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ORIGINAL ARTICLE

The effect of physical exercise on blood glucose levels in patients with type 2 diabetes mellitus

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ABSTRACT

Diabetes Mellitus (DM) is a chronic metabolic disease characterized by hyperglycemia. This study aimed to analyze the effect of physical exercise on blood glucose levels in patients with Type 2 DM at the Medan Johor Public Health Center. This analytical observational study utilized a case-control design and involved 34 respondents, divided into a case group (with uncontrolled blood glucose levels) and a control group (with controlled blood glucose levels). Data on physical activity, including frequency, duration, and intensity of exercise, were obtained through interviews using the GPAQ questionnaire, while blood glucose level data were sourced from medical records. The results showed a significant relationship between physical activity (p=0.028), frequency of physical exercise (p=0.006), duration of physical exercise (p=0.015), and intensity of physical exercise (p=0.034) with blood glucose levels. Physical exercise performed at least three times a week, for a minimum duration of 30 minutes per session, and at an appropriate intensity proved effective in controlling blood glucose levels in patients with Type 2 DM. This study emphasizes the importance of incorporating physical exercise into the management plan for Type 2 DM.

Keywords: Type 2 diabetes mellitus, physical exercise, blood glucose level, diabetes management

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease characterized by hyperglycemia resulting from insulin resistance and relative insulin deficiency. This disease has become a global health problem with an increasing prevalence, particularly in developing countries.[1,2] The main risk factors for T2DM include a sedentary lifestyle and unhealthy dietary patterns.[3] Prolonged hyperglycemia can lead to various microvascular and macrovascular complications, such as retinopathy, nephropathy, neuropathy, heart disease, and stroke, which significantly impact the quality of life and life expectancy of patients.[4–6]

Diabetes mellitus (DM) represents an escalating global health concern. The worldwide prevalence of DM was estimated at 8.3% in 2017, with projections indicating a rise to 7079 cases per 100,000 by 2030.[7,8] In 2019, approximately 463 million individuals were affected globally, with Type 2 diabetes accounting for the majority of cases.[9] The disease burden is increasing rapidly, particularly in developed regions like Western Europe, and there are concerning trends in lower-income countries.[8] In Indonesia, the prevalence of Diabetes Mellitus (DM) has shown a significant upward trend over the years. As of 2020, the prevalence was

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estimated at 9.19%, equating to approximately 18.69 million cases. By 2045, this figure is projected to rise to 16.09%, which would mean about 40.7 million cases if no significant interventions are implemented.[10] In 2019, North Sumatra reported a total of 249,519 cases of diabetes mellitus, yet only 144,521 patients accessed healthcare services. By 2022, Medan City emerged as the region with the highest prevalence of type 2 diabetes mellitus in North Sumatra, recording 40,609 cases.[11]

Optimal management of blood glucose levels is crucial for preventing and controlling complications associated with type 2 diabetes mellitus (T2DM). Various strategies have been developed to achieve glycemic targets, including pharmacological therapy, dietary modifications, and physical exercise.[12] Physical exercise, a key component of T2DM management, has been shown to enhance insulin sensitivity, lower blood glucose levels, and improve lipid profiles. Therefore, incorporating physical exercise into T2DM management programs is strongly recommended.[13] Various types of physical exercise, including aerobic exercise, resistance training, and combined exercise, have been shown to provide benefits for glycemic control. Aerobic exercises, such as walking, cycling, and swimming, can improve insulin sensitivity and lower blood glucose levels by increasing glucose uptake by muscles.[14,15] Resistance training, such as weightlifting, increases muscle mass and strength, which also contributes to improved insulin sensitivity and glycemic control.[16]

This study aims to conduct a quantitative analysis of the effect of physical exercise on blood glucose levels, HbA1c, and blood glucose variability in patients with type 2 diabetes mellitus. The hypothesis of this study posits that regular physical exercise significantly reduces blood glucose levels in patients with T2DM. This research is expected to provide robust scientific evidence supporting the benefits of physical exercise in managing T2DM, and it aims to offer practical guidance for healthcare professionals in designing effective physical exercise programs tailored for individuals with T2DM.

Method

This study utilized an observational analytical design, specifically a cross sectional approach. The research was conducted at the Medan Johor Public Health Center in Medan City, North Sumatra, located at Jl. Karya Jaya No. 29B, Pangkalan Masyhur, Medan Johor District, and spanned from November 2021 to July 2022. Inclusion criteria required participants to exhibit both good dietary habits and adherence to medication. Exclusion criteria included diabetic patients who were unable to stand or walk and pregnant individuals. Using consecutive sampling, the study recruited 34 participants from the population that met the inclusion and exclusion criteria.

Primary data were collected through structured interviews using the Global Physical Activity Questionnaire (GPAQ), which assesses respondents' physical activity and exercise engagement. Physical activity was defined as daily activities, measured using the GPAQ, with results expressed in Metabolic Equivalent of Task (MET) values, representing the estimated energy expenditure during physical activities. In addition to physical activity, the study also quantified the frequency, duration, and intensity of exercise. Exercise frequency was defined as the number of exercise sessions per week, categorized: < 3 times/week or ≥ 3 times/week. Exercise duration referred to the total time spent per exercise session, classified: < 30 minutes or ≥ 30 minutes. Exercise intensity, determined by the combination of frequency and duration, was categorized: < 3 x 30 minutes or ≥ 3 x 30 minutes. The dependent variable, blood glucose level, was measured as the random glucose concentration in capillary blood using a Benecheck glucometer, with results categorized as controlled (99-199 mg/dL) or uncontrolled (≥ 200 mg/dL).

