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Influence of Indonesia Series 6 Diabetes Gymnastics on Glucose Tolerance Test Results

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Abstract. A sedentary lifestyle or lack of physical activity can cause various diseases and metabolic disorders, such as diabetes. The primary problem faced by diabetics is increased glucose concentrations in the blood. Diabetes can be prevented by exercising regularly or by increasing daily physical activity. For example, people with diabetes can perform gymnastics regularly. The purpose of this study was to examine the effects of Indonesian Series 6 Diabetes Gymnastics on glucose tolerance test results. This study used a pretest and posttest design involving 35 females aged 21–60 years who all comprised one group treatment. All subjects in this study were healthy and had not been diagnosed with diabetes, as evidenced by their fasting blood glucose (GDP) levels before performing the Indonesia Series 6 Diabetes Gymnastics. Performing Indonesian Series 6 Diabetes Gymnastics can reduce GDP levels significantly ($p = 0.03$) but cannot significantly reduce the 2-hour postprandial blood glucose (GD2PP) levels ($p = 0.364$). Based on these results, one repetition of the Indonesian Series 6 Diabetes Gymnastics cannot affect glucose tolerance test results.

Keywords: *diabetes gymnastics, diabetes mellitus*

1 Introduction

Digital technology and its continuing development have radically influenced human life in recent decades. However, all the conveniences that can be gained from technological advances without having to move have an impact on lifestyle changes and lead to a more sedentary lifestyle. A sedentary lifestyle can lead to many health problems, such as lipid profile disorders and glucose uptake, greater energy intake and increased waist circumference, and ultimately an increased risk of death (Lepp, Barkley, Sanders, Rebold, & Gates, 2013).

Metabolic disorders, such as diabetes mellitus (DM), are one type of disease caused by a sedentary lifestyle or lack of physical activity. The main problem faced by diabetics is the increased glucose concentration in the blood. In Indonesia, 52,830,111 people had impaired blood glucose levels such as impaired glucose tolerance (TGT) and 12,191,564 people were affected by fasting blood glucose (GDP) disorder. Glucose metabolism disorders can lead to DM if not treated properly; the World Health Organization (WHO) and the International Dietetics Federation predict an increase in the number of diabetics in Indonesia to 21.3 million by 2030. Therefore, the likelihood of an increase in the number of diabetics will be a very serious problem in the future. (Soelistijo et al., 2015; WHO, 2016)

Diabetes can be prevented by exercising regularly or by increasing daily physical activity. The American Diabetes Association provides a recommendation for preventive measures against diabetes with the primary goal of controlling blood glucose levels; these recommendations require aerobic exercise of moderate intensity for at least 150 minutes a week. This is in line with (Soelistijo et al., 2015) in the consensus on the treatment of diabetes in Indonesia, which states that exercise should be performed regularly three to five times a week for a total of 150 minutes per week. There should be no more than two rest days in a row between exercise. Aerobic exercise will increase the number of mitochondria, oxidative enzymes, and insulin sensitivity, which will improve blood glucose control. During exercise, the muscles experience repeated contractions. These muscle contractions will play a role in the process of taking glucose from blood vessels into cells. Muscle contractions activate glucose transporters that do not depend on the presence of insulin so that glucose uptake can continue during exercise. The presence of these glucose transporters can lead to periodic decreases in basal glucose levels, which may affect the results of glucose tolerance tests (Colberg et al., 2016; American Diabetes Association, 2016).

One sport that can be performed by people with diabetes is diabetes gymnastics. Diabetes gymnastics is often performed because these exercises can affect all organs of the human body, from the brain to the toe.

According to as (2009), physical exercise can directly lead to the increased use of glucose so that more available insulin receptors become active, which will lead to decreased blood glucose levels in DM patients; thus, there is a change in blood sugar levels.20

The purpose of this research was to evaluate the effect of Indonesian Series 6 Diabetes Gymnastics on glucose tolerance test results.

2. Method

This experimental field study was conducted in the Medical Faculty of Airlangga University. This study used a pretest and posttest design involving 35 females aged 21–60 years old who all received one group treatment. All subjects in this study were healthy and had not been diagnosed with DM, as evidenced by the examination of their GDP levels before performing the Indonesia Series 6 Diabetes Gymnastics. After the sample size was met, the subjects were given a schedule for the examination and performed the Indonesia Series 6 Diabetes Gymnastics.

