure

Age (yrs)	Systolic BP			Total
	Normal <120	Pre-hypertension 120-139	Hypertension grade 1(140-159)	
15	25 (23.1%)	5 (12.5%)	1 (50%)	31 (20.7%)
16	50 (46.3%)	22 (55%)	1 (50%)	73 (48.7%)
17	28 (25.9%)	12 (30%)	0 (0%)	40 (26.7%)
18	4 (3.7%)	1 (2.5%)	0 (0%)	5 (3.3%)
19	1 (0.9%)	0 (0%)	0 (0%)	1 (0.7%)
Total	108 (72%)	40 (26.7%)	2 (1.3%)	150 (100%)

Students with pre-hypertensive systolic blood pressure were 40 (26.7%), and those with grade 1 hypertension were 2 (1.3%). Most (55%) pre-hypertensive students were 16 years old, then 17 years (30%), and 15 years (12.5%) (Table 2). Table 3 shows that in students with diastolic blood pressure. those with pre-hypertension were 25.3% (38 students). while those with grade 1 hypertension were 6.67% (10 students). BMI has a significant effect ($p<0.001$) on systolic blood pressure, while Spearman correlation test ($\alpha=0.05$) also shows that BMI has a significant influence ($p <0.001$) on diastolic blood pressure with moderate strength of correlation (Table 4).

Spearman's correlation test ($\alpha=0.05$) also showed that the students's age did not have a significant influence ($p=0.623$) on systolic blood pressure, but had a significant influence($p=0.002$) on systolic blood pressure with a correlation strength of 0.256 (weak) (Table 5). Chi-Square test ($\alpha=0.05$) showed a significant influence ($p <0.001$) of male sex on students' systolic blood pressure (Table 6). The same test also showed that sex had a significant influence ($p=0.007$) on diastolic blood pressure of the students.

The risk of male sex for pre-hypertension and grade 1 systolic hypertension is estimated by relative risk (RR) as can be seen in Table 8. The risk of male sex for pre-hypertension and grade 1 systolic hypertension was 5.36 times higher than of female sex (Table 8). The risk of male sex for pre-hypertension and grade 1 diastolic hypertension was estimated by relative risk (RR) (Table 9).

Table 3. Distribution of students by age and diastolic blood pressure

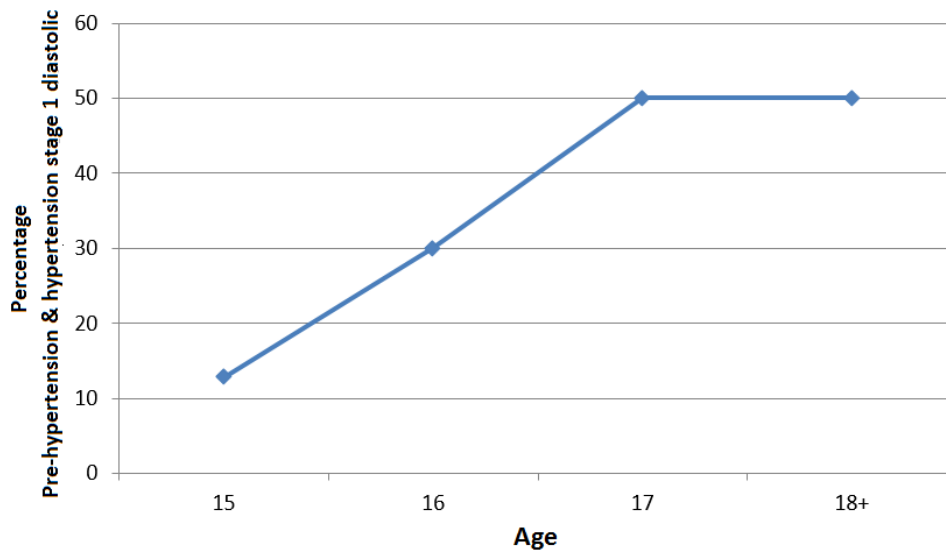| Age (yrs)	Diastolic BP			Total
	Normal < 80	Pre-hypertension 80-89	Hypertension grade 1(90-9 9)	
15	27 (26.5%)	3 (7.9%)	1 (10%)	31 (20.7%)
16	51 (50%)	17 (44.7%)	5 (50%)	73 (48.7%)
17	21 (20.6%)	15 (39.5%)	4 (40%)	40 (26.7%)
18	2 (2%)	3 (7.9%)	0 (0%)	5 (3.3%)
19	1 (1%)	0 (0%)	0 (0%)	1 (0.7%)
Total	102 (68%)	38 (25.3%)	10 (6.7%)	150 (100%)

Fig. 1. Trend of an increase in diastolic blood pressure by age.

