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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Association Between Nutritional Status, Antioxidant Intake (Vitamin C, Vitamin E, Selenium), Fiber Intake and Physical Activity with Blood Lipid Profile in Coronary Heart Disease

Eliza[1,2], Sri Anna Marliyati[2], Rimbawan[2] and Adi Teruna Effendi[2]
[1]Health Polytechnic Palembang, Sukabangun I Street, Palembang, Indonesia
[2]Department of Community Nutrition, Faculty of Human Ecology, Bogor Agricultural University, Bogor-16680, Indonesia

Abstract: The objectives of this study were to: analyze socio-economic characteristics; analyze nutritional status; analyze antioxidant (vitamin C, vitamin E, and selenium) and fiber intakes; analyze physical activity; and analyze the association between nutritional status, antioxidant and fiber intakes, as well as physical activity with blood lipid profile in coronary heart disease patients. The design of this study was cross-sectional. The research site was Pusri Medika Hospital in Palembang. The results showed that there were significant associations between age and total cholesterol levels (OR = 3.333; 95% CI: 1.050-10.586), physical activity and total cholesterol levels (OR = 3.300; 95% CI: 1.022-10.654), vitamin E intake and total cholesterol levels (OR = 3.929: 95% CI: 1.185-13.021), fiber intake and total cholesterol levels (OR = 4.875; 95% CI: 1.483-16.023), BMI and LDL-C levels (OR = 4.286; 95% CI: 0.933-19.678), as well as body fat percentage and triglyceride levels (OR = 4.583; 95% CI: 1.298-16.182).h

Key words: Antioxidant intake, fiber intake, lipid profile, nutritional status, physical activity

INTRODUCTION

Cardiovascular disease is one of the first leading cause of death in developed and developing countries these days. There were 7,249,000 deaths in 2008 due to coronary heart disease (CHD) or 12.7% of all deaths. There were two million deaths in India and China or more than 30% of deaths from CHD and there were 659,500 and 445,800 deaths in Russian Federation and United States of America, respectively (Finegold *et al.*, 2012).

Cardiovascular disease is the first leading cause of death of all deaths in Indonesia, in the amount of 37%, followed by infectious disease, maternal, perinatal and nutritional problems (22%), cancer (13%), other non-communicable diseases (10%), accidents (7%), diabetes (6%) and chronic respiratory disease (5%) (WHO, 2014). CHD is a narrowing of blood vessels (coronary arteries) which leads to insufficient blood supply that carries oxygen and nutrients to the heart (Wu *et al.*, 2014). Constriction of blood vessels occurs due to atherosclerosis.

Antioxidants are molecules that can interact with free radicals and counteract the chain reaction before vital molecules are damaged. The body has prepared an antidote through antioxidant system in order to fight free radical damage (Soobrattee, 2005). Vitamin C is an important antioxidant which helps in reducing the amount of fat in the body. It regenerates vitamin E and increase the elimination of cholesterol from the body (Knekt *et al.*, 2004). Vitamin E is an antioxidant which prevents the oxidation of low-density lipoprotein cholesterol (LDL-C) (Knekt *et al.*, 2004). An epidemiological study showed that people who consumed vitamin E-rich foods tended to have less atherosclerotic plaques and lower death rate from heart disease (Iannuzzi, 2004). Selenium is a trace element involved in protection against oxidative damage and serves as the main determinant of synthesis and activity of selenoprotein, such as glutathione peroxidase (GPx) (Rayman, 2000). Selenium bioavailability is a limiting factor in the synthesis of several selenoprotein antioxidants.

A component food recommended in controlling blood lipid levels is fiber. Fiber is a component food which can not be digested by digestive enzymes (Kusharto, 2006). Intake of dietary fibers plays an important role in CHD (Retelny *et al.*, 2008; Bernstein *et al.*, 2013).

Low physical activity is a risk factor of CHD (NCEP, 2001). Based on the results of the above descriptions, it is necessary to identify the association between nutritional status, antioxidant and fiber intakes, as well as physical activity with lipid profile in CHD patients. This study aimed to (1) analyze the subjects' socio-economic characteristics, (2) analyze the nutritional status, (3) analyze the intake of antioxidants (vitamin C, vitamin E and selenium) and fiber, (4) analyze the physical activity, and (5) analyze the association between nutritional status, antioxidant intake, fiber intake and physical activity with lipid profile in CHD patients.

