

The Relationship Between Obesity and Physical Activity to the Incidence of Diabetes Mellitus in Ledug, Kembaran, Banyumas, Central Java

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Abstract— Diabetes mellitus (DM) is a disease caused by metabolic disorders that occur in the pancreas which are characterized by an increase in blood sugar or often referred to as hyperglycemia due to a decrease in the amount of insulin from the pancreas (American Diabetes Association, 2012). The most common type of diabetes mellitus is type 2 diabetes. Risk factors for diabetes mellitus include obesity and physical activity. This study aimed to determine the relationship between obesity and physical activity to the incidence of diabetes mellitus. A correlational analysis with a crosssectional approach was applied in this study. The sampling technique used was simple random sampling. The samples of this study were members of Chronic Disease Management Program (Prolanis) in Ledug, Kembaran, Banyumas in June 2019. The samples were 480 respondents determined by the Slovin's formula. The type of data was the primary data obtained from questionnaire as the measurement instrument. The data analysis used was univariate frequency distribution and bivariate analysis of Chi-Square and Kolmogorov Smirnov. The results showed that there was a relationship between obesity (based on BMI range) and the incidence of diabetes mellitus, but there was no relationship between physical activity and the incidence of diabetes mellitus.

Keywords: *obesity, physical activity, diabetes mellitus*

I. INTRODUCTION

Non-communicable diseases are the leading cause of death in the world. The WHO data shows that of the 57 million deaths occurred globally in 2008, 36 million or almost two-thirds were caused by non-communicable diseases. More than two-thirds (70%) of the world's population will die from non-communicable diseases such as cancer, heart disease, stroke, and diabetes. The prevalence of non-communicable diseases in 2018 increased compared to the previous data in 2013, including cancer, stroke, chronic kidney disease, diabetes mellitus, and hypertension. Based on blood glucose tests, diabetes mellitus has risen from 6.9% to 8.5%. The increase in the prevalence of noncommunicable diseases is related to lifestyles, such as physical activity, and consumption of fruits and vegetables [1]. One of non-communicable

diseases that deserves attention is diabetes mellitus, a disease caused by metabolic disorders that occur in the pancreas which is characterized by an increase in blood sugar or often referred to as hyperglycemia due to a decrease in the amount of insulin from the pancreas [2]. The most common type of diabetes mellitus is type 2 diabetes. Diabetes mellitus is associated with morbidity and mortality in community. In addition, diabetes mellitus is associated with chronic progressive damage to the main organs, and some other organs are also at risk of problems due to diabetes mellitus such as corneas [3].

Diabetes mellitus can be prevented by knowing the risk factors [4]. Risk factors for diabetes mellitus are divided into two. First, reversible risk factors include dietary patterns, daily living patterns, sleep patterns, physical activity patterns, and stress management. Second, irreversible risk factors include age, gender, and genetic family history/genetic factor of diabetes [5]. Risk factors for type 2 diabetes mellitus are genetic and environmental factors. Genetic factors consist of family history and ethnicity/race, while environmental risk factors include age, obesity, food/nutritional factors and lack of physical activity [6].

The prevalence of diagnosed type 2 diabetes was 8.6%, representing 21.0 million adults in the United States. NonHispanic blacks were the highest prevalence of diagnosed type 2 diabetes. The estimated prevalence of diagnosed type 2 diabetes increased with age and decreased with higher levels of educational attainment [7]. The mean *Body Mass Index* (BMI) of diabetic respondents represents class I obesity, thus it is suggested to consume healthy food and do aerobic exercise to prevent complications [8]. Gillani (2018) in a journal of "Predicting the relationship of eating behavior, physical activity and smoking with type II diabetes and related comorbidities among Saudis: cross-sectional observational studies" stated that of 785 participants (72.55%) consisting of 436 (55, 54%) vs 349 (44.56%); male vs female; $p > 0.05$) had insufficient physical activity [9]. Previous studies have different results. Some state that there was a relationship and vice versa. In 2019, people in Ledug, Kembaran, Banyumas, Indonesia, have administered 3 Chronic Disease Management programs (Prolanis), and about 600 of 12,000 Ledug villagers in total have become members. The percentage of people with diabetes mellitus has reached 50% of the total. It is believed that they have type 2 diabetes mellitus after being diagnosed by a doctor, and most of them do not pay attention to the risk factors

associated with diabetes mellitus. Based on the problems, this study aimed to investigate the relationship among respondents' characteristics, obesity, and physical activity to the incidence of diabetes mellitus.

