The Correlation Between Physical Activity, Body Mass Index (BMI), and Abdominal Circumference with Type 2 Diabetes Mellitus (DM) Cases at Public Health Center Dinoyo Malang

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Abstract— **Diabetes Mellitus (DM) is the top 10 disease with highest patients in Indonesia and the highest prevalence is in East Java Province. Dinoyo Public Health Center was one of the most recipients of patients in 2018 with total of 10,355 Type 2 Diabetes Mellitus patients aged 40-69 years old. The modifiable risk factors for Type 2 Diabetes Mellitus include physical activity, body mass index (BMI), and abdominal circumference. This study aims to determine the correlation between physical activity, BMI, and abdominal circumference with Type 2 Diabetes Mellitus at Dinoyo Public Health Center Malang. This study is a quantitative study with cross sectional approach as correlational study method. The sample of this study were patients aged more than 40 years old at Dinoyo Public Health Center. Based on the analysis of bivariate test using the chi square test, there was the correlation between physical activity, body mass index (BMI), and abdominal circumference with Type 2 Diabetes Mellitus (DM) at Public Health Center Dinoyo Malang. According to multiariate test using the BMI regression test, it was found that BMI had eight times greater effect on triggering Type 2 Diabetes Mellitus at Dinoyo Public Health Center Malang.**

Keywords— *physical activity, BMI, abdominal circumference, Diabetes Mellitus.*

I. INTRODUCTION

Diabetes Mellitus (DM) is a chronic metabolic disorder due to the pancreas cannot be able to produce sufficient insulin or the body unable to use insulin effectively [1]. This disease still threatens public health around the world. Based on data in 2012 that around 1.5 million people worldwide have lost their lives due to diabetes [2]. Indonesia is the fourth country with the highest prevalence of DM in the world [3]. Diabetes is the top 10 of most common diseases in Indonesia and the highest prevalence is in East Java Province [4].

DM risk factors are divided into two factors, namely modified and cannot be modified [5]. Modifiable risk factors for Type 2 Diabetes Mellitus may worsen include obesity, physical inactivity, hypertension, dyslipidemia, and an unhealthy diet or high sugar and low fiber diet [6]. Obesity is closely related to BMI and affects abdominal circumference [7]. It is due to the lack of physical activity and unbalanced diet [7].

Obesity is a pathological condition with metabolic changes due to insulin resistance [5]. Controlling obesity can be done by measuring abdominal circumference[8]. Abdominal circumference or central obesity is dangerous accumulation of fat in the abdomen due to the adipocyte in this area is efficient and more resistant to insulin efffect than other parts of body [9]. The way of controlling blood sugar for diabetes patients is physical activity [10]. This physical activity plays role in controlling blood sugar by converting glucose into energy [11].

The cases of Type 2 Diabetes Mellitus in Malang, 2018 from January to September, the total number of Type 2 Diabetes Mellitus patients was 10,355 people of 40-69 years [12]. The public health center that handle many cases of Type 2 Diabetes Mellitus is Dinoyo Public Health Center, Kedungkandang Public Health Center, and Janti Public Health Center with 1,800 patients in average [12]. The high prevalence of DM proves that DM is a serious problem in the public health sector [13]. The risk factor is one of the correct preventive measures to reduce the prevalence of Type 2 Diabetes Mellitus patients [9]. Based on the background of problem above, the writer is interested to discuss about the correlation between physical activity, body mass index (BMI), and abdominal circumference with Type 2 Diabetes Mellitus (DM) at Public Health Center Dinoyo Malang.

II. METHOD

The study design is a quantitative study with a cross sectional approach as correlational study method. The correlational study method aims to determine whether there is a tendency for the correlation between one variable to another [14]. Cross sectional is a study design that obtain study variables at the same time [15].

Cross sectional is the epidemiological study design about the correlation between disease and its impact by observing the status of impact and disease at the same time [16]. The

dependent variable of this study was diabetes mellitus, while the independent variables in this study were physical activity, BMI, and abdominal circumference. The sampling technique used in this study is quota sampling. Quota sampling is a sampling technique by grouping the target population into categories then giving the quota of subjects for each stratum [16].

The sample required in this study is 73 samples. Consisting of people whose age over 40 years-old, the strata is divided into three categories with span of 10 years to classify age category easier. Bivariate analysis was used to test the related variables [17]. This study used the chi square test, because the data scale of this study was ordinal and nominal and included in the non-parametric statistical category. Multivariate analysis is the correlation between physical activity, BMI, and abdominal circumference with Diabetes Mellitus cases in which regression test used in multivariate analysis of this study.

