The Effect of Central Obesity, Smoking, and Fried Food Consumption on Dyslipidemia in Adults: A Prospective Cohort Study

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Abstract. Dyslipidemia is an important risk factor that can trigger the incidence of non-communicable diseases. This study aims to analyze the effect of central obesity, smoking, and consumption of fried foods on the incidence of dyslipidemia in adults aged 25–65 years. This study uses secondary data from the Non-Communicable Disease Risk Factor Study (2011/2012–2017/2018) conducted by the Center for Research and Development of Public Health Efforts, Agency for Health Research and Development, Ministry of Health, Republic of Indonesia. The study design was a prospective cohort. The population in this study were all household members aged 25–65 years in 5 urban villages in the city of Bogor. Subjects were all household members aged 25–65 years with the criteria still living in the study area (permanent residents), independent samples, not physically disabled, women who were not pregnant, and had normal lipid profile levels at the beginning of the study. The analyzed subjects consisted of 1477 men (n = 378) and women (n = 1099) who were followed for six years. The results showed that the incidence of dyslipidemia during the 6 years of observation was 41.7% (n = 616). The results also showed that central obesity, age group, smoking, and consumption of fried foods have an effect on dyslipidemia in adults aged 25–65 years. Subjects with central obesity had HR of 1.3 times (95% CI: 1.10–1.52) to be dyslipidemic compared to subjects who were not centrally obese after controlling for age, smoking, and consumption of fried foods. This study concludes that central obesity, age group, smoking, and consumption of fried foods have an effect on dyslipidemia which can increase the incidence of non-communicable diseases.

Keywords: central obesity · smoking · consumption of fried food · dyslipidemia · adults

1 Introduction

Dyslipidemia is the presence of abnormal lipid levels in the blood, characterized by an increase in the concentration of total cholesterol (TC), low-density lipoprotein (LDL), and triglycerides (TG), and a decrease in high-density lipoprotein (HDL) cholesterol [1–3]. Dyslipidemia has become a public health problem worldwide, and its prevalence

I. Nurlaila et al. (Eds.): ICHR 2022, AHSR 56, pp. 655–667, 2023.
https://doi.org/10.2991/978-94-6463-112-8_60

varies greatly according to socioeconomic, cultural, and ethnic characteristics [4]. Data on the prevalence of dyslipidemia in Indonesia is still limited, especially in longitudinal studies. Based on the 2007 Basic Health Research (Riskesdas) report, the prevalence of dyslipidemia base on total cholesterol >200 mg/dl was 39.8% [5].

Dyslipidemia is a modifiable risk factor for atherosclerosis and cardiovascular disease, which is a major contributor to morbidity and mortality in both developed and developing countries [6]. Jellinger *et al*. (2017) revealed that secondary risk factors causing dyslipidemia are antihypertensive medication, obesity, oral contraceptives, pregnancy conditions, excessive alcohol consumption, type 2 diabetes, hypothyroidism, steroid use [3]. Sun et al. (2014) found that age, gender, BMI, abdominal circumference, hypertension, type 2 diabetes, smoking behavior, alcohol drinking habits, education level, marital status, and family economic status affect the incidence of dyslipidemia [6]. Daoud *et al*. (2014) added that a low-fat diet can reduce total LDL (low-density lipoprotein) cholesterol and HDL (high-density lipoprotein) cholesterol, while a low-carbohydrate diet reduces levels of TG (triglyceride) and VLDL (very low-density lipoprotein) cholesterol, increases HDL cholesterol and LDL cholesterol [7].

The National Institute for Health Research and Development (NIHRD), Ministry of Health of the Republic of Indonesia has conducted a cohort study of risk factors for non-communicable diseases in Bogor City since 2011. At the study baseline, an analysis of the lipid profile data was carried out. The results showed that the prevalence of high total cholesterol is 16.9%, high LDL cholesterol is 17.6%, low HDL cholesterol is 16.2%, and the percentage of triglycerides (TG) high by 8.5% [8]. This study aims to analyze the effect of central obesity, smoking, and consumption of fried foods on the incidence of dyslipidemia in adults aged 25–65 years.