II. MATERIALS AND METHODS

A correlational analysis was applied to analyze relationship among variables. The variables in this study were obesity, physical activity, and the incidence of diabetes mellitus. A cross-sectional approach, a study of correlation between risk factors and effects to an approach, observation or data collection at a particular time was applied [10]. The population in this study was 600 members of Chronic Disease Management Programs (Prolanis) in Ledug, Kembaran, Banyumas, Central Java. This study was conducted in June 2019. The technique used was simple random sampling in which the researchers selected the samples randomly without considering their strata of the population. Simple random sampling is a technique to obtain samples carried out directly in the sampling unit [12]. The inclusion criteria were *prolanis* members in Ledug, Kembaran, Banyumas, in June 2019. The exclusion criteria were respondents who were not cooperative and they refused to be the researchers' respondents. The minimum number of samples determined by the Slovin's formula was about 240 people. The samples included 240 diabetics and 240 nondiabetics respondents selected using the "random number" method and thus the samples were 480 respondents in total.

The researchers used questionnaires as the primary data and the questionnaires contained some information such as name, age, level of education, employment status, obesity, and physical activity. Univariate analysis was performed to find out the percentage of each variable. Moreover, bivariate analysis was used to determine the relationship among respondent characteristics (age, level of education, and employment status), obesity, and physical activity to the incidence of diabetes mellitus. The data were measured using the Chi-Square and Kolmogorov-Smirnov test.

III. RESULTS

Most of diabetes mellitus respondents were in the category of elderly (41-65 years) (240 people, 100%), of primary education (160 people, 66,7%), and of unemployed (141 people, 58,8%) (Table 1). Besides, most of respondents did not have any family history of diabetes mellitus (192 people, 80%), but their dietary patterns

caused a risk of diabetes mellitus (71 people, 71,2%) (Table 2).

Elderly respondents (41-64 years) were likely to suffer from diabetes mellitus while the adults (18-40 years) did not have a tendency for diabetes mellitus. The result showed a significant relationship between age and the incidence of diabetes mellitus (p-value of 0,000 < 0,05). The contingency coefficient (0,637) showed a strong relationship between age and the incidence of diabetes mellitus.

Respondents with primary education had a tendency for diabetes mellitus while the respondents with tertiary education were not likely to have diabetes mellitus. The result showed a significant relationship between education and the incidence of diabetes mellitus (p-value of 0,000 < 0,05).

Unemployed respondents dealt with diabetes mellitus but employed respondents had a tendency for diabetes mellitus. The result showed a significant relationship between employment status and the incidence of diabetes mellitus (p-value of 0,04 < 0,05). The contingency coefficient (0,130) showed a very weak relationship between employment status and the incidence of diabetes mellitus.

Non-obese respondents were likely to have diabetes mellitus while obese respondents obviously had diabetes mellitus. The result showed that there was a significant relationship between obesity and the incidence of diabetes mellitus (p-value 0,000 < 0,05). The contingency coefficient (0,360) showed that there was a weak relationship between obesity and the incidence of diabetes mellitus.

Respondents with light physical activity could have diabetes mellitus, but they could also be free of diabetes mellitus. The result shows that there was no relationship between physical activity and the incidence of diabetes mellitus (p-value 0,637 > 0,05). The contingency coefficient (0,022) showed that there was very weak relationship between physical activity and the incidence of diabetes mellitus (Table 3).

Table 1. Frequency distribution of diabetes mellitus respondents' characteristics

Category	Diabetics		Non-Diabetics	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Age				
Adolescence	0	0.0	0	0.0
Adult	0	0.0	195	81.2
Elderly	240	100.0	45	18.8
Total	240	100.0	240	100.0

Level of Education				
Primary	160	66.7	69	28.8
Secondary	74	30.8	11	4.6
Tertiary	6	2.5	160	66.7
Total	240	100.0	240	100.0
Employment Status				
Unemployed	141	58.8	171	71.2
Employed	99	41.2	69	28.8
Total	240	100.0	240	100.0

Table 2. Frequency distribution of obesity and physical activity of diabetes mellitus respondents

