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The Effectiveness of Yoga Exercise to Reduce Blood Sugar Levels in Diabetes Mellitus Sufferers

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ABSTRACT

Diabetes Mellitus (DM) is considered scary because it is chronic and leads to complications from other serious diseases. However, the good news is that DM can be prevented and controlled. The heart, blood vessels, kidneys, eyes, nerves, and other organs can become involved. Therefore, non-pharmacological (lifestyle modification) control of physical activity is necessary to manage DM. One solution is yoga practice. This research aims to determine the effectiveness of yoga exercises in reducing blood sugar levels in diabetes mellitus sufferers. This research design is an analytic experiment with a quasi-experimental design using a non-equivalent control group approach and involving a control group not treated with the same pre and post-treatment samples (paired samples). A sample of 24 people. The research location is Tamalanrea Community Health Center, Makassar, Indonesia. The results showed a significant difference in GDS levels before and after yoga exercise. This is supported by the mean value of GDS levels, which decreased 74.25 mg/dL after yoga exercise. The correlation strength of the intervention is 0.965, so it can be said that yoga exercise is powerful in reducing GDS levels in DM patients. It was concluded that there was a significant difference in GDS levels before and after yoga exercise. The research contribution is recommended to provide education to patients with Diabetes Mellitus Type 2 to increase physical activity as a way of non-pharmacological therapy to keep blood sugar levels in a normal state.

Keywords: Yoga, Exercise, Physical Activity, Blood Sugar Level, Diabetes Mellitus

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1. INTRODUCTION

Diabetes Mellitus (DM) is a disease or chronic metabolic disorder (Menini et al., 2020) with multiple etiologies characterized by high blood sugar levels (Alam et al., 2021) with impaired carbohydrate, lipid, and protein metabolism due to insulin-function insufficiency and inability to use the insulin produced effectively (Bolli et al., 2021). Physical health problems are still a public health threat, especially in non-communicable diseases such as hypertension, stroke, heart disease, and diabetes mellitus (Arifin et al., 2022). Diabetes Mellitus is a non-communicable disease and is generally divided into two types, namely Type I Diabetes Mellitus, which is also often referred to as Insulin Dependent Diabetes Mellitus (IDDM) (Mukhtar et al., 2020). Noninsulin Dependent Diabetes Mellitus (NIDDM) is caused by decreased sensitivity of target tissues to the metabolic effects of insulin (Lee et al., 2022). Diabetes mellitus (DM) is a group of metabolic diseases with hyperglycemia characteristics that occur due to abnormalities in insulin secretion, insulin action, or both established based on examination of blood glucose levels, either fasting or post-prandial blood glucose (Lady et al., 2019).

The International Diabetes Federation (IDF) organization estimates that at least 463 million people aged 20-79 years worldwide suffer from diabetes in 2019, or equivalent to a prevalence rate of 9.3% of the same total population (Harding et al., 2024). Based on gender, IDF estimates that the prevalence of diabetes in 2019 is 9% in women and 9.65% in men (Haskas et al., 2022). The prevalence of diabetes is estimated to increase as the population to 19.9 % or 111.2 million people aged 65-79 years. The figure is predicted to grow to 578 million in 2030 and 700 million in 2045 (Saeedi et al., 2019). In Indonesia, diabetes mellitus also increases in cases at the district/city level, especially in Makassar City. They are based on data from the Makassar City Health Office, cases of DM in Makassar City in 2015, and as many as 8,457 cases in men and women, as many as 12,561 patients, so the total DM sufferers in Makassar City in 2015 were 21,561 cases, while the old cases were 57,087 of which men were 23,395 cases, and women were 33,692 cases. The number of deaths with diabetes cases included 450 men and 361 women; the total number of deaths of DM cases in the city of Makassar throughout 2015 was 811 cases (Hariawan et al., 2019).