2 Material and Methods

2.1 Study Design

This study was part of the "Cohort Study of Non-Communicable Disease Risk Factors (FRPTM)" which was conducted for six years (2011–2018) by the National Institute for Health Research and Development, Ministry of Health, Republic of Indonesia. The study design was a prospective cohort.

The population in this study were permanent residents aged 25–65 years in five urban villages in Central Bogor District, Bogor City, as evidenced by a personal identity card/Identity Card. Subjects were all household members aged 25–65 years with the criteria still living in the study area (permanent residents). The subject that met the inclusion criteria were willing to participate in all follow-up activities (FU) of the FRPTM cohort study. While the exclusion criteria were those who were seriously ill or unable to communicate well.

Based on observations for six years that met the inclusion criteria, a total of 1477 subjects were obtained for analysis. This sample size still meets the sample adequacy based on the calculation of the sample size, which gets a minimum number of samples of 892 samples [9].

Data was collected through interviews using a questionnaire (about health and nutrition) and laboratory blood tests (total cholesterol, LDL, HDL, and triglycerides). Questions in the health questionnaire include sociodemographic (gender, age, marital status, education, occupation), respondent's medical history, behavior (mental/emotional disorders, physical activity, smoking habits).

Gender consists of two categories, male and female. The marital status of the respondents was divided into 3 categories (unmarried, married, divorced). Age respondents were grouped into four categories, 25–34 years, 35–44 years, 45–54 years, and 55–65 years. Education based on the respondent's last education is divided into two categories, "low" if never attended school until graduating from junior high school and "high" if graduating from high school up to college. Employment is divided into 6 categories, namely laborers, traders/entrepreneurs, unemployed, domestic workers, housewives, civil servants/private employees.

Measurement of mental/emotional disorder variables using the Self Reporting Questionnaire instrument consisting of 20 questions (SRQ-20). Subjects are said to have mental/emotional disorders if at least 6 of the 20 questions in the SRQ instrument are answered with the code "1" (Yes) [10]. Measurement of physical activity variables is based on a composite calculation of the type and duration of activity (days per week and minutes per day) including the exercise performed. Heavy activity or heavy exercise weighs 8 times, moderate activity or moderate exercise weighs 4 times, light activity weighs 2 times. Subjects are categorized as less active if they have a total activity of less than 600 MET (metabolic equivalent) in one week [11]. Smoking habits are grouped into 4 categories, not smoking, passive smoking, ever smoking, and active smokers.

Food consumption questions include eating habits of fruits and vegetables and risky foods such as meat, offal, coconut milk, eggs, fried foods, instant noodles, and others. Nutrition interviews were conducted using "Recall Diet" 1 × 24 h to determine the type and amount of food consumed by respondents, and "Food Frequent Questionnaire" (FFQ) to determine eating habits in the past week. To estimate the amount/portion of food/beverage consumed by the subject, food aids/food models and food ingredient codebooks are used [10].

Nutrient content was calculated using the nutrisoft program developed by the NIHRD. Grouping of nutrient content (energy and protein) based on the nutritional adequacy rate (RDA) [12]. Consumption of energy is categorized into two, deficit (<70% RDA) and sufficient (≥70% RDA). Consumption of protein nutrients is categorized into two, namely: deficit (<80% RDA) and sufficient (≥80% RDA). Adequate consumption of carbohydrate nutrients is calculated by considering the adequacy of total energy according to age and gender minus the adequacy of protein and fat [13], categorized into two: deficit (<100% RDA) and sufficient (≥100% RDA). The habit of eating noodles, meat, offal, eggs, coconut milk food, fried food, vegetables, and fruit is categorized into three, namely: never, 1–6 times/week, and 7 times/week. Consumption of sugar, sodium, and fat is based on the Minister of Health Regulation No. 30 of 2013 concerning the inclusion of information on the content of sugar, salt, and fat as well as health messages for processed food and ready-to-eat food [14]. Sugar consumption is categorized into >50 g/day and 50 g/day, sodium consumption: >2000 mg/day and 2000 mg/day, fat consumption: >60 g/day and 60 g/day.

The collection of sociodemographic data, consumption of vegetables and fruit, smoking, and physical activity was carried out using a questionnaire developed specifically for a cohort study of risk factors for non-communicable diseases in Indonesia which was adopted from The WHO STEPS Instrument for Non-Communicable Diseases Surveillance [10]. Interviews were conducted by enumerators from health school graduates who had been previously trained. Likewise, food consumption interviews were conducted by enumerators who graduated from nutrition schools who had been given previous training.