Category	Diabetics		Non-Diabetics	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Obesity				
No	103	42.9	193	80.4
Yes	137	57.1	47	19.6
Total	240	100.0	240	100.0
Physical Activity				
Light	198	82.5	194	80.8
Moderate	42	17.5	46	19.2
Vigorous	0	0.0	0	0.0
Total	240	100.0	240	100.0

Table 3. The Relationship among respondents' characteristics (age, level of education, employment status), obesity, and physical activity to the incidence of diabetes mellitus

Category	Non-Diabetics		Diabetics		Total		p value	CC
	F	%	F	%	F	%		
Age							0.000	0.637
Adolescence	0	0.0	0	0.0	0	0.0		
Adult	195	40.6	0	0.0	195	40.6		
Elderly	45	9.4	240	50	285	59.4		
Total	240	50	240	50	480	100.0		
Level of Education							0.000	-
Primary	69	14.4	160	33.3	229	47.7		
Secondary	11	2.3	74	15.4	85	17.7		
Tertiary	160	33.3	6	1.2	166	34.6		
Total	240	50	240	50	480	100.0		
Employment Status							0.04	0.130
Unemployed	171	35.6	141	29.4	312	65		
Employed	69	14.4	99	20.6	168	35		
Total	240	50.0	240	50.0	480	100.0		
Obesity							0.000	0.360
No	193	40.2	103	21.5	296	61.7		
Yes	47	9.8	137	28.5	184	38.8		
Total	240	50.0	240	50.0	480	100.0		

Physical Activity							0.637	0.022
Light	194	40.4	198	41.2	392	81.7		
Moderate	46	9.6	42	8.8	88	18.3		
Vigorous	0	0.0	0	0.0	0	0.0		
Total	240	50	240	50	480	100.0		

IV. DISCUSSION

A. Relationship Between Age and Diabetes Mellitus

The results showed that elderly respondents (41-64 years) were likely to suffer from diabetes mellitus while the adults (18-40 years) did not have a tendency for diabetes mellitus. Age had a relationship with the incidence of diabetes mellitus (p value $0,000 < 0,05$). The contingency coefficient (0,637) showed a strong relationship between age and the incidence of diabetes mellitus. The result showed that most of diabetes mellitus respondents were elderly (41-65 years) (240 people, 100%).

In line with Kurniawaty's research (2016), age increases the incidence of type 2 diabetes mellitus. People aged ≥ 45 years could have 9 times risk of type 2 diabetes mellitus compared to those aged less than 45 years and it was statistically significant (p -value = 0,000 and odds ratio/ OR of 9.3) [12]. Nur et. al. (2017) mentioned that chances of developing diabetes increase up to 2,16 times greater especially for people aged > 50 years [13]. Supported by Trisnawati's research (2013), people aged ≥ 50 could develop the incidence of type 2 diabetes mellitus because aging causes decreased insulin sensitivity and decreased body function for glucose metabolism [14].

The risk of having diabetes mellitus up to 4,568 times increases as people age compared to younger people. Age has a big role in the incidence of diabetes mellitus. As age increases, the ability of tissues to take blood glucose decreases so that the possibility of developing diabetes mellitus increases [15]. Age is a major factor in the increase in diabetes prevalence and impaired glucose tolerance. It is also stated that age is a factor in adults in which increasing age can decrease the ability of tissues to take blood glucose. This disease is more common in people aged over 40 years than in younger people [5].

On the other hand, Nur's research (2016) stated that most diabetic patients under 46 years old were included in adults. This research showed that there was a shift in the age of diabetes mellitus [16]. Diabetes mellitus can occur at a younger age (under 46 years). In her research, people aged 20-59 years were at risk of diabetes mellitus (8,7%) [17].

B. The Relationship Between Level of Education and Diabetes Mellitus

The results showed that respondents with primary education had a tendency to develop diabetes mellitus while respondents with tertiary education did not have diabetes mellitus. Therefore, education had a significant relationship with the incidence of diabetes mellitus (p -value $0,000 < 0,05$). The result showed that most of respondents were in primary education of 160 people (66,7%). It indicates that respondents have less information about the factors and prevention of diabetes mellitus.

In line with Handayani's research (2018), 94% of respondents with type 2 diabetes mellitus were in the lower education [18]. Gandini (2015) mentioned that there were 64% of diabetes mellitus patients with secondary education. This relates to one's level of understanding of the illness and its prevention [19]. Pradana (2015) stated that most diabetes mellitus patients with lower education are not compliant with the pharmacological therapy of diabetes mellitus [17].