Diabetes Mellitus is a crucial issue in Indonesia because it is one of the Non-Communicable Diseases (NCDs) with a relatively high mortality rate, so self-management is an important thing to do to be able to reduce blood sugar levels in type 2 DM patients. Self-management in DM patients consists of 4 main pillars: managing a healthy diet, physical activity, blood sugar management, and foot care (Collein, 2023; Sundayana et al., 2021). Chronic complications can occur if a person's normal blood sugar levels are not maintained regularly. People who suffer from DM are most likely to experience diseases of the heart, blood vessels, kidneys, eyes, and nerves, so efforts are needed to manage diabetes mellitus, which aims to eliminate complaints or symptoms, maintain a sense of comfort and health, prevent complications, reduce morbidity and mortality. One of the efforts to control type 2 diabetes is non-pharmacological (lifestyle modification) by regulating physical activity. Yoga is an alternative that can be done to lower blood sugar levels. Yoga can be a non-pharmacological treatment option that does not have side effects and can be done independently by patients at home.

Several factors can cause weakness in muscle strength in diabetic patients, such as lack of exercise and decreased physical activity, which can significantly reduce muscle strength. In addition, abnormal mitochondrial function, abnormal free fatty acid metabolism, and increased inadequate microvascular blood supply during exercise are likely to affect muscle function (Asada et al., 2017).

Physical activity can reduce the risk of developing diabetes through the effects of body weight and insulin sensitivity. A person with low-fat content has a lower risk of developing diabetes as well. In addition, lack of physical activity also makes the secretion system in the body run slowly. As a result, fat accumulation in the body will continue to increase, resulting in excess weight and leading to the onset of diabetes mellitus (Malone & Hansen, 2019). When exercising, the body needs extra energy. Energy causes the muscles in the body to absorb glucose, which helps lower blood sugar levels. It is known that age is closely related to increasing blood sugar levels because insulin production begins to decrease. This is an increase in muscle fat levels, so glucose is more difficult to use as energy for activities. Still, when a person does activities regularly and correctly, it will help muscle movement. It can accelerate blood circulation and, by doing activities, can lower blood sugar levels (Sriwahyuni et al., 2021). The need for self-management training on the knowledge, frequency, and accuracy of self-monitoring of blood glucose, dietary habits, glycemic control will be more effective if it involves collaboration of patients and health workers (Norris et al., 2001) in addition to self-efficacy or self-confidence which has a vital role in implementation of the DM diet where respondents who have confidence in the implementation of the DM diet which will be carried out by the recommendations of the respondent's health workers can maintain blood glucose levels within normal limits.

Previous research found that practicing Yoga 3 times a week is better than 2 and 1 times a week to achieve normal blood sugar levels. The exercise showed good blood sugar levels, less than 200 g/dl. So, the more frequently exercise is done, the better it is for people with diabetes mellitus to control blood sugar levels. Regular practice of yoga reduces the risk of complications related to diabetes. Autonomic dysfunction of the heart is believed to be the cause of sudden death in people with diabetes mellitus. Clinical studies have shown that regular yoga practice improves cardiac autonomic function independently of glycemic control and reduces the risk of cardiovascular events (Raveendran et al., 2018). Adherence to yoga affects blood glucose parameters in diabetes. Therefore, strategies to motivate participants to undergo 'lifestyle modification practices', including maximizing adherence to yoga, should focus on experiencing the beneficial effects of yoga (Angadi et al., 2017). Based on the background above, this research aims to determine the effectiveness of yoga exercises in reducing blood sugar levels in diabetes mellitus sufferers.

2. METHOD

This research design is experimental research that is analytic in nature with a quasi-experimental design using a non-equivalent control group design approach. This approach involved an untreated control group with the same pre- and post-treatment (paired samples). The research location is Tamalanrea Community Health Center, Makassar, Indonesia. A sample of 24 people was divided into two

groups: the experimental group, with 12 people who received intervention (yoga exercise and 500 mg metmorphine therapy), and the second group, the control group (500 mg metformin therapy), with a sample of 12 people. The intervention group and control group both received 500 mg of metformin therapy. Blood sugar levels were measured during or post-test on the 3rd day after doing yoga practice. In the next step, the researchers analyzed the results of blood sugar examinations before and after doing yoga exercises and compared them with the control group. This design was used to determine the effect of yoga exercises on changes in blood. The statistical hypothesis of this research is that there is a significant difference in GDS levels before and after yoga exercise.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1
Distribution of Characteristics of DM Patients at the Tamalanrea Health Center