III. RESULT

The following are the univariate results of this study.

TABLE I.   FREQUENCY DISTRIBUTION

Variable	Total	
	N (N=73)	%
Education		
Elementary School	13	17.8
Junior High School	15	20.5
Senior High School	26	35.6
College	19	26.0
Age		
40-49	20	27.4
50-59	20	27.4
>60	33	45.2
Sexes		
Male	30	41.1
Female	43	58.9
DM Type 2		
Yes	43	58.9
No	30	41.1
Physical Activities		
Light	39	53.4
Medium	29	39.7
Heavy	5	6.8
IMT		
Skinny	8	11.0
Normal	27	37.0
Fat	38	52.1
Stomach Circle		
Yes	47	64.4
No	26	35.6

Based on data presentation in Table I, the education characteristics are divided into four, namely primary school, secondary school, high school, and university with the largest percentage in high school with 35% and the lowest percentage with 17.8 % in primary schools. Respondents' ages were divided into three stratums. 20 respondents are 40-49 years old, 20 respondents are 50-59 years old, and 33 respondents are over 60 years old. Meanwhile, based on gender, the majority of respondents were women with percentage of 58.9 %.

There are 43 out of 73 respondents or more than 50% suffered from Type 2 Diabetes Mellitus. The highest physical activity was respondents with low physical activity with percentage of 53.4% and the lowest of physical activity was 6.8% of respondents with intense physical activity. The majority of respondents are fat category in BMI with percentage of 52.1 %, 37% of them are normal, and 11% of them are thin. There are 47 respondents exceeded the specified standard and 26 respondents did not exceed the specified abdominal circumference standard.

The following table describe three chi square tests, namely the correlation between physical activity and the cases of Type 2 Diabetes Mellitus, the correlation between BMI and the cases of Type 2 Diabetes Mellitus, and the correlation between abdominal circumference and the cases of Type 2 Diabetes Mellitus as follows:

TABLE II.   THE CORRELATION BETWEEN PHYSICAL ACTIVITY AND DM TYPE 2 OCCURANCE

Physical Activities	Occurrence of DM Type 2				Total		OR (CI 95%)	p-value
	No	%	Yes	%	N	%		
PAL 1.40-1.69	9	30.0	30	69.8	39	100	5.385 (1.948-14.881)	0.001
PAL 1.70-2.40	21	70.0	13	30.2	34	100		
Total	30	100	43	100	73	100		

Based on table above, the *p-value is* 0.001 < 0.05, this means that there is significant correlation between physical activity and the cases of Type 2 Diabetes Mellitus at Dinoyo Public Health Center. Meanwhile, the value of OR = 5,385 with confidence interval of 1,948 < OR < 14,881. Therefore, low physical activity respondents with PAL 1.40-1.69 have the smallest risk of 1,948 times and the highest risk is 14,881 times to have Type 2 Diabetes Mellitus. The data above also shows that 30 out of 39 respondents are suffer from Type 2 Diabetes Mellitus.

TABLE III.   THE CORRELATION BETWEEN IMT AND OCCURANCE OF DM TYPE 2

IMT	Occurrence of DM Type 2				Total		OR (CI 95%)	p-value
	No	%	Yes	%	N	%		
≤ 25,0	23	76.7	12	27.9	35	100	0.118 (0.040-0.346)	0.000
≥ 25,1	7	23.3	31	72.1	38	100		
Total	30	100	43	100	73	100		

The table above shows *p-value* of 0.000 < 0.05, so it can be concluded that there is significant correlation between BMI and the cases of Type 2 diabetes. The OR value is 0.118 or can be read as 1/0.118 which is equivalent to 8,474, with confidence interval 0.040 < OR < 0.346. This indicates that people with BMI ≥ 25.1 (overweight/obese) have eight times risk of Type 2 Diabetes Mellitus. Based on the table above, the respondents with Type 2 Diabetes Mellitus are 43 people and 38 people are overweight, it means that 72.1%

were Type 2 diabetes patients at Dinoyo Public Health Center Malang.

