Original Article

Association between Physical Activity and Obesity with Diabetes Mellitus in Indonesia

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Abstract

Diabetes Mellitus (DM) is a chronic disease with impaired pancreatic gland function that releases the hormone insulin. The pancreas plays a role in transporting sugar in the blood to the tissue muscles for energy supply. This study aims to determine the relationship between physical activity and obesity with Diabetes Mellitus in Indonesia. We use Indonesian Family Life Survey (IFLS)-5 data. Participants in this study were 5,260 people who had been examined HBA1C. The main risk factors in this study were physical activity and obesity by including age, sex, education, marital status, and history of TB as a potential confounding variable. The results of statistical tests on bivariate analysis showed that physical activity had a protective effect on diabetes mellitus with POR 0.614 (95% CI 0.49-0.77). Obese people have a higher risk of developing DM than those who were not obese with POR 1.63 (95% CI 1.29-2.05). Multivariate analysis showed the highest risk for DM was in people with insufficient physical activity and obesity with POR 1,551 compared with those who had sufficient physical activity and obesity with POR 1,072. While the risk of DM in people with insufficient physical activity but not obese provides a protective effect with POR 0.451. People with obesity and insufficient physical activity were 1,551 times to develop DM or increase by 13.4% if obesity and insufficient physical activity appear together.

Keywords: Physical activity; obesity; diabetes mellitus; Indonesia

Introduction

DM is one of the non-communicable diseases. DM causes people unable to control glucose levels in their blood. In a healthy body pancreas glands easily release the insulin hormone. DM includes metabolic disorders of glucose distribution in the body (Irianto, 2014).

Glucose which was usually obtained from carbohydrates which were circulated throughout the body functions as fuel used in daily body activities. If in a condition the body does not receive food intake, the sugar reserves in the liver were broken down and released into the bloodstream replacing energy from food intake. However, if the body still needs additional sugar, the second reserve, fat and protein, will be broken down into glucose. People with DM cannot produce enough insulin or cannot be used effectively, resulting in excess sugar in the blood (Irianto, 2014).

Based on WHO data the number of people with diabetes has increased from 108 million in 1980 to 422 million in 2014. The prevalence of diabetes in adults over 18 years has increased from 4.7% in 1980 to 8.5% in 2014. The prevalence of diabetes has increased more rapidly in low and middle income countries (WHO, 2016).

According to the Basic Health Research (Riskesdas) 2007 it was found that the proportion of deaths from diabetes mellitus in the 45-54 year age group in urban areas was in the 2nd position, which was 14.7%, while the rural population was in the 6th position at 5.8%

(Nainggolan, 2013). The results of the Basic Health Research (Riskesdas) 2013 showed an increase in the prevalence of DM from 2007 to 2013 from 1.1% to 2.1%. From the results of the Riskesdas 2013, it is estimated that only 26.3% have been diagnosed with DM. Patients who have not been diagnosed will eventually experience serious complications (Ministry of Health RI, 2014).

In addition to insulin resistance, there were still many other factors that play a role in disrupting the metabolism of the insulin hormone in the blood thereby increasing the risk of DM. According to Ministry of Health RI (2014) the factors that also play a role in influencing the body's metabolism were modifiable risk factors such as unhealthy behavior or lifestyle, such as overweight, obesity, lack of physical activity, unbalanced diet, history of glucose tolerance disrupted or disturbed fasting blood glucose and smoking. While the factors that cannot be modified were age, sex, family history of DM, childbirth history with a body weight of more than 4000 grams (Ministry of Health RI, 2014). Various risk factors of Diabetes Mellitus were known, but not much is known about the joint effect of physical activity and obesity with the incidence of Diabetes Mellitus in Indonesia so this study needs to be done.

Method

This study uses a cross-sectional design with IFLS-5 data (RAND, 2018). This survey collects information on data at the individual, household and community level with a multistage stratified random sampling approach. The IFLS survey and their procedures were reviewed and approved by Institutional Review Boards (IRBs) in the United States (in RAND). Informed consent was obtained from all respondents before interviewed.

IFLS-5 has interviewed 50,148 people. IFLS-5 was conducted in 13 provinces in Indonesia (Strauss et al, 2016). The study population was the subjects of the IFLS-5. While the sample is the age group ≥18 years who examined HBA1C and had complete questionnaire data on the variables studied. We investigated factors related to Diabetes Mellitus in Indonesia that were associated with physical activity and obesity by controlling confounding variables. Sampling was done by means of a total population that meets the inclusion and exclusion criteria. The total number of sample obtained 5,260 people.