Corresponding Author: Eliza, Health Polytechnic Palembang, Sukabangun I Street, Palembang, Indonesia

MATERIALS AND METHODS

The design of this study was cross-sectional. The research site was Pusri Medika Hospital in Palembang. This study was conducted from February to August 2015 and has been approved by Health Research Ethic Committee of Faculty of Medicine, University of Indonesia Number: 339/UN2.F1/ETIK/2015. The subjects of this study were CHD patients (outpatients and inpatients) who met the inclusion criteria. Sampling method was purposive sampling. The inclusion criteria were: (1) male and female patients who were diagnosed to have CHD by doctors, proven by chest pain (angina pectoris) and myocardial infection, as well as ECG abnormalities, (2) new patients (maximum 2 weeks) diagnosed to have CHD, (3) were willing to participate in this study by signing the informed consent, (4) could communicate well. The number of subjects required for this study was 53 people.

Socioeconomic characteristics: Data of socioeconomic characteristics (age, gender, education level, occupation) were collected through direct interview using a questionnaire.

Body mass index: Body weight was measured using a digital scale with a capacity of 200 and 0.1 kg accuracy. Height was measured using microtoise with a capacity of 200 and 0.1 cm accuracy. Body mass index was calculated by the ratio of body weight in kilograms divided by the square of the height in meters. Overweight and obese was defined as BMI = 23 kg/m^2 (WHO Western Pacific Region, 2000).

Waist circumference: Waist circumference (WC) was measured using a measuring tape with 0.1 cm accuracy. It was measured by wrapping the tape to the navel as the main boundary. A participant was categorized as obese if WC = 90 cm for men and = 80 cm in women (WHO, 2008).

Body fat percentage: Body fat percentage (BFP) were measured by Bioelectrical Impedance Analysis (BIA). Participants were categorized as overweight and obese if their BFP were >22% in men and >35% in women for 40-59 age group; while >25% in men and >36% in women for $\geq$60 age group (Gallagher *et al*., 2000).

Antioxidant and fiber intakes: Data of antioxidant (vitamin C, vitamin E and selenium) and fiber intakes were collected using 1 x 24 h food recall method.

Physical activity levels (PAL): Physical activity data were collected using a structured questionnaire with 2 x 24 h recall activity method in weekday and weekend. Physical activity levels (PAL) were categorized into three categories, namely light or sedentary (1.4 = PAL = 1.69), moderate (1.70$\leq$PAL$\leq$1.99) and vigorous (2.00$\leq$PAL$\leq$ 2.39) (FAO, 2001).

Blood lipid profile: Blood lipid profile data were collected from medical records. Lipid profile level measurement was preceded by 8-12 hours fasting before the blood samples were collected. Venous blood samples were taken by hospital laboratory workers and then analyzed by CHOD-PAP method for total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and LDL-C levels and GPO-PAP method for triglyceride (TG) levels.

Statistical analysis: The data were processed and analyzed using descriptive and inferential statistics by 2013 Microsoft Excel computer program and SPSS version 16 software. Chi-square test was used to analyze the variables (age, education level, physical activity level, antioxidant intake, fiber intake and nutritional status) that were allegedly related to lipid profile. It was also used to determine the odds ratio (OR) of the associated variables. An OR is a measure of association between a risk factor and incidence of a disease.

RESULTS

Based on gender, most of the subjects were males (79.2%) and there was only a small percentage of female subjects (20.8%). Subjects' distribution based on gender was presented in Table 1.

Based on age, more than half of men (52.4%) were in more than or equal to 60 years age group while more than half of women (54.5%) were in 45-59 years age group. More than half of the men (54.8%) graduated from senior high school while women (45.5%) graduated from junior high school. More than half of men (54.8%) were retirees, either as retired civil servants or retirees of state-owned enterprises (SOE) or Pusri limited liability company (PT. Pusri) while most women (81.8%) were housewives. Economic status and education needs to be identified because they can affect the behavior in selecting food/dietary pattern and purchasing power/ability for foodstuffs. Subjects' characteristics based on age, education level and occupation were presented in Table 2.