Stomach Circle	Occurance of DM Type 2				Total		OR (CI 95%)	p-value
	No	%	Yes	%	N	%		
Yes	14	46.7	33	76.7	47	100	3.771 (1.377-10.329)	0.008
No	16	53.3	10	23.3	26	100		
Total	30	100	43	100	73	100		

The test results of chi square in Table IV shows that the p-value of 0.008 while the OR value of 3.771. *P-value* smaller than the value $\alpha = 0.05$ means that there is significant correlation between abdominal circumference with cases of Type 2 Diabetes, while the OR value among the confidence interval values is $1.377 < OR < 10.329$. Therefore, the abdominal circumference of more than 80 for women and 90 for men, the risk is lowest risk two times and the highest risk is up to ten times. The table above show that there are 47 people with excess abdominal circumference and 33 of them suffer from Type 2 Diabetes at Dinoyo Public Health Center Malang.

This following table describe the correlation between three independent variables, namely physical activity, BMI, and abdominal circumference with the cases of Type 2 Diabetes at Dinoyo Public Health Center Malang.

		B	Sig.	Exp (B)	95% CI for Exp (B)	
					Lower	Upper
Step 1	Physical Activity	1.694	0.005	5.441	1.688	17.542
	IMT	-1.827	0.007	0.161	0.043	0.607
	Stomach Circle	0.552	0.426	1.737	0.446	6.765
Step 2	Physical Activity	1.640	0.005	5.153	1.633	16.266
	IMT	-2.103	0.000	0.122	0.038	0.389

The multivariate result in Table V indicates that there are two of the most determiner variables as the risk factors of Type 2 Diabetes Mellitus. The variables are physical activity and BMI. Comparing both variables, BMI shows 0.122 times higher risk or 1/0.122 that is equivalent to 8,197 times higher risk to have Type 2 Diabetes Mellitus with OR between confidence interval score $0.038 < OR < 0.389$, while BMI variable is 5.153 times of risk to Type 2 Diabetes Mellitus.

IV. DISCUSSION

The Correlation between Physical Activity and Cases of Type 2 DM

Based on findings, there is significant correlation between physical activity and the cases of type 2 diabetes mellitus at Dinoyo Publiv Health Center. It is supported with previous study about physical activity had significant correlation with the cases of type 2 diabetes, with *p-value* of 0.001 [18]. Physical activity plays role in reducing the development of type 2 diabetes about 30-50%.

This study has 33 respondents aged over 60 as majority respondents who suffer from type 2 diabetes. These respondents face difficulties. Physical activity makes insulin work effectively and helps strengthen heart [10].

Physical activity is the most important component of healthy lifestyle. Regular physical activity helps to maintain normal blood glucose level and reduces the risk of type 2 diabetes. Different types of physical activity can be helpful to react against the risk of type 2 diabetes and reduce the death risk for patients with type 2 diabetes [19].

The finding shows that the most respondents with low physical activity have PAL 1.40 to 1.69, 39 people out of 73 respondents. Based on questionnaire, the most respondents did activities such as watching TV and sitting. This is supported by previous study about sitting in long period and not doing physical activity will cause accumulation of calories which can lead to insulin resistance [20]. The women with type 2 diabetes are people with with fewer steps per day and other physical activities [21].

The correlation between BMI and the cases of Type 2 DM

In this study, the *p-value* is 0.000, which was smaller than *a-value,* namely 0.05, so there was significant correlation between BMI and the cases of type 2 diabetes. Moreover, if the higher BMI, the higher blood sugar level. This study is relevant with the study of Adnan, et al. (2013) that there is a significant correlation between BMI and type 2 DM at Tugurejo Hospital Semarang with *p-value* 0.000. High BMI has double greater risk of type 2 diabetes. compared to low BMI.

BMI is a simple measuring tool for monitoring the nutritional status of adults. BMI is also a simple index used to classify a person's underweight, normal, overweight, and obese [22]. Obesity will make the higher risk of degenerative diseases, one of them is DM [23].

This study is supported by other research which has 30,133 respondents aged over 15 years old [24]. The results of chi square analysis is p-value of 0.0001 which has risk to diabetes mellitus of 3.378 times compared to people who are not overweight. Moreover, obesity is one of predisposing factors that improve blood sugar as DM indicator [24].

Generally, obesity is one of causes that improve risk of type 2 diabetes [25]. In this study, respondents who had a BMI ≥ 25.1 were 38 people and 72. 1% had type 2 diabetes. Normal BMI had 2.07 times risk to DM compared to those who were thin [26]. Meanwhile, respondents with excess BMI have a 3.7 times risk to diabetes, and also one kilogram of body weight can improve the risk of diabetes by 4.5 % [26]. The worst the obesity, the greater the risk to have DM. The negative impact of obesity is insulin resistance, which is the inability of insulin to produce normal biological functions or the degradation of insulin sensitivity. This is indicated by improvement in the amount of fasting insulin that improve blood glucose levels. Obesity in society is related to insulin resistance and DM.

