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# The effect of aerobic exercise on blood sugar control in diabetes mellitus patients

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**ABSTRACT**

Diabetes mellitus is a global health problem with increasing prevalence. According to data from the International Diabetes Federation (1), more than 537 million people worldwide suffer from DM. Aerobic exercise has been recommended as a non-pharmacological intervention to control blood glucose levels, but further research is needed to determine its effectiveness in various clinical contexts. Various measures are taken to prevent and control diabetic neuropathy and improve peripheral circulation through the five pillars of DM management, namely education, nutrition, physical activity, pharmacological therapy, and blood glucose monitoring. Physical activity is an important element in preventing and managing type 2 DM. Aerobic exercise is a series of deliberately selected movements that follow the rhythm of music that is also selected so as to create certain rhythmic, continuity, and duration provisions. Subjects and Method: This study used 30 subjects with a quasi-experimental method with one group pretest and posttest design with control. The total sample was 30 patients, namely 15 in the intervention group and 15 in the control group. This study was conducted on subjects aged 40-60 years in Tohudan Village, Colomadu, Karanganyar. The intervention group underwent an aerobic exercise program three times a week for 12 weeks, while the control group did not receive any intervention. Blood sugar levels were measured before and after the intervention. Results: There was a significant effect between random blood glucose levels in patients given the intervention, with a mean difference of -46,000, indicating that after being given an aerobic exercise intervention, random blood glucose could decrease by about 46 mg/dl. Conclusion: There is an effect of aerobic exercise on blood sugar control in patients with diabetes mellitus.



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# INTRODUCTION

Diabetes Mellitus (DM) is a non-communicable disease but can be fatal if not treated (Type & City, 1994),(Cahyati et al., 2021). According to the Institute of Health Metrics and Evaluation, diabetes is the leading cause of death in Indonesia and ranked 3rd in 2019. According to the International

Diabetes Federation (IDF), the number of people with diabetes mellitus is expected to continue to increase until 2045.(Febriansyah, 2024),(Maulrani, 2023). The prevalence in the world according to WHO., (2023) is 422,000,000 people in the world. The prevalence of the Indonesian population itself is 19,465,100 people who suffer from diabetes mellitus, in Central Java it is ranked 12th with diabetes mellitus sufferers and in the city of Surakarta there are 1,370 people who suffer from diabetes mellitus Health Research and Development Agency(Azriful, Adnan, Bujawati, Alam, & Nildawati, 2024),(Istikharoh, Suryadi, & Stella, 2025).

Diabetes Mellitus is a chronic metabolic disorder characterized by increased blood sugar levels caused by impaired insulin secretion and insulin resistance. Health Research and Development Agency (Kurniasari, Sari, & Warmi, 2020),(Fau, 2024). The results of research conducted by Febriyani (2020) stated that diabetes mellitus is caused by a family history of the disease, such as age, obesity, hypertension, and lack of physical activity. In Indonesia, the management and treatment provided to diabetes mellitus sufferers focuses on four pillars: education, dietary management, exercise, and pharmacological therapy. There are various types of exercise or complementary therapies for diabetes mellitus sufferers, including yoga and diabetic foot exercises. Made et al (Suryati & Kep, 2021),(Bingga, 2021).

Increased blood glucose levels occur due to insulin resistance disorders so that glucose cannot enter cells, resulting in glucose remaining in the blood vessels and increasing levels in the blood. Factors that cause increased blood glucose levels are due to the inability to control or reduce blood glucose levels to remain stable, lack of physical activity, increased life expectancy, unhealthy food intake, obesity and a modern lifestyle (Nurfita Sari, Achwandi, & Azizah, 2024),(Lalla & Rumatiga, 2022).