Characteristics	Group; N(%)		Total
	Control (N=12)	Treatment (N=12)	(N=24)
Age			
40-49 years old	2 (16.7)	1 (8.3)	3 (12.5)
50-59 years old	10 (83.3)	11 (91.7)	21 (87.5)
Level of education			
No school	2 (16.7)	3 (25.0)	5 (20.8)
Elementary School	5 (41.7)	4 (33.3)	9 (37.5)
Junior High School	0 (0.0)	1 (8.3)	1 (4.2)
Senior High School	4 (33.3)	4 (33.3)	8 (33.3)
College	1 (8.3)	0 (0.0)	1 (4.2)
Long time suffering from DM			
<1 year	4 (33.3)	5 (41.7)	9 (37.5)
1 year	8 (66.7)	7 (58.3)	15 (62.5)
The family that has cared for			
Husband	2 (16.7)	2 (16.7)	4 (16.7)
Child	10 (83.3)	10 (83.3)	20 (83.3)

Table 1 shows the distribution of characteristics of DM patients in the control group and the treatment group. When viewed from the age of the respondents, the majority of respondents were in the age range of 50-59 years in the control group and the treatment group , respectively 83.3% and 91.7%. Based on education level, respondents in the control group tended to have the last education of elementary school (41.7%) and the treatment group tended to have the last education of elementary school (33.3%) and senior high school (33.3%). Respondents in the control (66.7%) and treatment (58.3%) groups mostly had diabetes for more than 1 year and the majority of respondents were cared for by their children (83.3%).

Table 2
Differences in GDS Levels in DM Patients Before and After Yoga Exercise

GDS Level	Mean±SD	Mean Difference	r	P-Value (Paired Sample T-test)
Before yoga exercise	217.75±107.42	74.25 mg/dL	0.965	<0.001
After yoga exercise	143.50±79.33			

Table 2 shows the results of different tests using the paired sample t-test because the data on GDS levels are normally distributed. The test results showed that there was a significant difference in GDS levels before and after yoga exercise ($p<0.001$) . This is supported by the mean value of GDS levels which decreased after yoga exercise of 74.25 mg/dL. The correlation strength of the yoga exercise intervention is 0.965, which means it is very strong, so it can be said that yoga exercise is very strong in reducing GDS levels in DM patients. Changes in the average GDS levels are presented in graphical form as follows.

Figure 1
The Difference in Mean GDS Levels Before and After Yoga Exercise

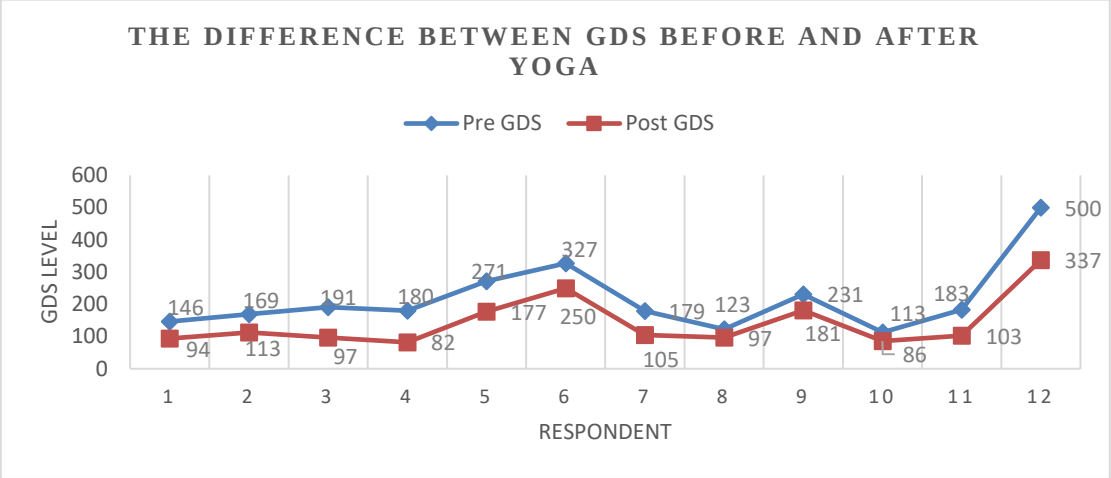

Figure 1 shows that all respondents experienced a decrease in GDS levels after yoga exercise. The largest decrease was experienced by the 12th respondent from 500 gr/dL to 337 gr/dL, meaning that GDS decreased by 163 gr/dL after yoga exercise.