2.2 Measurement of Weight and Height

Measurement of the subject's weight using the "AND" brand scale with an accuracy of 0.1 kg with a maximum weight capability of 140 kg. Weight scales are calibrated with a standard weight of 10–90 kg and are repeated every 200 times of use. Stages of weight measurement were carried out according to the guidelines.

Measurement of height using a height measuring device made of fiber glass with an accuracy of 0.1 cm and a maximum size of 230 cm. Stages of height measurement are carried out according to the guidelines. The categories of body mass index (BMI), which is the ratio of body weight and height squared (kg/m2), are normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese ($\geq$30 kg/m^2) [15].

2.3 Central Obesity Measurement

Measurement of central obesity by measuring the circumference of the abdomen using a medline tape with an accuracy of 0.1 cm. Abdominal circumference measurements were taken from the marked midpoint and then parallel to the waist and abdomen and returned to the marked midpoint. Central obesity status was categorized as obese if the waist circumference was $>$ 90 cm for men and $>$ 80 cm for women [16].

2.4 Lipid Profile Examination

Lipid profile examination includes total cholesterol, triglycerides, LDL, and high-density HDL cholesterol using the colorimetric enzymatic method. Before the examination, subjects were asked to fast for 12–14 h until the time of blood collection (it is permissible to drink water). Brachial venous blood was used for further examination and around 10 ml of blood sample was taken from the subject. Blood collection and lipid profile examination were carried out by the "P" laboratory. The lipid profile category (according to NCEP), namely total cholesterol (TC) was categorized into two, namely normal ($<$200 mg/dL) and high ($\geq$200 mg/dL). dL. LDL cholesterol levels, consisting of: normal ($<$100 mg/dL) and high ($\geq$100 mg/dL). HDL cholesterol levels are categorized into two, namely normal 40 mg/dL (men), 50 mg/dL (women) and low $<$40 mg/dL (men), $<$50 mg/dL (women). Furthermore, triglyceride (TG) levels are categorized into two, consisting of: normal ($<$150 mg/dL) and high ($\geq$150 mg/dL) [3]. Respondents with dyslipidemia have at least one level of high TC, high LDL, high TG, or low HDL.

Subjects who met the inclusion criteria were those who at the beginning of the study had normal lipid profile levels, did not suffer from other non-communicable diseases (diabetes mellitus, cancer, stroke, COPD), and had complete data.

2.5 Statistical Analysis

The data analyzed included gender, age, marital status, education, occupation, stress, smoking habit, physical activity, eating habits (meat, offal, coconut milk, eggs, fried food, instant noodles, fruits, and vegetables), consumption (sugar, fat, sodium), consumption (energy, protein, carbohydrates) as the independent variable, while dyslipidemia as the dependent variable.

The data analyzed were the conditions of risk factors and events (events) of dyslipidemia that appeared during six years of observation (baseline 2011–2017, baseline 2012–2018) through two measurements (baseline study and six years of the study). The censor is the condition of the subject who does not or has not experienced dyslipidemia at the time the incident was determined. Subjects who met the completeness of the variables for 6 years of observation obtained a total of 1477 for analysis.

The stages of univariate and bivariate analysis were carried out before multivariate analysis. The candidate variable included in the multivariate analysis is if it has a p-value <0.25 in the bivariate analysis [17]. Cox regression multivariate analysis modeling was conducted to determine the risk factors obesity and the habit of eating fried foods that contribute to the incidence of dyslipidemia. The relationship between the independent variables and the incidence of dyslipidemia was measured by the hazard ratio.

Ethical considerations for conducting research have obtained ethical approval from the Health Research Ethics Commission (KEPK), NIHRD of the Ministry of Health of the Republic of Indonesia with the number: KE.01.05/EC/394/2012 and is updated annually.

3 Results

Over six years the observation showed that the incident of dyslipidemia (event) was found to be 41.7%. The characteristics of the subjects according to sociodemography, physical activity, smoking habits, food consumption, and eating habits are described in Table 1. Subjects who have central obesity by 45%. Meanwhile, according to BMI (Body Mass Index), subjects who are overweight and obese are 43.9%. Most of the subjects were women (74.4%). According to the age group, it appears that the subjects in the 35–44 year age group are the highest among other age groups, which is 37%.