Aerobic exercise is a physical activity that improves cardiorespiratory capacity and energy metabolism. Studies show that aerobic exercise can lower HbA1c levels and improve insulin sensitivity in people with type 2 diabetes. Aerobic exercise affects blood sugar control by improving insulin sensitivity, glucose utilization by muscles, and regulating metabolic hormones (Astuti & HUSADA, 2016),(MUSTOFA, nd). Physical exercise with the right dosage can trigger an adaptation process in the systems, namely the nervous system, hormonal system, cardiorespiratory system, metabolic system, neuromusculoskeletal system, and immune system. Aerobic exercise is carried out three times a week for 45 minutes. Physical exercise or aerobic exercise in people with diabetes mellitus plays an important role in controlling blood glucose levels, where during exercise there is an increase in glucose utilization by muscles, which can cause a decrease in blood glucose (Nababan & Nababan, 2022),(Hutagalung & Amalia, 2022). This decrease in blood glucose levels is caused when exercising or gymnastics, glucose and fat are the main sources. After exercising or gymnastics for 10 minutes, glucose is needed 15 times compared to when resting 8 The influence of aerobic gymnastics on changes in blood glucose levels is due to aerobic gymnastics being a systematic process using movement stimuli that aims to improve or maintain the functional quality of the body which includes heart-lung endurance, muscle strength and endurance, flexibility and body composition (Hokon, Milwati, & Rosdiana, 2016),(Febrianti, 2022). The pancreas can influence the decrease in blood glucose levels by reducing insulin and increasing glucagon. Acute exercise is less effective as a stressor in reducing blood glucose levels. Endurance aerobic exercise performed for 20-40 minutes at least 3 times a week can reduce blood glucose, improve glucose tolerance and peripheral insulin sensitivity, reduce body weight, and reduce several risk factors for cardiovascular disease. The decrease in blood glucose levels varies due to the type of method used and may be due to the use of energy sources from the method (Bafirman, 2016),(Fatriany & Marsan Dirdjo, 2021). Aerobic exercise at the right dosage can trigger an adaptation process in the nervous, skeletal, and immune systems. After 10 minutes of aerobic exercise, glucose needs increase up to 15 times the normal amount. After 60 minutes, it can increase up to 35 times the resting glucose requirement. According to Chaveu and Kaufman, exercise in people with diabetes can cause

increased glucose utilization by active muscles, so that exercise can directly reduce blood glucose (AULIA, 2022),(Ariyanti, 2023).

# RESEARCH METHOD

**Study Design**

The type of research used in this study was a quasi-experimental one-group pretest-posttest design. In this study, the subjects consisted of one group, group I being the group given aerobic exercise.

**Population and Sample**

The research will be conducted from July to August 2025 in Tohudan Timur Village, Colomadu, Karanganyar. The subjects used in this research are elderly people who meet the inclusion and exclusion criteria that have been determined. The inclusion criteria include: (1) Type 2 DM sufferers aged 40–60 years (2) subjects willing to participate in the research program.

**Study Variables**

The independent variables in this study include aerobic exercise, while the dependent variables include blood sugar control in diabetes mellitus patients.

**Operational Definition of Variables**

Aerobic exercise: aerobic exercise is done for 30 minutes, 3 times a week for 4 days.

Blood Sugar Levels: Blood sugar levels are measured using a Glucometer.

**Study Instruments**

Random blood sugar level checks are carried out using a glucometer with capillary blood sugar level checks.

**Data analysis**

The data analysis technique used quantitative descriptive analysis with the SPSS program. The stages are as follows: a) Normality Test, the normality test used is Shapiro-Wilk or Kolmogorov-Smirnov; b) Hypothesis Testing, test the influence before and after treatment of group I and group II with a paired t-test or using the Wilcoxon test. Test the difference in influence between group I and II after treatment using an unpaired t-test if the data is normally distributed and using the Mann Whitney test if the data is not normal. If the results show a p value > 0.05, it means there is a significant difference between the treatment of group I and II and vice versa.

**Research Ethics**

This proposal has been submitted and approved by the Research Ethics Committee of Faculty of Medicine, University of Muhammadiyah Surakarta with ethical clearance number 3570/B.2/KEPK-FKUMS/VI-/2025.

# RESULTS AND DISCUSSIONS

**Sample Characteristics**

a. Univariate Analysis

**Table 1**. Blood glucose beforedo aerobic exercise regularly

| Group | N | *Mean* | Elementary School |
|---|---|---|---|
| Intervention | 15 | 195.73 | 39,443 |
| Control | 15 | 196.86 | 49,894 |

Based on table 1, it is known that the average random blood glucose level of respondents in the intervention group was 195.73 with a standard deviation of 39.443, and in the control group,

the average random blood glucose level of respondents was 196.86 with a standard deviation of 49.894.

**Table 2**. Blood glucose after exercise regular aerobic exercise in the intervention and control groups

| Group | N | *Mean* | |
|---|---|---|---|
| Intervention | 15 | 153.82 | 40,898 |
| Control | 15 | 205.92 | 41,326 |

Based on table 2, it is known that the average random blood glucose level of respondents in the intervention group was 153.82 with a standard deviation of 40.898, and in the control group, the average random blood glucose level of respondents was 205.92 with a standard deviation of 41.326.

**Bivariate Analysis**

a. Differences in blood glucose before and after regular aerobic exercise in the intervention group.

**Table 3**. Differences in blood glucose before and after the research (aerobic exercise) in the intervention group

| Group | | N | Mean (mg/dl) | Elementary School (mg/dl) | p-value |
|---|---|---|---|---|---|
| Intervention | Pretest | 15 | 195.73 | 39,443 | 0.001 |
| | Posttest | 15 | 153.82 | 40,898 | |

Based on table 3, it shows that in the intervention group before being given aerobic exercise intervention, the average random blood glucose level was 195.73 with a standard deviation of 39.443, then decreased to an average of 153.82 with a standard deviation of 40.898.