On the contrary, Nur's research (2016) reveals that there was no significant relationship between education and blood glucose levels in patients with diabetes mellitus. The result showed that most of diabetes mellitus patients were in secondary education. The level of education does not directly affect the onset of diabetes mellitus. However, it affects dietary patterns/food selection [13].

C. The Relationship Between Employment Status and Diabetes Mellitus

The results showed that unemployed could suffer from diabetes mellitus. Employment status had a significant relationship with the incidence of diabetes mellitus (p value $0,04 < 0,05$). The contingency coefficient (0,130) showed a very weak relationship between employment status and the incidence of diabetes mellitus. The result showed that most of respondents were unemployed (141 people, 58,8%).

In line with Mahmud's research (2017), it is found that there was a significant relationship between employment status and diabetes mellitus [20]. Unlike Mahmud's research, Nur (2016) argued that there was no significant relationship between employment status and blood glucose levels in patients with diabetes mellitus [13]. In reference to Isnaini's research (2018), there was no significant relationship between employment status and the incidence of diabetes mellitus. The variables of occupations were related to physical activities and sports. Unemployed people (e.g. housewives) do some activities at home such as washing, cooking, cleaning the house and doing many other activities that require energy [21].

Those who do not work (e.g. housewives, unemployment, and retirees) can reduce their physical activity patterns. Unemployed people have lack of body movements and can be a trigger for obesity. This will cause insulin resistance. This situation causes body tissues less sensitive to the effects of insulin. Thus, sugar in the blood is not allowed to leave blood and enter cells [22].

D. The Relationship Between Obesity and Diabetes Mellitus

The results showed that non-obese respondents did not tend to suffer from diabetes mellitus, but obese respondents did. Therefore, there was a significant relationship between obesity and the incidence of diabetes mellitus (p value 0,000

$< 0,05$). The contingency coefficient (0,360) showed that there was a weak relationship between obesity and the incidence of diabetes mellitus. The data revealed that most of diabetes mellitus respondents were overweight (137 people, 57,1%).

In line with Fadila's research (2016), 68% of female patients with type 2 diabetes mellitus in Kardinah Regional Hospital were obese [23]. Moreover, Nangge (2018) stated that on average respondents were categorized as obese and there was a relationship between obesity and the incidence of diabetes mellitus [24]. Being overweight and obese causes abnormal glucose metabolism, which is strongly associated with the increase in insulin resistance. Obesity can trigger changes in the body's metabolism that causes fatty tissue (adipose) to release more fatty acids, glycerol, hormones, inflammatory cytokines, and other factors that trigger the development of insulin resistance [25].

Wardiah (2018) stated that BMI in obese range could have 3,340 times risk of diabetes mellitus compared to that in the non-obese range [15]. Obesity causes a reduction in the number of insulin receptors inside cells in skeletal muscle and fatty tissue. Obesity also damages beta cells to release insulin when there is an increase in blood glucose [26]. In this case, blood vessels of overweight people are already filled with fat, and insulin is blocked and cannot be absorbed into tissue cells, therefore, it causes high blood sugar level [27].

Handayani (2018) stated that there was a significant relationship between obesity and the incidence of type II diabetes mellitus, and obese respondents could have 4,529 times risk of type II diabetes mellitus compared to nonobese respondents [18]. Asmarani (2017) stated that there was a significant relationship between the variables of obesity and the incidence of type 2 diabetes mellitus, and obese respondents could have 7,164 times risk of type 2 diabetes mellitus compared to non-obese respondents with BMI of $<25 \text{ kg/m}^2$ [28].

Obesity is a predisposing factor for insulin resistance. It describes that the more the fatty tissue in the body, the more resistance the body to the action of insulin, especially if fat is in the central area or abdominal area (central obesity). At this point, fat can block the action of insulin and thus glucose cannot be transported into cells but it accumulates in blood vessels, hence an increase in blood glucose levels [29].

Kurniawaty (2016) argued that obesity (based on BMI range) could not increase the incidence of type 2 diabetes. Nutritional status of overweight could have a risk 2 times of developing type 2 diabetes compared to people having normal nutritional status but not statistically significant [12]. Nur (2016) stated that there was no significant relationship between BMI and blood glucose levels [13]. Rahayu (2018) also clarified that there was no relationship between obesity status and blood sugar levels because most of respondents were obedient in consuming medicine to control their blood sugar levels [30].