Most of the subjects' education was low (58.2%). Of most of the subjects, 41.4% worked as domestic workers (laundering and ironing clothes, taking care of toddlers, cleaning the house, etc.). Most of the subjects were married (86.9%). Most of the subjects' physical activity was in the sufficient category (90.4%). Subjects who smoked by 27.6%, and who did not smoke by 14.7%. Most of the subjects' energy and protein consumption was above 50% in the sufficient category, while most of the subjects' carbohydrate consumption was in a deficit (89.3%). From the eating habits of the subjects, it is known that only a small proportion of the subjects (2.8%) have never consumed noodles. Consumption of offal food 7 times/week is only 2.0%. The habit of eating fried food 7 times/week was 15.2%. Subjects who never ate vegetables and fruit were 12.9%. Meanwhile, sugar consumption >50 g/day is only 1.8%.

Table 1. Subject characteristics according to sociodemography, physical activity, smoking habits, food consumption, and eating habits

Characteristic	n = 1477	%	Characteristic	n = 1477	%
Central obesity			Protein consumption		
- Normal	812	55.0	- Defisit	618	41.8
- Obese	665	45.0	- Sufficient	859	58.2
BMI			Carbohydrate consumption		
- Normal	729	49.3	- Defisit	1319	89.3
- Underweight	100	6.8	- Sufficient	158	10.7
- Overweight	475	32.2	Noodles consumption		
- Obese	173	11.7	- Never	580	2.8
Gender			- 1–6 times/week	855	57.9
- Female	1099	74.4	- ≥7 times/week	42	39.3
- Male	378	25.6	Meat consumprion		
Age group (years)			- Never	253	17.2
- 25–34	348	23.6	- 1–6 times/week	807	54.6
- 35–44	547	37.0	- ≥7 times/week	417	28.2
- 45–54	396	26.8	Offal food consumption		
- 55–65	186	12.6	- Never	1224	82.9
Education			- 1–6 times/week	223	15.1
- Low	860	58.2	- ≥7 times/week	30	2.0
- High	617	41.8	Egg consumption		
Employment			- Never	265	17.9
- Laborers	130	8.8	- 1–6 times/week	860	58.2
- Traders/entrepreneurs	290	19.6	- ≥7 times/week	352	23.9
- Unemployed	82	5.6	Coconut milk consumption		
- Domestic workers	611	41.4	- Never	722	48.9
- Housewives	237	16.0	- 1–6 times/week	644	43.6
- Civil servants/private employees	127	8.6	- ≥7 times/week	111	7.5
Mental emotional disorder			Fried food consumption		
- No	1055	71.4	- Never	681	46.1

(*continued*)

Table 1. (*continued*)

Characteristic	n = 1477	%	Characteristic	n = 1477	%
- Yes	422	28.6	- 1–6 times/week	571	38.7
Marital status			- ≥7 times/week	225	15.2
- Ummarried	76	5.1	Fruits and vegetables consumption		
- Married	1283	86.9	- ≥7 times/week	1111	75.3
- Divorced	118	8.0	- 1–6 times/week	175	11.8
Physical activity			- Never	191	12.9
- Sufficient	1355	90.4	Sugar consumption		
- Inactivity	142	9.6	- ≤50 g/day	1451	98.2
Smoking habits			- >50 g/day	26	1.8
- Not smoking	217	14.7	Natrium consumption		
- Passive smoking	565	38.3	- ≤2000 mg/day	1132	76.6
- Ever smoking	286	19.4	- >2000 mg/day	345	23.4
- Active smokers	409	27.6	Fat consumption		
Energy consumption			- ≤60 g/day	974	65.9
- Defisit	299	20.2	- >60 g/day	503	34.1
- Sufficient	1178	79.8			

Table 2 showed that the variables included in the multivariable analysis stage ($p < 0.25$) were central obesity, BMI, gender, age group, occupation, mental-emotional disorder, smoking habits, carbohydrate consumption, eating habits/consumption (noodles, meat, offal, eggs, coconut milk, fried foods, vegetables, and fruits). In the next stage, a multivariate cox regression analysis was carried out (Table 3).