Table 4. Influence of BMI on blood pressure

Influence	n	Correlation	Correlation Coefficient	P Value
BMI with Systolic blood pressure	150	Pearson	0.513	< 0.001
BMI with Diastolic blood pressure	150	Spearman	0.429	< 0.001

Table 5. Influence of age on blood pressure

Influence	n	Spearman Correlation Coefficient	P Value
Age with systolic blood pressure	150	0.040	0.623
Age with diastolic blood pressure	150	0.255	0.002

Table 6. Influence of sex on systolic blood pressure

Sex	Systolic blood pressure			Total	P Value
	Normal	Pre-hypertension	Hypertension grade 1		
Male	50 (46.3%)	35 (87.5%)	2 (100%)	87 (58%)	
Female	58 (53.7%	5 (12.5%)	0 (0%)	63 (42%)	< 0.001
Total	108 (72%)	40 (26.7%)	2 (1.3%)	150 (100%)	

Table 7. Influence of sex on diastolic blood pressure

Sex	Diastolic blood pressure			Total	P Value
	Normal	Pre-hypertension	Hypertension grade 1		
Male	52 (51%)	26 (68.4%)	9 (90%)	87 (58%)	
Female	50 (49%	12 (31.6%)	1 (10%)	63 (42%)	0.007
Total	102 (68%)	38 (25.3%)	10 (6.7%)	150 (100%)	

Table 8. Level of risk of male sex for systolic blood pressure

Sex	Systolic blood pressure		Total	RR (95%CI)
	Normal	Pre-hypertension & Hypertension grade 1		
Male	37 (42.5%)	50 (57.5%)	87 (100%)	
Female	5 (7.9%)	58 (92.1%)	63 (100%)	5.36
Total	42 (28%)	108 (72%)	150 (100%)	(2.232 – 12.865)

Table 9. Level of risk of male sex for diastolic blood pressure

Sex	Diastolic blood pressure		Total	RR (95%CI)
	Normal	Pre-hypertension & Hypertension grade 1		
Male	35 (40.2%)	52 (59.8%)	87 (100%)	
Female	13 (20.6%)	50 (79.4%)	63 (100%)	1.95
Total	48 (28%)	102 (72%)	150 (100%)	(1.127 – 3.372)

Table 10. Distribution of systolic blood pressure by nutritional status

Systolic blood pressure	Nutritional Status			Total
	Under	Normal	Overweight	
< 120	26 (83.9%)	69 (75%)	13 (48.1%)	108 (72%)
120 – 139	5 (16.1%)	23 (25%)	12 (44.4%)	40 (26.7%)
140 – 159	0 (0%)	0 (0%)	2 (7.4%)	2 (1.3%)
Total	31 (20.7%)	92 (61.3%)	27 (18%)	150 (100%)

Table 11. Distribution of diastolic blood pressure by nutritional status

Diastolic blood pressure	Nutritional Status			Total
	Under	Normal	Overweight	
< 80	28 (90.3%)	65 (70.7%)	9 (33.3%)	102 (68%)
80 – 89	3 (9.7%)	22 (23.9%)	13 (48.1%)	38 (25.3%)
90 – 99	0 (0%)	5 (5.4%)	5 (18.5%)	10 (6.7%)
Total	31 (20.7%)	92 (61.3%)	27 (18%)	150 (100%)

Table 12. Influence of nutritional status on blood pressure

Influence	n	Spearman Correlation Coefficient	P Value
Nutritional Status with systolic blood pressure	150	0.250	0.002
Nutritional Status with diastolic blood pressure	150	0.382	< 0.001

Table 13. Risk of nutritional status on systolic blood pressure

Nutritional Status	Systolic blood pressure		Total	RR (95%CI)
	Normal	Pre-hypertension & Hypertension grade 1		
Overweight	14 (51.9%)	13 (48.1%)	27 (100%)	
Under & Normal	28 (22.8%)	95 (77.2%)	123 (100%)	2.278 (1.398 – 3.710)
Total	42 (28%)	108 (72%)	150 (100%)	

Table 14. Level of risk of nutritional status on diastolic blood pressure

Nutritional Status	Diastolic blood pressure		Total	RR (95%CI)
	Normal	Pre-hypertension & Hypertension grade 1		
Overweght	18 (66.7%)	9 (33.3%)	27 (100%)	
Under & Normal	30 (24,4%)	93 (75,6%)	123 (100%)	2.733 (1.814 – 4.118)
Total	48 (28%)	102 (72%)	150 (100%)	

The risk of male sex for pre-hypertension and grade 1 diastolic hypertension was 1.95 times compared to female sex. Of 150 students, 18% had overnutrition and 51.8% had pre-hypertension to grade 1 hypertension. A total of 66.7% (18 people) of students who were overweight suffered from pre-hypertension to diastolic grade 1 hypertension (Table 11). Based on Spearman correlation test (?=0.05), nutritional status had a significant effect (p=0.002) on systolic blood pressure, as well as a significant effect (p <0.001) on diastolic blood pressure (Table 12). The risk of nutritional status for pre-hypertension and grade 1 systolic hypertension was estimated by relative risk (RR) as can be seen in Table 13. Students with overnutrition status had a risk

of getting pre-hypertension and grade 1 systolic hypertension by 2,278 times compared to students with normal and undernutrition status.