The Correlation between Abdominal Circumference and the Cases of Type 2 Diabetes

The findings shows that there is significant correlation between abdominal circumference and the cases of type 2 diabetes at Dinoyo Public Health Center. *P-value* of 0. 008 is smaller than the value of $a = 0.05$, so that Ha Ho accepted and rejected. This study is relevant with previous studies which had *p-value* of 0.023 that less than 0.05, which indicates the correlation between abdominal circumference and blood sugar levels for adult people with high risk of type 2 diabetes [27]. This is supported by OR of 8,419, which means that people with excess waist circumference will have eight times risk to type 2 diabetes.

The Waist to Hip Ratio has positive correlation value with p-value of 0.005 [28]. This study shows that central obesity or accumulation of body fat in the stomach is very dangerous because adipocytes in abdominal area are efficient and more resistant to insulin than adipocytes in other areas. Excess abdominal circumference is a risk factor that can improve insulin resistance.

Insulin resistance is initial phase of metabolic abnormality until glucose intolerance occurs. It is this pancreatic cell failure that causes inadequate insulin secretion. Therefore, there was a transition from insulin resistance to diabetes. The causes of high abdominal circumference include lifestyle, diet, and inactivity. Moreover, there are factors of age and genetic factors [29]. The findings are consistent to theory that abdominal fat is the most dangerous fat. There are 47 out of 73 respondents in this study had excess abdominal circumference.

Central obesity based on abdominal circumference play active role as risk factor for diabetes [30]. Farida states that central obesity is one of metabolic syndrome. The metabolic syndrome is collection of symptoms that improving the risk of cardiovascular disease and diabetes. The metabolic syndrome can occur to one out of five people and its prevalence higher based on age.

The Correlation between Physical Activity, BMI, and Abdominal Circumference with Type 2 DM

The multivariate test results used logistic regression test. In this study, the results obtained from the previous bivariate test that three variables in this study impact on the cases of Type 2 diabetes mellitus in Dinoyo Public Health Center Malang. These three variables are candidates for logistic regression test.

The first logistic regression test of abdominal circumference has significance value of more than 0.05, which is equal to 0. 426. This study is supported by previous study which shows that no significant correlation between central obesity and the cases of Type 2 diabetes in Janti Public Health Center [30]. The results of chi square test showed that p-value = 0.851 which was greater than 0.05. It happened due to the average abdominal circumference is not more than the normal standard for both men and women, 86 cm for men and 80 cm for women [30].

The next test has result on significance value of 0.005 physical activity and BMI of 0.000. Moreover, the OR value of 5.153 for physical activity and 0.12 for BMI. Physical activity is only five times smaller than BMI with eight times risk, this is due to the most of respondents are elderly and housewives who have less mobility. Having rest is important role for health, but for patients with DM, it is an inhibitor of hypoglycemia [31].

The results of the multivariate analysis of three factors, the BMI variable is 0.12 times greater or 1/0.122 which is equivalent to 8.19 times greater risk of Type 2 diabetes. The findings also show the OR value between the internal values confidence $0.038 < OR < 0. 389$ with significance value of 0.000 [32]. Excess BMI is due to low physical activity and high consumption of carbohydrates, protein, and fat. It impacts to the improvement of fatty acids or Free Fatty Acid (FFA) in the cells. The higher fatty acids, the lower the translocation of glucose transporter to the plasma membrane and causes insulin resistance in adipocytes muscle tissue [32].

Obesity is the risk factor for type 2 diabetes. Excessive and continuous intake of nutritional foods without balanced physical activity causes fat accumulation [33]. Moreover, some influence factors of the cases of Type 2 DM include age, genetic, and gender.

In this study, 30 respondents suffered from excessive BMI. This study is supported by a study in the United States that among 11,400 women, there are women with BMI of 22-26. 9 kg/m^2, the risk of suffering from Type 2 diabetes is eight times greater and this risk will improve 40 times greater for woman with BMI > 31 kg/m^2 [34].

V. CONCLUSION

1. There is significant correlation (*p*-value = 0.001) between physical activity and the cases of type 2 diabetes mellitus.

2. There is significant correlation (*p-value* = 0.000) between BMI and the cases of type 2 diabetes.

3. There is significant correlation (*p-value* = 0.008) between abdominal circumference and the cases of type 2 diabetes.

4. BMI has eight times greater effect on type 2 diabetes with significance of 0.000.

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