Based on Table 3, using the multivariate cox regression it can be seen that the risk of the dyslipidemia increased with central obesity (HR = 1.30 [95%, CI: 1.10–1.52]), age group 45–54 y (HR = 1.35 [95%, CI: 1.07–1.70]), fried food consumption 1–6 times/week (HR = 1.19 [95%, CI: 1.00–1.42]), fried food consumption ≥ 7 times/week (HR = 1,36 [95%, CI: 1.08–1.70]), and active smoker (HR = 1.31 [95%, CI: 1.01–1.71]).

4 Discussion

The results showed that obesity was significantly associated with the incidence of dyslipidemia. Excess body fat is associated with several conditions such as diabetes, cardiovascular disease, dyslipidemia, hypertension, metabolic syndrome, inflammation, thrombosis, and certain cancers [17–21]. Obesity increases cardiovascular risk through risk factors such as increased fasting plasma triglycerides, high low-density lipoprotein (LDL) cholesterol, low high-density lipoprotein (HDL) cholesterol, high blood sugar and insulin levels, and high blood pressure [22].

Table 2. The results of cox regression analysis of risk factors for dyslipidemia in adults

Risk factors	p	HR (95%CI)	Risk factors	p	HR (95%CI)
Central obesity			Protein consumption		
- Normal		1	- Defisit		1
- Obese	0.001	1.29(1.10–1.52)	- Sufficient	0.601	0.97(0.87–1.07)
BMI			Carbohydrate consumption		
- Normal		1	- Defisit		1
- Underweight	0.131	0.75(0.51–1.08)	- Sufficient	0.628	0.96(0.81–1.13)
- Overweight	0.120	1.15(0.96–1.37)	Noodles consumption		
- Obese	0.091	1.23(0.96–1.57)	- Never		1
Gender			- 1–6 times/week	0.473	0.89(0.65–1.21)
- Female		1	- ?7 times/week	0.662	0.93(0.68–1.27)
- Male	0.239	1.07(0,95–1.20)	Meat consumption		
Age group (years)			- Never		1
- 25–34		1	- 1–6 times/week	0.738	0.97(0.84–1.12)
- 35–44	0.874	0.98(0.86–1.13)	- ?7 times/week	0.551	0.95(0.81–1.11)
- 45–54	0.420	1.06(0.91–1.22)	Offal food consumption		
- 55–65	0.387	1.08(0.90–1.29)	- Never		1
Education			- 1–6 times/week	0.681	1.03(0.89–1.18)
- Low		1	- ?7 times/week	0.310	0.82(0.57–1.19)
- High	0.769	0.98(0.88–1.09)	Egg consumption		
Employment			- Never		1
- Laborers		1	- 1–6 times/week	0.740	0.97(0.85–1.12)
- Traders/entrepreneurs	0,733	0.96(0.78–1.18)	- ?7 times/week	0.694	0.96(0.82–1.13)
- Unemployed	0,799	0.96(0.73–1.27)	Coconut milk consumption		

(*continued*)

Table 2. (*continued*)

Risk factors	p	HR (95%CI)	Risk factors	p	HR (95%CI)
- Domestic workers	0,475	0.93(0.77–1.12)	- Never		1
- Housewives	0,658	0.95(0.76–1.18)	- 1–6 times/week	0.897	0.99(0.89–1.10)
- Civil servants/private	0,383	1.11(0.87–1.42)	- ?7 times/week	0.949	0.99(0.81–1.21)
employees			Fried food consumption		
Mental emotional disorder			- ever		1
- No		1	- 1–6 times/week	0.586	1.03(0.92–1.15)
- Yes	0.678	0.97(0.87–1.09)	- ?7 times/week	0.554	1.04(0.90–1.21)
Marital status			Fruits and vegetables consumption		
- Ummarried		1	- ?7 times/week		1
- Married	0.681	0.95(0.75–1.20)	- 1–6 times/week	0.769	0.97(0.83–1.14)
- Divorced	0.691	0.94(0.70–1.25)	- Never	0.347	1.07(0.92–1.25)
Physical activity			Sugar consumption		
- Sufficient		1	- ???50 g/day		1
- Inactivity	0.807	1.02(0.85–1.21)	- >50 g/day	0.822	1.04(0.70–1.54)
Smoking habits			Natrium consumption		
- Not smoking		1	- ??2000 mg/day		1
- Passive smoking	0.969	0.99(0.85–1.16)	- >2000 mg/day	0.305	0.93(0.83–1.05)
- Ever smoking	0.928	1.00(0.84–1.20)	Fat consumption		
- Active smokers	0.266	1.09(0.93–1.29)	- ?60 g/day		1
Energy consumption			- >60 g/day	0.471	0.96(0.86–1.07)
- Defisit		1			
- Sufficient	0.392	0.94(0.83–1.07)			