We include demographic information and behavioral factors as confounding variables. We include age, sex, categorizing education levels by respondents to low and high, while marital status was classified as unmarried, married or divorced. We also included a history of tuberculosis as a factor that was considered as confounding variable, history of TB was identified by asking whether suffering from tuberculosis diagnosed by a doctor or paramedic or taking TB drugs.

Physical activity as an independent variable was assessed through a series of questions (a modified short form of the International Physical Activity Questionnaire (IPAQ)) on the type and timing of physical activity involved in all parts of life: work, home and training and subsequently classified as sufficient and insufficient physical activity (GPAQ, 2018).

Obesity was calculated based on body mass index as an independent variable categorized as BMI <25 kg / m^2: not obese; and; ≥25.0 kg / m^2: obesity comes from the height and weight measurement during a physical examination. Height was measured by the Shorr measurement board and weight was measured using the Seca floor-scale model. The floor-scale model has digital readings and was accurate to the nearest 0.1 kg. In this study measurements of body weight and height were carried out by interviewers or enumerators who were competent in their fields and had received prior training.

In IFLS-5, a dried blood spot (DBS) was taken. Retesting C-reactive protein, a measure of body inflammation, which has been shown to correlate with chronic adult diseases, including heart disease and HbA1c to diagnose DM. DBS was collected together using the Hemocue system to measure blood hemoglobin. The first drop of blood was used with hemoglobin and after that is put on the Whatman card. Hand warmers were used before puncture to increase blood flow. Whatman cards were left to dry for at least 4 hours on a special drying rack and then put in a small ziplock bag together with desicant. Ziplock bags with desicants help keep blood samples dry. The sample was stored in a cooler with a cooling plastic bag until the sample can be sent back to Yogyakarta. Usually DBS cards were sent twice per week in a special envelope isolated to keep the envelope cool. The envelope reaches the checkpoint usually in 2 days, where they were put in the freezer (stored at -40^{o}C) for storage until tested. Each ziplock bag has a label with a

household identification number, person, age and sex. In this study the HbA1C category was determined based on the American Diabetes Association, namely ≥6.5%; diabetes and <6.5%; not diabetes.

Data analysis in this study was carried out using logistic regression to calculate risks in all age groups based on HbA1c. This study has the effect of joining obesity and physical activity to the diabetes mellitus which is controlled by confounding variables, namely the variables of age, sex, education level, marital status, and history of TB by including it in multivariate analysis. If there is a difference of more than 10% between POR crude and POR adjusted, these variables were considered as confounding variables and were not included in the next model. The same procedure was used to estimate POR adjusted (95% confidence intervals) for DM (Seaman and White, 2013). In the final model we evaluated the risk of physical activity and obesity.

Results

The description of each study variable can be seen in table 1. Of the 5,260 respondents, the proportion of diabetes mellitus was 93.7%. The high proportion of DM in this study was due to diagnostic criteria using HBA1C so that many cases of DM were found. In this study also found the proportion of obesity was 49.1% and the proportion of insufficient physical activity was 40.8%.

Table 1. Distribution of Diabetes Mellitus Based on Other Variables

Variable	Non-Diabetes Mellitus		Diabetes Mellitus		Total	P Value	POR 95% CI
	n = 330	%	n = 4930	%			
Sex							
Female	145	5,4	2541	94,6	2686	0,009	1
Male	185	7,2	2389	92,8	2574		1,36 (1,08-1,69)
Age							
18-27	27	6,3	404	93,7	431	0,019	1
28-37	49	5,3	871	94,7	920		1,12 (0,73-1,93)
38-47	103	8,2	1149	91,8	1252		0,75 (0,48-1,12)
48-57	82	6,1	1261	93,9	1343		1,03 (0,66-1,61)
>57	69	5,3	1245	94,7	1314		1,21 (0,76-1,91)
Education							
High	123	6,5	1782	93,5	1905	0,724	1
Low	207	6,2	3148	93,8	3355		0,95 (0,76-1,20)
Marital Status							
Single	69	6,6	977	93,4	1046	0,332	1
Married	222	6,0	3479	94,0	3701		1,11 (0,84-1,46)
Divorced	39	7,6	474	92,4	513		0,86 (0,57-1,29)
History of TB							
No	326	6,2	4898	93,8	5224	0,392	1
Yes	4	11,1	32	88,9	36		1,87 (0,66-5,34)
Physical Activity							
Insufficient	172	8,0	1975	92,0	2147	<0,001	1
Sufficient	158	5,1	2955	94,9	3113		0,61 (0,49-0,77)
Obesity							
No	205	7,7	2471	92,3	2676	<0,001	1
Yes	125	4,8	2459	95,2	2584		1,63 (1,29-2,05)
Obesity+Physical Activity							
Not Obesity + Sufficient Physical Activity	81	5,2	1463	94,8	1544	<0,001	1
Not Obesity + Insufficient Physical Activity	124	11,0	1008	89,0	1132		0,45 (0,34-0,60)
Obesity + Sufficient Physical Activity	77	4,9	1492	95,1	1569		1,07 (0,78-1,48)
Obesity + Insufficient Physical Activity	48	4,7	967	95,3	1015		1,11 (0,78-1,61)