Data retrieval was conducted for eight days, before taking the data, scheduling data retrieval on each research subject. GDP and GD2PP data were obtained before performing the Indonesian Series 6 Diabetes Gymnastics and the day after performing the gymnastics.

The statistical analysis was performed using SPSS version 16.0. The descriptive analysis test calculated the mean and standard deviation. Normality was assessed using the Shapiro-Wilk test. To detect differences, paired t-tests were used when the data were normally distributed and the Wilcoxon test was used when the data were not normally distributed. A p-value of <0.05 indicates a significant difference between the variables.

3. Result

The descriptive data obtained included age, weight, height, BMI, heart rate, GDP levels, and GD2PP. Table 1 shows the data of the entire study population.

Table 2 illustrates the mean and standard intersections of GDP and GD2PP levels before and after the Indonesian Series 6 Diabetes Gymnastics. After performing a descriptive analysis test, the Shapiro-Wilk test was used to assess the normality of the variables, which was indicated by a p-value of >0.05.

The GDP level data were normally distributed, so the difference between pretest and posttest were assessed using a paired t-test. The results of the paired t-test are shown in Table 3. The paired t-test reported a p-value of 0.03, which indicates that there is a significant difference in GDP levels between the pretest and posttest.

The GD2PP data were not normally distributed, so the Wilcoxon test was used to compare between the pretest and posttest, as shown in Table 4. Based on the Wilcoxon test, $p = 0.364$, which indicates that there was no significant difference in GD2PP levels between the pretest and posttest.

Table 1. The average value and standard deviation of the study subjects

Variable	N	Mean ± SD
Age (year)	35	32.40 ± 10.310
Weight (kg)	35	61.23 ± 12.074
Height (cm)	35	153.86 ± 4.380
BMI	35	25.49 ± 4.937

Table 2. Mean and standard values of fasting glucose (GDP) and 2-hour postprandial blood glucose (GD2PP) (mg/dl) levels pretest and posttest

Variable	Mean ±SD	
	Pretest	*Posttest*
GDP (mg/dl)	83.829 ± 11.218	79.486 ± 11.348
GD2PP (mg/dl)	117.743 ±24.244	113.857 ± 20.900

Table 3. The results of the paired t-test for fasting glucose (GDP) levels pretest and posttest

Variable	N	Mean ± SD	Significance (p)
Fasting blood glucose (GDP) *pretest*	35	83.829±11.218	0.03*
Fasting blood glucose (GDP) *post test*	35	79.486±11.348	

Information: * significant when $p < 0.05$

Table 4. Wilcoxon test 2-hour postprandial blood glucose (GD2PP) level results

Variable	N	Significance (p)
2- hour postprandial blood glucose (GD2PP) pretest	35	0.364*
2-hour postprandial blood glucose (GD2PP) posttest	35	

4. Discussion

High glucose levels are a result of unhealthy dietary patterns and sedentary activities. High levels of glucose over a long period of time can cause carbohydrate metabolism disorders that can display a signature typical of DM. Currently, epidemiological studies show a tendency of increased incidence rates and prevalences of type 2 DM in different parts of the world. Increased blood glucose levels should be prevented so that DM does not develop. DM is diagnosed by examining blood glucose levels, including the examination of glucose tolerance (Soelistijo et al., 2015).

This study assessed the role of an aerobic exercise, the Indonesia Series 6 Diabetes Gymnastics, performed once at a moderate intensity for 30 minutes. The results of this study indicate that performing the Indonesia Series 6 Diagnostic Gymnastics only once can reduce GDP levels. Acutely, aerobic exercise may produce muscle contractions that increase glucose uptake even though blood glucose levels are always maintained by glycogenolysis and gluconeogenesis occurring in the liver. The uptake of glucose during aerobic exercise occurs through the insulin-independent mechanism (Colberg et al., 2010; Boule et al., 2005; Colberg et al., 2016).