Table 3
The Difference in GDS Levels in the Control Group and the Treatment Group

The Difference in pre-Post Group GDS Levels	Mean Rank	P-Value (Mann-Whitney)
Control	6.83	<0.001
Treatment	18.17	

Table 3 shows the results of statistical tests with a p value of <0.001 on the difference in blood sugar levels between the control group and the treatment group. This means that there are differences in GDS levels in the control group (not given anything) with the treatment group (given yoga exercises). The value of the mean rank or mean rank shows a higher decrease in GDS levels in the treatment group compared to the control group so that it can be concluded that yoga exercise was effective in lowering blood sugar levels during DM patients. the difference in the decrease in blood sugar levels when presented in graphical form in Figure 2 Decrease in GDS levels in the control and treatment groups.

Figure 2
Difference in Decreasing GDS Levels of Control and Treatment Group

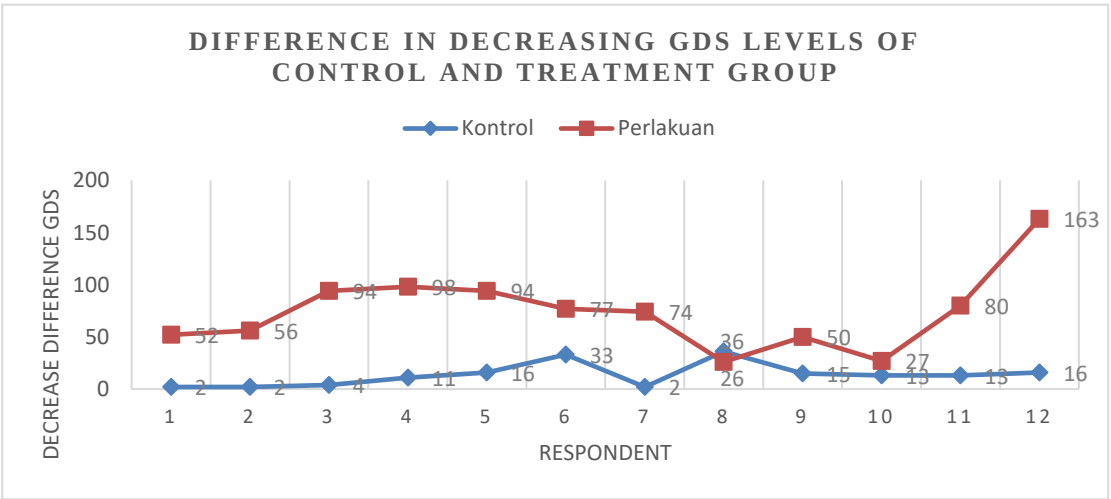

Figure 2 shows that all respondents experienced a decrease in GDS levels in both the control and treatment groups. From the graph, it can be seen that the difference in the decrease in GDS pre post test was significant and quite large in the treatment group with a difference ranging from 26 to 163 gr/dL after yoga exercise, while in the control group the decrease was relatively small with a difference of 2 to 36

gr/dL . This shows the effectiveness of yoga exercise in lowering blood sugar levels when people with diabetes mellitus.

3.2. Discussion

From the research results that have been presented in tables and diagrams, it can be seen from the age of the respondents, the majority of respondents are in the age range of 50-59 years in the control group and the treatment group respectively 83.3% and 91.7%, from previous studies it was obtained that complications of diabetes mellitus with neuropathy can attack diabetics of all ages due to degenerative factors, namely the decreasing function of the human body, especially the ability of pancreatic cells to produce insulin. which means that the increasing age of a person, the higher the risk of developing diabetic peripheral neuropathy, the average age of diabetics is 53 years with the lowest age being 31 years and the highest age being 72 years. This does not rule out the possibility that the incidence of peripheral neuropathy can be felt by young diabetics. Women have a higher risk of suffering from neuropathic complications related to parity and pregnancy, both of which are risk factors for diabetes mellitus (Broni et al., 2022; Mousavi et al., 2021).