Table 2. Multivariate Analysis of Obesity and Physical Activity to Diabetes Mellitus

Variable	Non-Diabetes Mellitus n (%)	Diabetes Mellitus n (%)	Unadjusted			Adjusted*		
			POR	95%CI	P value	POR	95%CI	P value
Obesity								
Not Obesity	205 (7,66)	2471 (92,34)	1	1	0,000	1	1	0,000
Obesity	125 (4,84)	2459 (95,16)	1,63	1,29-2,05		1,74	1,38-2,00	
Physical Activity								
Sufficient Physical Activity	158 (5,1)	2955 (94,9)	1	1	0,001	1	1	0,001
Insufficient Physical Activity	172 (8,01)	1975 (91,99)	0,614	0,49-0,77		0,616	0,49-0,77	

* Note: Adjusted by age, sex, education, marital status, TB history

Table 3. Multivariate Analysis of Obesity and Physical Activity to Diabetes Mellitus

Combination of Obesity and Physical Activity	Non-Diabetes Mellitus	Diabetes Mellitus	Unadjusted			Adjusted*		
			POR	95%CI	P value	POR	95%CI	P value
Not Obesity + Sufficient Physical Activity	81	1463	1	1		1	1	
Not Obesity + Insufficient Physical Activity	124	1008	0,450	0,336-0,602	0,001	0,451	0,337-0,604	0,001
Obesity + Sufficient Physical Activity	77	1492	1,073	0,779-1,478	0,667	1,072	0,778-1,476	0,672
Obesity + Insufficient Physical Activity	48	967	1,115	0,773-1,609	0,559	1,551	0,775-1,613	0,551

*Note: Adjusted by age, sex, education, marital status, TB history

Based on table 2, obese people were at risk of developing DM 1.74 times compared to people who were not obese. In addition, it is known that physical activity can reduce DM by 38% with POR 0.616. Based on table 3, it can be seen that people who are not obese and lack physical activity will reduce their risk of developing diabetes mellitus by 55%. In the multivariate analysis it can be seen the highest risk of developing DM was in people with insufficient physical activity and obesity with POR 1,551 compared to those who have sufficient physical activity and obesity with POR 1,072. While the risk of DM in people who have less physical activity but were not obese provides a protective effect with POR 0.451. In this study can be seen if obesity was an important variable in causing DM because the protective effect will be if a person was not obese even though their physical activity is lacking. In addition, it can be seen that if a person was obese and physical activity is less, the risk is increased by 10% compared to people with obesity, but their physical activity was enough.

Discussion

The results of this study indicate that the risk of developing DM will increase by 1,551 times due to the interaction of obesity and insufficient physical activity compared to people with obesity alone and insufficient physical activity. In the results of multivariate analysis the increased risk of developing DM due to the interaction of obesity and insufficient physical activity can be calculated using the following equation:

- (1,551-1) = (1,072-1) + (0,451-1)
- 0,551 = 0,072 + (-0,549)
- 0,551 = 0,477
- 0,551 > 0,477
- 0,551-0,477/0,551 = 13,4%

Paramitha's study showed the results of the Pearson correlation test obtained p value=0.001 and the value of r = -0.433. This means there was a negative relationship between physical activity and blood glucose levels in patients with type 2 diabetes mellitus (Paramitha, 2014). Physical activity is any bodily movement produced by skeletal muscle that requires energy. Lack of physical activity was an independent risk factor for chronic diseases and overall was expected to cause death globally (WHO, 2013).

The effect of physical activity or exercise was directly related to the increase in the speed of muscle glucose recovery (how much muscle takes glucose from the bloodstream). When exercising, the muscles use glucose stored in the muscle and if glucose decreases, the muscle fills the void by taking glucose from the blood. This will result in a decrease in blood glucose, thereby increasing blood glucose control (Barnes, 2011).