Trisnawati (2013) stated that obesity (based on BMI range) could not increase the incidence of type 2 diabetes. Respondents aged ≥ 50 years (elderly) both in case or control groups, both exposed and not exposed to risk factors were higher in obesity problem than those aged < 50 years [14]. Based on BMI, obesity is determined by the body shape and proportion, therefore, it may not necessarily

provide the same obesity in all populations, especially in the elderly and in athletes with muscle mass [31].

E. The Relationship Between Physical Activity and Diabetes Mellitus

The results showed that respondents with light physical activity were not likely to have diabetes mellitus. Physical activity had no relationship with the incidence of diabetes mellitus (p value $0,637 > 0,05$). Most of diabetes mellitus respondents (198 people, 82,5%) had light activity. In this study, most of unemployed respondents (41-65 years) did not have any intense or vigorous activities. As age increases, respondents became less active and tend to do light physical activities.

Supported by Dolongseda (2017), type 2 diabetes mellitus patients had light activity (96%) and moderate activity (4%) (Dolongseda et al., 2017). Nuraini (2016) also stated that there was no relationship between physical activity and type 2 diabetes mellitus [33]. Gillani (2018) explained that there was a strong inverse correlation between the level of physical activity (leisure) and type 2 diabetes mellitus ($p = 0,022$) [9].

Physical activity is a circadian rhythm in humans. Each individual has a unique rhythm in carrying out their activities especially for work, food, rest, recreation and others. To meet these needs, coordination, protection, and efficiency are needed to produce good movements and maintain balance during activities [34].

Fadilah (2016) stated that 55% of patients had sufficient activity and 45% of type 2 diabetes mellitus female patients in Kardinah Regional Hospital did less activity. It can be concluded that both people with insufficient or sufficient activity can suffer from diabetes mellitus [23]. Nur (2016) clarified that there was no significant relationship between physical activity and exercise with blood glucose levels [16]. Rahayu (2018) found similar results showing that there was no relationship between the level of physical activity and blood sugar levels [30].

Trisnawati (2013) argued that people who do not perform physical activity could not increase the risk of type 2 diabetes mellitus due to their daily physical activities (e.g. walking to the market, hoeing, washing, and gardening) [14]. Handayani (2018) explained that there was no significant relationship between physical activity and the incidence of type II diabetes mellitus, and physical activity is a protective factor (protecting) that can reduce the risk of the incidence of type II diabetes mellitus [18].

On the other hand, Nurayati (2017) stated that there was a relationship between physical activity and fasting blood sugar levels of respondents with type 2 diabetes [35]. Widodo (2016) also found out the same result that there was a significant relationship between physical activity and blood sugar levels [36]. Hariawan (2014) argued that most of respondents with type 2 diabetes perform light physical activity leading to the risk factors for diabetes mellitus [37]. Sundari (2016) also believed that activity indicated a significant but weak correlation between the incidence of type 2 diabetes mellitus and physical inactivity as a highrisk factor for the incidence of type 2 diabetes mellitus [38].

Kurniawaty (2016) stated that regular physical activity increases insulin sensitivity and glucose tolerance. Recent prospective studies have also shown that physical activity

was associated with a reduced risk of type 2 diabetes. Furthermore, there was a risk gradient of increased physical activity. The relationship between physical inactivity and diabetes mellitus was still visible, even after adjusted with obesity, hypertension, and family history of type 2 diabetes. Thus, exercise has a protective effect to lose weight by increasing one's physical activity. People who do exercise (< 3 times/week for 30 minutes) could have a higher risk of developing diabetes mellitus than those who do regular exercise [12].

Light physical activity or lack of movements results in an energy imbalance showing a difference between energy intake and energy expenditure. At rest, muscle metabolism only requires little glucose in the blood as an energy source, while in physical activities (physical exercise/sports), muscles need blood glucose and fat as the main energy source [39]. Physical activity is directly related to the speed of recovery of glucose in muscles. As physical activity is carried out, glucose in muscles decreases [40].

V. CONCLUSION

This study revealed that there was a relationship between respondents' characteristics (age, level of education, employment status) and obesity to the incidence of diabetes mellitus. However, there was no relationship between physical activity and diabetes mellitus. Health workers should provide appropriate information and education to the community about diabetes mellitus such as improving lifestyles, managing dietary patterns, and exercising regularly. Taking regular diabetes mellitus screening checks is also important.

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