Based on education level, respondents in the control group tended to have the last education of elementary school (41.7%) and the treatment group tended to have the last education of elementary school (33.3%) and senior high school (33.3%). Education level and age are included in risk factors for diabetes mellitus which cannot be changed / modified but have a close relationship with the incidence of diabetes mellitus, so that by knowing these two factors, people who are at risk of suffering from diabetes mellitus can do prevention by controlling other factors related to diabetes mellitus. incidence of diabetes mellitus. Education level has an influence on the incidence of diabetes mellitus. People who have a high level of education usually have a lot of knowledge about health. With this knowledge, people will have awareness in maintaining their health. The level of knowledge also affects a person's physical activity because it is related to the work done. People with high levels of education usually work more in offices with little physical activity. Meanwhile, people with low levels of education are more likely to become laborers or farmers with sufficient or heavy physical activity. Increasing the level of education will increase awareness for healthy living and pay attention to lifestyle and diet. Individuals with low education are at risk of paying less attention to lifestyle and diet and what to do to prevent DM (Juan & Yang, 2020; Powers et al., 2020). Respondents in the control (66.7%) and treatment (58.3%) groups had mostly suffered from DM for more than 1 year and the majority of respondents were cared for by their children (83.3%) based on the length of suffering in the previous study. there is a negative relationship between uncontrolled blood sugar levels with cognitive function and there is a negative relationship between long suffering from diabetes and cognitive function but statistically not significant in type 2 DM subjects. This is due to several main factors causing impaired insulin function, high carbohydrate foods, infection, disease, stress and activity can affect blood sugar levels (Alam et al., 2021; Daryabor et al., 2020; Galicia-Garcia et al., 2020).

Doing good and regular exercise increases the flow to the muscles by opening the capillaries (small blood vessels in the muscles) and this will reduce the pressure on the muscles which in turn will increase the supply in the muscle tissue itself, thereby reducing carbohydrate metabolism disorders in sufferers. Diabetes Mellitus so that it lowers its glucose levels, the purpose of exercise is to increase insulin sensitivity, prevent obesity, improve blood flow, stimulate the formation of new glucogen. The recommended exercise for people with Diabetes Mellitus is low impact and rhythmic aerobics, such as swimming, jogging, riding a bicycle, and gymnastics, because it uses all the large muscles, respiration and heart. Yoga exercise is useful for lowering blood chemistry. Yoga movements that can lower blood sugar, cholesterol, lose weight, and improve insulin sensitivity12. Aerobic exercise movements using large muscles carried out continuously and rhythmically can increase insulin receptor sensitivity. The increase in these receptors is able to increase the transfer of glucose to cells, resulting in a decrease in blood glucose levels in people with Type 2 Respiratory Diabetes Mellitus . Yoga that makes up and down movements of the stomach will suppress the work of the pancreas. Yogasana and conventional balance exercises effective in improving the performance of static and dynamic balance, lower extremity muscle strength (Kanjirathingal et al., 2021), this makes the insulin hormone active and the need for insulin decreases, so there is no increase in blood sugar levels (Huising, 2020). The same thing that in Diabetes Mellitus patients, physical exercise is a very important program in preventing the occurrence of diabetic complications (Amanat et al., 2020), because by exercising, glucose is widely used by the muscles to move actively, and Glycogen in the liver is used to meet glucose in the body, so that glucose levels are high. blood remains stable or decreases. Yoga has a definite role as adjuvant therapy as it improves standard medical care and is therefore even more significant in the routine clinical management of diabetes, improving physical condition and lung function (Balaji et al., 2019; Batrakoulis, 2022), with yoga practice can improve fitness, especially muscle strength and cardiorespiratory fitness. For many patients with T2DM, Yoga as a light-intensity physical activity is a type of exercise that has the potential

to overcome the barriers for T2DM patients to perform physical activity (Bassin & Srinath, 2023; Harrington & Henson, 2021; Wibowo et al., 2022).