Based on BMI, nutritional status of most subjects (58.5%) was classified as obese. Based on waist circumference, more than half of them (64.2%) were obese. Based on body fat percentage, most of them were overweight (43.4%) and obese (26.4%). Based on PAL, more than half of them (64.2%) had low PAL. Distribution of the subjects based on nutritional status and physical activity was presented in Table 3.

More than half of the subjects had adequate intake of vitamin C (58.5%) and selenium (98.1%). Meanwhile,

Table 1: Distribution of the subjects based on gender

Gender	n	%
Men	41	79.2
Women	11	20.8

Table 2: Subjects' characteristics based on age, education level and occupation

	Men		Women		Total	
Characteristics	n	%	n	%	n	%
Age (years)						
<45	1	2.4	0	0	1	1.9
45-59	19	45.2	6	54.5	25	47.2
≥60	22	52.4	5	45.5	27	50.9
Education level						
Primary school graduate	3	7.1	0	0.0	3	5.7
Junior high school graduate	7	16.7	5	45.5	12	22.6
Senior high school graduate	23	54.8	2	18.2	25	47.2
Diploma/college graduate	9	21.4	4	36.4	13	24.5
Occupation						
Civil servants/INAF/INP	5	11.9	0	0.0	5	9.4
Private-sector/SOE employee	6	14.3	0	0.0	6	11.3
Entrepreneur	7	16.7	0	0.0	7	13.2
Laborer	1	2.4	0	0.0	1	1.9
Retiree	23	54.8	2	18.2	25	47.2
Housewife						

Abbreviation: INAF: Indonesian national armed forces, INP: Indonesian national police, SOE: State-owned enterprises

Table 3: Distribution of the subjects based on nutritional status

	Men		Women		Total	
Nutritional status	n	%	n	%	n	%
Body mass index (kg/m^2)						
Underweight (BMI<18.5)	-	-	-	-	-	-
Normal weight (18.5≤BMI<22.9)	8	19.0	1	9.1	9	17.0
Overweight (23.0≤BMI<24.9)	11	26.2	2	18.2	13	24.5
Obesities (IMT≤25.0)	23	54.8	8	72.7	31	58.5
Mean±SD	25.26±2.94		27.50±4.34		25.72±3.36	
Waist circumference (cm)						
Normal (Men<90 cm; Women<80 cm)	13	31.0	6	54.5	19	35.8
Obesities (Men ≥90 cm; Women ≥80 cm)	29	69.0	5	45.5	34	64.2
Mean±SD	89.07±7.37		89.00±15.76		89.06±9.52	
Body fat percentage (%)						
Moderate	10	23.8	6	54.5	16	30.2
Over fat	20	47.6	3	27.3	23	43.4
Obese	13	28.6	2	18.2	14	26.4
Mean±SD	26.57±4.14		33.66±7.095		28.04±5.787	
Physical activity levels (PAL)						
Low (1.40≤PAL≤1.69)	24	57.1	10	90.9	34	64.2
Moderate (1.70≤PAL≤1.99)	18	42.9	1	9.1	19	35.8

SD: Standard deviation

Table 4: Distribution of the subjects based on antioxidant and fiber intakes

	Men		Women		Total	
Antioxidant and fiber intakes	n	%	n	%	N	%
Vitamin C						
Inadequate (<90 mg)	23	54.8	8	72.2	31	41.5
Adequate (≥90 mg)	19	45.2	3	27.3	22	58.5
Mean±SD	38.61±30.71		31.15±25.82		37.07±29.68	
Vitamin E						
Inadequate (<15 mg)	28	66.7	7	63.6	35	66.0
Adequate (≥15 mg)	14	33.3	4	36.4	18	34.0
Mean±SD	9.72±5.01		7.43±4.71		9.25±4.99	
Selenium						
Inadequate (<30 mcg)	-	-	1	9.1	1	1.9
Adequate (≥30 mcg)	42	100	10	90.9	52	98.1
Mean±SD	91.64±48.69		83.62±40.77		89.98±46.90	
Fiber						
Inadequate (<25 g)	25	59.5	7	63.6	32	60.4
Adequate (≥25 g)	17	40.5	4	36.4	21	39.6
Mean±SD	19.04±6.6		18.9±6.9		1901±6.56	