The risk of nutritional status for prehypertension and grade 1 diastolic hypertension was obtained by estimating RR (Table 14). Students with overnutrition status had 2.733 times the risk of pre-hypertension and grade 1 diastolic hypertension compared to those with normal and undernutrition status.

DISCUSSION

Students who were overweight (BMI >25) were 18%, and 66.7% of them suffered from pre-hypertension to grade 1 hypertension. Of the 150 students, those who suffered from systolic pre-hypertension were 26.7%, and grade 1 systolic hypertension 1.3%, while those with diastolic pre-hypertension were 25.3%, and grade 1 diastolic hypertension 6.7%.

Descriptively, the results of this study indicated that the trend for pre-hypertension to diastolic grade 1 hypertension increased with age. Age had a significant effect ($p=0.002$) on diastolic blood pressure. The older the age, the more rigid the blood vessels, so that peripheral resistance increases. This condition is consistent with the results of a 2009 Ministry of Health study, which showed that the proportion of hypertension in age group 45 - 54 years and older was always higher than those with normotension in a percentage of 27.7%. The age group of 25-34 years had a risk of hypertension 1.56 times higher compared to the age of 18-24 years. The risk of hypertension increases significantly with increasing age, and the age group >75 years has a risk of 11.53 times higher.

In this study, male sex was proven to be a risk factor for pre-hypertension to grade 1 systolic or diastolic hypertension. Male sex had level of risk of pre-hypertension to grade 1 systolic hypertension 5.36 times higher compared to women, and the risk of pre-hypertension to grade 1 diastolic hypertension 1.95 times higher compared to women. Factors that play a role in men are likely smoking, drinking alcohol, stress, type A personality and so forth.

In this study, BMI had a significant effect ($p < 0.001$) on blood pressure. This was in accordance with the results of Zazariani's research (2011) which showed there was correlation ($p=0.02$) between BMI and the incidence of increased blood pressure. The results of Leni's research (2012) in Bojonegoro, Indonesia, also showed an association between being overweight and obesity with hypertension.

Weight and BMI correlate directly with blood pressure, especially systolic blood pressure. The relative risk for suffering from hypertension in obese people is 5 times higher compared to individuals with normal weight. About 20-30% of hypertensive individuals are overweight (Sutanto 2010)

The higher the BMI, the higher the systolic and/or diastolic blood pressure. The higher the body mass, the more blood is needed to supply oxygen and food to body tissues. This means that the volume of blood circulating through blood vessels increases so that it puts more pressure on artery walls. Being overweight also increases heart rate frequency and insulin levels in blood. Increased insulin causes the body to retain sodium and water (Theodosha et al 2000).

Individuals with overnutrition status have a risk of developing grade 1 systolic pre-hypertension and hypertension by 5.36 times compared to individuals with normal and undernutrition status, and have a risk of pre-hypertension and grade 1 diastolic hypertension by 1.95 times compared to individuals with normal and undernutrition status. Hypertension in obesity is the result of interaction of several factors, ie. food consumption habits, genetic, epigenetic, and environmental factors. The failure of adipocyte function in obese patients causes vascular and insulin resistance. This will cause failure of sympathetic nerve function and the renin angiotensin system which play a role in the development of hypertension (DeMarco et al 2014). Rahajeng and Tuminah's research results in 2009 showed that risk factors significantly related to hypertension were old age (OR 11.5 with CI 9.01-9.98), male (OR 1.3 with CI 1.21-1.29), low education (OR 1.6 with CI 1.51-1.71), obesity (OR 2.8 with CI 2.67-2.91), and abdominal obesity (OR 1.4 with CI 1.36 - 1.44).

CONCLUSION

The trend for pre-hypertension to grade 1 diastolic hypertension increases with age and age has influence on diastolic blood pressure. The risk of males to suffer from pre-hypertension to grade 1 systolic hypertension is 5.36 times that of women, and the risk of pre-hypertension to grade 1 diastolic hypertension is 1.95 times that of women. The higher the BMI, the higher the systolic and/or diastolic blood pressure. Being overweight has a risk of pre-hypertension to grade 1 systolic (RR 2,278) or diastolic (RR 2,273) hypertension.

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