Based on the dependent t-test, the p-value was 0.001. It can be seen that the p-value is less than α (0.005). This indicates that there is a significant difference in blood glucose levels in the intervention group before and after the intervention.

b. Differences in blood glucose before and after the study (without aerobic exercise) in the control group.

**Table 5.** Differences in blood glucose before and after the study (without aerobic exercise) in the control group

| Group | | N | Mean (mg/dl) | Std Deviation (mg/dl) | p-value |
|---|---|---|---|---|---|
| Control | Pretest | 15 | 196.86 | 49,894 | 0.123 |
| | Posttest | 15 | 205.92 | 41,326 | |

Based on table 4, it shows that in the control group before being given the research, the average random blood glucose level was 196.86 with a standard deviation of 49.894, then increased to an average of 205.92 with a standard deviation of 41.326. Based on the dependent t test, the p-value was 0.123. It can be seen that the p-value is more than α (0.005). This shows that there is no significant difference in blood glucose levels in the control group before and after the study. that before the respondents did the study, the glucose levels were 1.632 lower than the values after, with a change from the previous -20.980 mg/dl and a maximum of 2.846 mg.

c. The effect of aerobic exercise on random blood glucose levels in patients with type 2 diabetes mellitus

**Table 6**. The effect of aerobic exercise on blood glucose levels during patients with type 2 diabetes mellitus

| Group | n | Mean (mg/dl) | Elementary School (mg/dl) | Mean Difference (mg/dl) | T | p-value |
|---|---|---|---|---|---|---|
| Intervention | 15 | -38.93 | 36,825 | -46,000 | -4,359 | 0,000 |
| Control | 15 | 9.07 | 21,512 | | | |

Based on table 5, it can be seen that the difference in the average value of respondents after the study was -38.93 which indicates a decrease of 38.93 mg / dl with a standard deviation of 36.825, and in the group of respondents who were not given intervention, the difference in the average value was 9.07 which indicates an increase of 9.07 mg / dl with a standard deviation of 21.512. Based on the independent t test, a p-value of 0.000 was obtained. It can be seen that the p-value of 0.000 < (0.05) indicates that there is a significant influence between random blood glucose levels in patients who were given intervention.

**Discussion**

a. Differences in blood glucose before and after regular aerobic exercise in the intervention group

Management of diabetes mellitus consists of 5 main pillars, exercise or physical training is one of the management besides diet, medication, education and monitoring, exercise in the sense of physical movement or muscle work can increase metabolism or the formation and expenditure of body energy (energy output), resulting in oxygen and energy consumption increasing about 20-fold. So the use of glucose can also be used in large quantities without requiring large amounts of insulin because muscle fibers become more permeable to glucose due to contraction of the muscle itself(Suryati & Kep, 2021).

The decrease in average blood glucose levels after aerobic exercise intervention in this study is consistent with the opinion of Chaveau and Kaufman, who stated that physical exercise can directly cause increased glucose utilization by active muscles. Regular exercise causes permeability. membrane increases in contracting muscles so that insulin resistance training is reduced and insulin sensitivity is increased.If the exercise is done for a total of 30 minutes, it will maintain or increase the pulse capacity which is manifested in the form of exercise movements which consist of 3 stages, namely the first warm-up, core and cool-down.(Dinata, 2020).

Aerobic exercise will activate muscles and increase insulin receptor sensitivity. Insulin will bind to insulin receptors, triggering the glucose transporter (GLUT) to the cell membrane, which functions to help glucose enter the cell. Glucose enters the blood circulation and then enters the peripheral tissue (interstitium) to muscle tissue. Glucose (G) is converted into glucose-6-phosphate (G6P) which is assisted by the enzyme hexokinase and the process of glycogenesis occurs, namely the formation of glycogen into glucose and stored in liver and muscle cells. Glycolysis occurs, namely the process of breaking down glucose into ATP or energy used during aerobic exercise, so that the result is a decrease in blood glucose levels.(Nurcahyani, Pakarti, & Ayubbana, 2025),(YANG, 2022).

This research is in line with Nugraha (2016) who stated that there was a difference in blood glucose levels before and after the implementation of diabetes gymnastics, with a p-value = 0.0000 with an average blood glucose level before the implementation of diabetes gymnastics being 164.50 mg/dl with a standard deviation of 10.750. In the same respondents, the average blood glucose level after the implementation of diabetes gymnastics was 145.13 mg/dl with a standard deviation of 16.193. The criteria for this test are if the p-value <α with a confidence level of 5% (0.05) then it is concluded that there is a difference in blood glucose levels of type 2 DM patients before and after diabetes gymnastics.(Ruben, Rottie, & Karundeng, 2016),(Taher, 2020).