SD: Standard deviation

Table 5: Distribution of the subjects based on lipid profile

	Men		Women		Total	
Profile lipid	n	%	n	%	n	%
Total cholesterol (TC)						
High (≥240 mg/dL)	25	59.5	7	63.6	32	60.4
Normal (<200 mg/dL)	17	40.5	4	36.4	21	39.6
Mean±SD	247.64±44.58		254.18±31.81		249.00±42.05	
HDL-cholesterol						
Low (<40 mg/dL)	33	78.6	9	81.8	42	79.2
Normal (≥40 mg/dL)	9	21.4	2	18.2	11	20.8
Mean±SD	35.43±7.01		35.36±7.58		35.42±7.05	
LDL-cholesterol						
High (≥160 mg/dL)	25	59.5	8	72.7	33	62.3
Normal (<160 mg/dL)	17	40.5	3	27.3	20	37.7
Mean±SD	173.43±41.653		178.45±27.750		174.47±38.99	
Triglycerides						
High (≥200 mg/dL)	23	54.8	7	63.6	30	56.6
Normal (<200 mg/dL)	19	45.2	4	36.4	23	43.4
Mean±SD	215.17±79.63		203.91±59.03		212.83±75.44	

SD: Standard deviation

Table 6: Association between subjects' characteristics and physical activity with lipid profile

	TC		LDL-C		HDL-C		TG	
Variables	p-value	OR	p-value	OR	p-value	OR	p-value	OR
Age (years)								
≥60	0.038*	3.333	0.215	2.038	0.277	2.118	0.691	1.247
<60		(1.050-10.586)		(0.658-6.302)		(0.538-8.341)		(0.420-3.701)
Education level								
Low (≤senior high school)	0.063	3.323	0.056	0.222	0.583	0.626	0.290	0.491
High (>senior high school)		(0.907-12.176)		(0.044-1.135)		(0.117-3.359)		(0.130-1.860)
PAL								
Inactive (<1.6)	0.042*	3.300	0.094	2.667	0.505	0.609	0.887	0.921
Active (≤1.6)		(1.022-10.654)		(0.833-8.542)		(0.141-2.639)		(0.296-2.865)

*Chi-square test, significant at α <5%, TC: Total cholesterol, LDL-C: LDL cholesterol, HDL-cholesterol, TG: Triglycerides, PAL: Physical activity levels

most of them had inadequate intake of vitamin E (66.0%) and fiber (60.4%). Low intake of vitamin C, E and fiber was caused by low consumption of fruits and vegetables. Data of antioxidant and fiber intakes could be seen in Table 4.

More than half of the subjects (60.4%) had high TC levels. Mean TC levels was 249.00±42.05 mg/dL. Most of the subjects (79.2%) had low HDL-C levels. Mean HDL-C levels of the subjects was 35.42±7.05 mg/dL. Most of the subjects (62.3%) had high LDL-C levels. Mean LDL-C levels of the subjects was 174.47±38.99 mg/dL. The majority of the subjects (56.6%) had high TG levels. Mean TG levels of the subjects was 212.83±75.44 mg/dL. Data of subjects' distribution based on lipid profile could be seen in Table 5.

Statistical analysis showed that there were significant associations between age and TC levels (OR = 3.333; 95% CI: 1.050-10.586), PAL and TC levels (OR = 3.300; 95% CI: 1.022-10.654), vitamin E intake and TC levels (OR = 3.929: 95% CI: 1.185-13.021), fiber intake and TC levels (OR = 4.875; 95% CI: 1.483-16.023), BMI and LDL-C levels (OR = 4.286; 95% CI: 0.933-19.678), as well as body fat percentage and TG levels (OR = 4.583; 95% CI: 1.298-16.182).

DISCUSSION

In general, the proportion of men with CHD was higher than women and men had a higher risk of having heart disease. These results were consistent with the studies conducted by Chung *et al.* (2009) and Kristofferzon *et al.* (2005) which showed that most of subjects suffering from CHD were men. The incidence of CHD in women was lower because of the protective effect of endogenous estrogen (Perk *et al.*, 2012). The estrogen plays a role in maintaining blood cholesterol levels in which keeping HDL-c levels to remain high and LDL-C levels to remain low.