In type 2 diabetes mellitus exercise plays a role in regulating blood glucose levels. The main problem in type 2 diabetes mellitus was the lack of a response to insulin (insulin resistance) so that glucose cannot enter the cell. Membrane permeability to glucose increases when muscles contract because muscle contraction has insulin-like properties. Therefore, during physical activities such as exercise, insulin resistance decreases. Physical activity in the form of exercise was useful as a control of blood glucose and weight loss in type 2 diabetes mellitus. The great benefits of physical activity or exercise in diabetes mellitus include lowering blood glucose levels, preventing obesity, contributing to overcoming complications, blood lipid disorders and increased blood pressure (Ilyas, 2011).

Study by Dolongseda et al showed that 93.3% of respondents with type 2 diabetes mellitus in the Internal Medicine Unit Pancaran Kasih Hospital in Manado had low physical activity with high blood glucose level. Based on statistical tests show that there is a significant relationship between physical activity and blood glucose levels.

Physical activity increases blood glucose control in type 2 diabetes, reduces cardiovascular risk factors, contributes to weight loss, and increases well-being (Chen et al, 2015; Lin et al, 2015). Regular exercise can prevent or delay the development of type 2 diabetes (Schellenberg et al, 2013). Regular exercise was also beneficial for the health of people with type 1 diabetes (eg improvement in cardiovascular fitness, muscle strength, insulin sensitivity, etc) (Yardley et al, 2014).

Challenges related to blood glucose management vary with the type of diabetes, type of activity, and the presence of diabetes-related complications (American Diabetes Association, 2016; Coldberg et al, 2010). Therefore, physical activity and exercise recommendations should be adjusted to meet the specific needs of each individual.

The results of this study were in line with the study of Nangge et al. Pearson chi-square results with a confidence level of 95% ($\alpha = 0.05$) obtained p value<0,001 which means there was a relationship between obesity and DM in the Ranomut Public Health Center, Manado.

Study by Sharah showed that someone who was obese has a significant relationship with DM which was 7.14 times greater than the normal BMI group, as well as study according to Sanjaya obese people have 2.7 times greater risk of developing DM than people who were not obese.

Increased obesity in Indonesia seen from BMI> 25 in women aged> 18 years has increased. In 2007 it amounted to 13.9%, then in 2010 amounted to 15.5% and in 2013 amounted to 32.9%, as well as in men in 2007 amounted to 13.9%, in 2010 it dropped to 7.8% and increased back in 2013 at 19.7% (Ministry of Health RI, 2013).

Obesity was a condition where a person's body has too high fat content. Too high fat levels in the body can cause various health problems. One of the risks faced by obese people was DM. According to some results of study on DM was very closely related to obesity. In patients with DM, the pancreas produces insulin in sufficient quantities to maintain blood glucose levels at normal levels, but insulin cannot work optimally to help body cells absorb glucose because it was disturbed by obesity complications, one of which was blood fat levels especially high cholesterol and triglycerides (Al-Goblan et al, 2014; Czech, 2017).

There was strong and consistent evidence that obesity management can delay the development of prediabetes into type 2 diabetes (Wilding, 2014) and may be useful in the treatment of type 2 diabetes. In overweight and obese patients with type 2 diabetes, slow and sustained weight loss has been shown to increase glycemic control and to reduce glucose drug use (Johansson et al, 2014). Weight loss-an induced increase in glycemia most likely to occur early in type 2 diabetes when obesity associated with insulin resistance has caused reversible beta cell dysfunction but insulin secretion capacity remains relatively good (Rothberg et al, 2014; Jackness et al, 2013).

This study used a cross sectional design so that the temporal relationship of exposure and

outcome might not be ascertained. In addition, the variables measured using the questionnaire were very dependent on honesty and respondent's memories, especially those related to physical activity variables. Measurement bias possibilities can also occur in the measurement of body weight and height caused by measuring instruments, but this occurs in all the population of study that was non-differential so that it can still be tolerated. These things were minimized by measuring using standardized questionnaires and measurements carried out by trained medical personnel and calibration of equipment before use.

Conclusions

The proportion of DM in Indonesia based on IFLS-5 data on HBA1C examination was 93.7%. In this study, the proportion of obesity and lack of physical activity was 49.1% and 40.8%. Multivariate analysis showed that the greatest risk for developing DM was in people with insufficient physical activity and obesity with POR 1,551 or the risk increased by 13.4% due to the interaction of obesity and insufficient physical activity.

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