A different study conducted by Yates et al. (2007) on the effect of exercise on IGT(impaired glucose tolerance) in individuals with prediabetes physical activity was carried out. to initiate diet and weight loss in individuals with IGTwhich it can reduce the risk of type 2 diabetes in individuals with prediabetes although it is not yet known that changes in sugar levels occur due to lifestyle changes. In addition to yoga as a physical activity, walking was also found to be better than the yoga group in improving variables such as body weight, BMI, and blood sugar. the yoga group had a favorable impact on HbA1c and hip circumference (Saberipour et al., 2020). While for physical fitness training in outpatients with DMT2 who have or are at high risk for ASCVD (Atherosclerotic Cardiovascular Disease) because the fitness level is very low, so stronger efforts are needed to carry out activities that can be controlled and adhered to as the basis for T2DM treatment (Jarvie et al., 2019). One that can cause changes in blood sugar levels besides physical activity is lifestyle changes that need to be controlled, especially intervention sports which are considered to have contributed to reducing the incidence of CVD (Dobrosielski, 2021; Ozemek et al., 2018). Yoga if practiced regularly and controlled can promote improvements in several indices that are very important in the management of DM2, including glycemic control, lipid levels, and body composition. Yoga can also lower oxidative stress and blood pressure, improve lung and nervous system function, improve mood, sleep, and quality of life, and reduce drug use in adults with DM2 (Ughreja & Ughreja, 2019). Doing yoga can reduce anxiety and as an adjunct therapy by type 2 diabetics to reduce long-term complications but must be done with the right duration to practice yoga the previous state must be relaxed because if the intervention is done Irregular eating allows no effect on glycemic control or other cardiovascular risks (Singh & Khandelwal, 2020). Yoga is a body exercise and stretching combined with deep breathing and meditation for body relaxation (Agnihotri et al., 2018). The yoga movements in this study include calming meditation and asanas of therapeutic options for diabetes therapy, asanas movements must also have benefits that are in accordance with the disease experienced. In this study, for example, here are some yoga movements or poses that are appropriate in dealing with diabetes in sufferers: 1) Suptha Baddha Konasana This pose makes all the organs of the chest and abdomen in a horizontally stretched state, so as to maximize blood circulation and make it able to work in a relaxed manner. maximum capacity, including the pancreas and liver related to the needs of diabetics. The kidneys and adrenal glands will also get positive stimulation from this movement. 2) Janu sirsasana this movement as well as stretching can increase the body's energy and will stimulate the nervous system of the digestive organs which is useful for diabetics. 3) Adho Mukha Virasana which is also called the hero pose (vira) facing down is done by sitting cross-legged by placing a bolster between the knees (can also be done). The heart is placed parallel to the earth's gravity so that it can stabilize its performance, besides this movement is very good for relieving problems in diabetics related to energy fluctuations that sometimes occur in extreme cases experienced by sufferers. But even so it should be understood that the type of diabetes is a determining factor in the effect of the intervention the effect of T2DM is higher than T1DM, and this is especially the case with exercise intervention but various aspects are estimated that lifestyle changes, produce a stable decrease in HbA1C in T2DM if good self-management is carried out. and applied to T1DM because it is difficult to maintain stable blood glucose, so there is a risk of hypoglycemia (Cho & Kim, 2021).

4. CONCLUSION

From the results of the study, it can be concluded that there is a significant difference in GDS levels before and after yoga exercise ($p<0.001$) . This is supported by the mean value of GDS levels which decreased after yoga exercise of 74.25 mg/dL. The correlation strength of the yoga exercise intervention is 0.965, which means it is very strong, so it can be said that yoga exercise is very strong in reducing GDS levels in DM patients. Changes in the average GDS levels are presented in the form of a graph as follows, showing that all respondents experienced a decrease in GDS levels after yoga exercise. The largest decrease was experienced by the 12th respondent from 500 gr/dL to 337 gr/dL, meaning that GDS decreased by 163 gr/dL after yoga exercise. This research contributes to educating patients to increase physical activity as a non-pharmacological therapy to keep blood sugar levels normal. Community nurses can use this research to socialize yoga exercise as a non-pharmacological treatment that can control blood sugar levels in type 2 diabetes mellitus patients.

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