Most of the subjects had high TC, LDL-C and TG levels while their HDL-C levels were low (Table 4). A decrease in HDL-C concentrations and an increase in TG and LDL-C concentrations were responsible for atherosclerotic lesions (Patsch *et al.*, 1992; Abbasi *et al.*, 2000). These results were similar with the results of Maher and Gutbi (2013) who showed that the mean TC, TG, LDL-C and HDL-C levels of 72 out patients with CHD in El-Shaap Teaching Hospital in Khartoum State were 237±15.3, 192±12.4, 148.8±12.1 and 38.7±12.3 mg/dL, respectively.

Age had a significant association with TC levels. This finding was similar with the previous studies which

Table 7: Association between nutritional status with lipid profile

	TC		LDL-C		HDL-C		TG	
Nutritional status	p-value	OR	p-value	OR	p-value	OR	p-value	OR
BMI (kg/m²)								
Obese	0.745	1.271	0.049*	4.286	0.054	4.229	0.122	3.176
Non-obese		(0.299-5.406)		(0.933-19.678)		(0.904-19.786)		(0.700-14.421)
WC (cm)								
Obese	0.148	2.323	0.624	1.333	0.146	2.677	0.111	2.521
Non-obese		(0.734-7.352)		(0.422-4.214)		(0.690-10.380)		(0.798-7.967)
BFP (%)								
Obese	0.686	1.278	0.522	0.667	0.215	2.348	0.014*	4.583
Non-obese		(0.389-4.202)		(0.192-2.314)		(0.596-9.258)		(1.298-16.182)

*Chi-square test, significant at α <5%, BMI: Body mass index, WC: Waist circumference, BFP: Body fat percentage

Table 8: Association between the intake of antioxidants and fiber with lipid profile

	TC		LDL-C		HDL-C		TG	
Antioxidants and fiber intakes	p-value	OR	p-value	OR	p-value	OR	p-value	OR
Vitamin C								
Inadequate (<90 mg)	0.872	1.096	0.329	1.750	0.324	1.950	0.052	3.033
Adequate (≥90 mg)		(0.359-3.345)		(0.567-5.404)		(0.510-7.449)		(0.974-9.442)
Vitamin E								
Inadequate (<15 mg)	0.022*	3.929	0.635	0.0750	0.366	1.859	0.912	1.067
Adequate (≥15 mg)		(1.185-13.021		(0.228-2.467)		(0.479-7.208)		(0.339-3.354)
Selenium								
Inadequate (<30 mcg)	0.413	1.677	0.195	2.737	0.605	1.268	0.249	2.364
Adequate (≥30 mcg)		(1.341-2.098)		(1.913-3.916)		(1.102-1.460)		(1.721-3.247)
Fiber								
Inadequate (<25 g)	0.007*	4.875	0.090	0.646	0.256	2.160	0.528	0.697
Adequate (≥25 g)		(1.483-16.023)		(0.205-2.033)		(0.192-3.005)		(0.227-2.141)

*Chi-square test, significant at α<5%

showed that 60-65 years of age had a significant relationship with high TC levels (Okecka-Szymanska *et al.*, 2011; Marhoum *et al.*, 2013). The aging process is associated inversely with the body's immune function and directly proportional to IL-6 and TNF-α levels. Increased level of proinflammatory cytokine IL-6 is initiated when reaching the age of 39-59 years. The incidence and duration of systemic inflammatory response syndrome in the elderly is higher than young people; thus, the ability to produce inflammatory cytokines (IL-6 and TNF-α) by peripheral blood mononuclear cells (PBMC) will be increased in the elderly. The existence of inflammatory cytokines in the circulation may then persist for a long time so that the elderly tend to have comorbidities such as stroke and CHD (Effendi, 2013).

Physical activity level had a significant association with TC levels. This finding was similar with the study of Oluseye *et al.* (2012) in Nigeria which showed that men and women who had high physical activity significantly had lower TC levels than the ones with low physical activity. Study conducted by Cuhadar *et al.* (2013) showed that people with high physical activity had lower risk of CHD. The subjects had low PAL because most of them were old and had already retired (not working anymore). Physical activity was associated with decreased BMI and led to a better lipid profile (Cugnetto *et al.*, 2008).