HR; hazard ratio

In this study, the results showed that the age variable affected the occurrence of dyslipidemia. The risk of developing dyslipidemia increases with age. In line with the

Table 3. The model of multivariate cox regression analysis of risk factors for dyslipidemia in adults

Risk factors	p	AHR	95%CI
Central obesity			
– Normal		1	
- Obese	0.001	1.30	1.10–1.52
Age group (years)			
- 25–34		1	
- 35–44	0.200	1.15	0.92–1.44
- 45–54	0.011	1.35	1.07–1.70
- 5–65	0.051	1.32	0.99–1.74
Fried food consumption			
- Never		1	
- 1–6 times/week	0.045	1.19	1.00–1.42
- ≥7 times/week	0.007	1.36	1.08–1.70
Smoking habits			
- Not smoking		1	
- Passive smoking	0.393	1.11	0.86–1.43
- Ever smoking	0.559	1.08	0.81–1.44
- Active smokers	0.041	1.31	1.01–1.71

AHR: Adjusted hazard ratio

research of Qi et al. in China, which found that age was significantly associated with the incidence of dyslipidemia [4]. The prevalence of TC, LDL, and TG increased significantly with age and then began to decline in the age group 65 years and over. The low prevalence of HDL decreases initially and then increases with advancing age, with the lowest prevalence observed in the 55–64 year age group [23]. It is possible that there is a change in the behavior of someone over the age of 50 after undergoing several therapies, consultations, taking certain drugs, eating behavior that tends to be better or tends to reduce fat. The use of steroid drugs and consuming low-fat foods will affect the levels of lipid profiles [3, 7].

This study also found that fried food consumption was associated with dyslipidemia. Fried foods contain free fatty acids. Klop et al. (2013) stated that the hallmark of dyslipidemia in obesity is the occurrence of hypertriglyceridemia due to an increase in free fatty acids (FFA) in the liver, which causes the accumulation of triglycerides (TG) in the liver. This results in a large increase in hepatic very-low-density lipoprotein (VLDL) synthesis, which inhibits lipolysis from chylomicrons due to competition primarily at lipoprotein lipase (LPL) levels with increased residual TG transported to the liver [22].

This study found that smoking was associated with the incidence of dyslipidemia ($p < 0.05$). Subjects who actively smoke have a risk of experiencing dyslipidemia by 1.31

times compared to subjects who do not smoke. This study is in line with Sun et al. 2014 who found that there was a relationship between smoking and the prevalence of low HDL and high TG [6]. Yan-Ling et al. 2012 found that only subjects who currently smoked were associated with low TC levels, but smoking was not associated with other serum lipids/lipoproteins. The results of this study indicate that the effect of smoking on serum TC does not depend on smoking frequency [23]. Mouhameda et al. (2013) also corroborated the results that smoking and smoking duration were correlated with impaired lipid profile [24]. Limitations in this study may be the recall bias in the measurement of food consumption, food habits, physical activity questions, stress, and smoking habits. In addition, this study was not analyzed in terms of medication history, including drug use related to lipid profile.

5 Conclusion

The study concluded that central obesity, age group, smoking, and consumption of fried foods have an effect on dyslipidemia in adults aged 25–65 years. The need to limit fried foods and maintain ideal body weight is one of the factors that can reduce the risk of dyslipidemia. In addition, the dissemination of information about the dangers of smoking is an alternative to preventing the occurrence of dyslipidemia. This predictive model can be developed for other studies by adding more complete variables.

Acknowledgments. The authors are grateful to the Head of the National Institute of Health Research and Development, and assistance from the non-communicable disease cohort study team.

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