Aerobic exercise is a physical activity that improves cardiorespiratory capacity and energy metabolism. Studies show that aerobic exercise can lower HbA1c levels and improve insulin sensitivity in people with type 2 diabetes. Aerobic exercise affects blood sugar control by improving insulin sensitivity, glucose utilization by muscles, and regulating metabolic hormones (Shah et al., 2021).

Physical exercise with the right dose can cause an adaptation process in the system, namely the nervous system, hormonal system, cardiorespiratory system, metabolic system, neuromusculoskeletal system and immune system (Dewi R, 2019).

b. Differences in blood glucose before and after the study (without aerobic exercise) in the control group

Although data analysis results showed no difference in average blood glucose levels, this is likely due to the lack of exercise intensity and other factors influencing blood glucose. Physical activity and exercise routine can affect the action of insulin in glucose and fat metabolism in skeletal muscle.Physical activity stimulates insulin production and blood glucose utilization, and can increase muscle function. Physical activity increases insulin levels, thus reducing blood glucose levels. People who rarely engage in physical activity and exercise will not burn the nutrients they consume, but instead will be stored as fat and sugar. If the pancreas fails to produce enough insulin and is unable to convert glucose into energy, diabetes can develop (Ministry of Health, 2010).

The results of this study are in line with Sharoh's (2017) study, which found that the average blood glucose levels before and after treatment in type 2 DM patients in the control group were 228 with a standard deviation of 20.4, and the average blood glucose levels after treatment in type 2 DM patients in the control group were 235.7 with a standard deviation of 21.5. Most respondents did not experience a decrease in their average blood glucose levels..

c. The effect of aerobic exercise on random blood glucose levels in patients with type 2 diabetes mellitus

Aerobic exercise is performed three times a week for approximately 40 minutes for 12 weeks. Physical exercise or aerobic exercise plays a crucial role in controlling blood glucose levels in people with diabetes mellitus. Exercise increases glucose utilization by muscles, which can lower blood glucose levels. This decrease in blood glucose levels is due to the primary sources of glucose and fat during exercise.

Lowering blood glucose levels can be influenced by the pancreas by reducing insulin and increasing glucagon. Acute exercise is less effective as a stressor in lowering blood glucose levels. Endurance aerobic exercise performed for 20-40 minutes at least three times a week can lower blood glucose, improve glucose tolerance and peripheral insulin sensitivity, promote weight loss, and reduce several risk factors for cardiovascular disease (Siswantoyo, 2009).

The decrease in blood glucose levels varies depending on the type of method used. This is likely due to the energy source used in this method. Aerobic exercise, when administered appropriately, can trigger adaptation processes in the nervous, skeletal, and immune systems. After 10 minutes of aerobic exercise, glucose needs increase.will increase up to 15 times the normal requirement. After 60 minutes, it can increase to 35 times the resting glucose requirement. According to Chaveu and Kaufman, exercise in diabetics can cause increased glucose utilization by active muscles, so that exercise can directly reduce blood glucose (Siswantoyo, 2009).

This research is in line with that conducted by Kayman et al (2010) namely regular physical activity by exercising at least 3 times a week for at least 30 minutes each time and for 12 weeks will be able to reduce body weight. This research is supported by Nella (2015) who stated that there is an effect of aerobic exercise on blood glucose levels in type 2 DM sufferers with an average pre-test blood glucose level of 207.1mg/dl, an average post-test blood glucose level of 174.9mg/dl, the results of the Paired t-test P = 0.000.

# CONCLUSION

The results of this study indicate a significant effect of aerobic exercise on blood sugar control in patients with diabetes mellitus with a p value of 0.001. Future research is expected to compare the effects of various types of aerobic exercise, such as zumba, diabetes exercise, brisk walking, and cycling on blood glucose levels, and analyze differences in results based on the intensity and duration of exercise, whether light, moderate, or heavy. Furthermore, it is also necessary to examine the effects of exercise frequency and duration of intervention, for example from three to four times per week, on long-term glycemic control. Although the results of this study show

significant findings, there are several limitations, including the relatively small sample size so that the results cannot be generalized, the limited duration of the intervention so that long-term effects cannot be known, and the presence of external factors such as diet, stress, and medication adherence that cannot be fully controlled. The clinical implications of these findings indicate the importance of integrating aerobic exercise into a comprehensive therapy program for patients with diabetes mellitus, because regular physical activity can increase insulin sensitivity, lower blood glucose levels, and improve physical fitness. Physiotherapists can make aerobic exercise part of a routine intervention that is tailored to the patient's physical condition and age, accompanied by education about the benefits and implementation techniques to increase patient compliance in the long term.

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