BMI-based nutritional status had a significant association with LDL-C levels. Obese subjects were 4.286 times at higher risk of having high LDL-C levels than the ones with normal nutritional status. This result was consistent with the previous studies which stated that obesity based on BMI had a significant association with high LDL-c levels and an increased incidence of CHD (Li *et al.*, 2006; Sandhu *et al.*, 2008; Zamani *et al.*, 2012). Body fat percentage had a significant association with TG levels. Subjects who were categorized as obese based on body fat percentage were 4.583 times at higher risk of having high TG levels than the ones with normal body fat percentage. This finding was similar with the study of Sanlier and Yabanci (2007) who stated that body fat percentage categorized as obese was significantly associated with the high TG levels in the blood. Study conducted in Malaysia analyzed body fat percentage, waist circumference, waist-hip ratio, waist-to-height ratio and BMI to determine the variable which had the most significant association with CHD. The results showed that body fat percentage was the most significant indicator than other nutritional status measurements (Su *et al.*, 2015).

Vitamin E intake had a significant association with TC levels. This finding was consistent with the previous studies which showed that there was a significant association between vitamin E intake and serum TC levels in CHD patients (Muzakar, 2008; Helmizar *et al.*, 2010). Vitamin E is an antioxidant which prevents LDL-C oxidation (Knekt *et al.*, 2004). An epidemiological study showed that people who consumed vitamin E-rich foods tended to have less atherosclerotic plaques and lower death rate from CHD (Iannuzzi, 2004). Vitamin E is known as peroxyl scavenger which breaks the chain reaction of lipid peroxidation and prevents the oxidation of LDL-C in the cell membrane (Mortzzavimoghaddam *et al*., 2007).

Fiber intake had a significant association with TC levels. This result was similar with the study of Mumford *et al*. (2010) who stated that there was a significant association between fiber intake, categorized into less than 22 g/day and more than 22 g/day, with TC levels. Meta-analysis research by Wu *et al*. (2014) showed that fiber intake had inverse relation with CHD risk, particularly for fiber derived from cereals and fruits. Besides, soluble and insoluble fibers had the same effect on CHD. Fiber has hypocholesterolemic effect through the mechanism of the increase in the viscosity of intestinal contents thereby reducing the reabsorption of bile acids and delaying the absorption of other macronutrients; thus, increasing the excretion of bile acids and decreasing the overall energy intake. Fiber also delays gastric emptying (Mahan *et al*., 2012) which can reduce blood pressure, improve the viability of coronary artery endothelial cells and decrease intracellular reactive oxygen species (ROS) (Srimahachota *et al*., 2010).

Conclusion and recommendation: The results of descriptive analysis showed that most of the subjects were males (79.2%). There were 50.9% subjects aged more than or equal to 60 years. There were 47.2% subjects graduating from senior high school while there were 5.7% subjects graduating from primary school. Most of the subjects were obese based on BMI (58.5%) and waist circumference (64.2%). Most of them were overweight (26.4%) and obese (26.4%) based on body fat percentage. More than half of them (64.2%) had low physical activity. Most of them had high TC levels (60.4%), low HDL-C levels (79.2%), high LDL-C levels (62.3%) and high TG levels (56.6%). Analysis results of correlation test showed that there were significant associations between age and TC levels (OR = 3.333; 95% CI: 1.050-10.586), physical activity and TC levels (OR = 3.300; CI: 1.022-10.654), vitamin E intake and TC levels (OR = 3.929; 95% CI: 1.185-13.021), fiber intake and TC levels (OR = 4.875; 96% CI: 1.483-16.023), BMI and LDL-C levels (OR = 4.286; 95% CI: 0.933-19.678), as well as body fat percentage and TG levels (OR = 4.583; 95% CI: 1.298-16.182).

Nutrition education to patients and community is needed in order to increase the intake of foods rich in vitamin C, vitamin E, selenium and fiber, as well as to increase physical activity to decrease body weight and also TC, LDL-C and TG levels.

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