At rest and in postprandial conditions, glucose uptake is regulated by insulin and stored in the form of glycogen in the muscle. During exercise, increased muscle contraction increases glucose uptake without the need for insulin, which is a mechanism called the insulin-independent mechanism. Muscle contraction increases the activity of mitogen-activated protein kinase (MAPK). MAPK activity then increases GLUT-1 expression. The increased GLUT-1 expression will be followed by a decrease in GLUT-4 expression and activation of the insulin-stimulating pathway. Increased GLUT-1 expression leads to decreased GDP levels because GLUT-1 provides glucose for cells at a basal time. Increased GLUT-1 causes periodic basal blood glucose reduction, reduces dependance on insulin and drugs, and improves glucose uptake. The increase in GLUT-1 causes increased glucose uptake into cells that are eventually used to produce energy so that blood glucose levels will decrease. GLUT-1 reactions are expressed in basal conditions, such as fasting and while sleeping at night (Heled et al., 2005).

Decreased function and GLUT-1 expression can be observed from the results of the GDP examination. The decrease in GLUT-1 expression correlates with elevated basal glucose levels and the body's need for insulin stimulation. If there is no food intake during exercise, blood glucose levels do not increase, and the stimulation of insulin will be low. The muscles do not receive enough insulin stimulation, so GLUT-4 expression decreases. Instead, glucose uptake persists, which does not involve GLUT-4 but activates another GLUT.

GDP a predictor variable for diagnosing DM. Elevated GDP levels are associated with an increased incidence of DM. There are various methods to control blood glucose levels ranging from applying a healthy lifestyle (nutritional therapy and physical activity) to pharmacological interventions. Each intervention will have different effects. The incorporation of an intervention is necessary to reduce the higher fasting blood glucose and consequently blood sugar levels (Soelistijo et al., 2015; Kriska et al., 2006; Nakagami et al., 2016).

The results found in the GD2PP examination did not have a significant impact. This result is caused by the postprandial condition, in which insulin regulates the blood glucose level. Insulin sensitivity is affected when aerobic exercise of moderate intensity is performed at least twice a week. Regular exercise can lead to multiple muscle adaptation processes, such as being able to produce ATP more efficiently so that muscles are more resistant to fatigue, increasing activity and the amount of mitochondria, and increasing muscle responsiveness to insulin by increasing the expression and activity of proteins that play a role in glucose metabolism and insulin signaling (Colberg et al., 2010; Rockl et al., 2008).

One of the proteins that plays a role in glucose metabolism is GLUT-4. GLUT-4 is the main glucose transporter that carries glucose from the blood into the cells to maintain the balance of glucose levels. Increased concentration and activity of GLUT-4 occurs in response to regular exercise and thus plays a role in facilitating glucose uptake in the muscles trained during the exercise process. Muscle contractions produced during exercise can occur due to the interaction process between actin and myosin. This interaction occurs because of calcium ions in muscle cells. The calcium ions will activate calcium/calmodulin-dependent protein kinase (CaMK), which will then activate protein kinase A (PKA). Active PKA plays a role in the transplantation of GLUT-4 into the cell membrane (Jensen et al., 2014; Richter & Hargreaves, 2013).

During exercise, energy generation is lower than energy use, depending on the intensity of the exercise being performed. This will lead to a decrease in creatine phosphate and ATP concentrations, whereas AMP concentrations continue to increase. Changing this condition activates AMP-activated protein kinase (AMPK). Increasing the activity of CaMK and AMPK will increase the concentration of GLUT-4. Participating in gymnastics may decrease GD2PP levels but not significantly. This is presumably because the revitalization of GLUT-4 through increased ATP by GLUT-1 is not enough to lower blood glucose levels significantly (Huang and Czech, 2007; Merry & McConell, 2009).

The expression and function of GLUT-4 can be observed by examining GD2PP levels. After a meal, blood glucose levels increase, which stimulates the secretion of insulin from pancreatic beta cells. The decrease in GLUT-4 expression is correlated with the increase in GD2PP levels.

5. Conclusion

A series of one-time diabetes gymnastics exercises cannot affect the results of glucose tolerance tests because even once, these exercises can only reduce GDP but not GD2PP levels.

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