Univariate analysis was conducted to describe respondent characteristics, including age, gender, and type of physical activity, and to outline the distribution of each independent and dependent variable. Independent variables included physical activity, exercise frequency, exercise duration, and exercise intensity. The dependent variable was blood glucose level in individuals with Type 2 Diabetes Mellitus. Bivariate analysis was employed to examine the relationship between independent and dependent variables, specifically to determine the association between physical activity, exercise frequency, exercise duration, and exercise intensity with mean blood glucose levels in T2DM patients. Chi-square tests were employed to determine the statistical significance of these relationships ($p < 0.05$).

Results

Table 1 presents the characteristics of the 34 patients included in the study. The data encompass the distribution of age, gender, type of physical activity, level of physical activity, frequency, duration, and

intensity of physical exercise. The majority of patients were in the 50-60 year age range, with 15 individuals representing 44.1% of the total sample. Eleven patients (32.4%) were over 60 years old, while 8 patients (23.5%) were between 40 and 50 years old. This indicates that the study involved a population primarily composed of middle-aged and elderly adults.

Table 1. Patient characteristics (n= 34)

Characteristic	n	%
Age		
40-50 years	8	23,5
50-60 years	15	44,1
> 60 years	11	32,4
Gender		
Male	18	52,9
Female	16	47,1
Type of physical exercise		
Gymnastics	4	11,8
Jogging	20	58,8
Running	2	5,9
None	8	23,5

The gender distribution was nearly balanced, with 18 male patients (52.9%) and 16 female patients (47.1%). This suggests that the sample is reasonably representative of both genders. Jogging was the most common type of physical activity among the patients, with 20 individuals (58.8%) choosing this option. Gymnastics was selected by 4 individuals (11.8%), and running was chosen by 2 individuals (5.9%). Interestingly, 8 patients (23.5%) did not engage in any physical activity.

Table 2 presents an analysis of the association between physical activity and blood glucose control, categorized by total physical activity (METs), frequency, duration, and exercise intensity. Patients with physical activity levels below 600 METs exhibited a high proportion of uncontrolled blood glucose (88.2%, n=15/17), compared to only 47.1% (n=8/17) in those with controlled levels. Conversely, patients with physical activity levels between 600 and 3000 METs demonstrated a low proportion of uncontrolled blood glucose (11.8%, n=2/17) and a high proportion of controlled blood glucose (52.9%, n=9/17). This difference was statistically significant (p=0.028), with a relative risk (RR) of 3.587 (95% CI: 0.989-13.013), indicating a 3.587-fold increased risk of uncontrolled blood glucose in patients with METs <600. However, interpretation warrants caution due to the lower confidence interval limit approaching 1.

Patients exercising fewer than three times per week had a high proportion of uncontrolled blood glucose (82.4%, n=14/17) compared to those with controlled levels (29.4%, n=5/17). In contrast, patients exercising three or more times per week showed a low proportion of uncontrolled blood glucose (17.6%, n=3/17) and a high proportion of controlled blood glucose (70.6%, n=12/17). This difference was highly significant (p=0.006), with an RR of 3.684 (95% CI: 1.293-10.499), indicating a 3.684-fold increased risk of uncontrolled blood glucose in patients exercising fewer than three times per week.

Table 2. Association of physical activity with blood glucose control

Variable	Blood glucose levels				p	RR 95%CI
	Uncontrolled		Controlled			
	n	%	n	%		
Physical activity						
MET < 600	15	88,2	8	47,1	0,028	3,587 (0,989-13,013)
600 ≤ MET < 3000	2	11,8	9	52,9		
Physical activity frequency						
< 3 times/week	14	82,4	5	29,4	0,006	3,684 (1,293-10,499)
≥ 3 times/week	3	17,6	12	70,6		
Duration of physical exercise						
< 30 minutes per session	11	64,7	3	17,6	0,015	2,619 (1,271-5,398)
≥ 30 minutes per session	6	35,3	14	82,4		
Physical exercise intensity						
< 3 x 30 minutes per week	14	82,4	7	41,2	0,034	2,889 (1,024-8,153)
≥ 3 x 30 minutes per week	3	17,6	10	58,8		

Patients with exercise durations of less than 30 minutes per session had a high proportion of uncontrolled blood glucose (64.7%, n=11/17) compared to those with controlled levels (17.6%, n=3/17).

Conversely, patients with exercise durations of 30 minutes or more per session showed a low proportion of uncontrolled blood glucose (35.3%, n=6/17) and a high proportion of controlled blood glucose (82.4%, n=14/17). This difference was significant (p=0.015), with an RR of 2.619 (95% CI: 1.271-5.398), indicating a 2.619-fold increased risk of uncontrolled blood glucose in patients whose exercise duration was less than 30 minutes per session.

Patients engaging in exercise at an intensity of fewer than three times for 30 minutes per week had a high proportion of uncontrolled blood glucose (82.4%, n=14/17) compared to those with controlled levels (41.2%, n=7/17). In contrast, patients exercising at an intensity of three or more times for 30 minutes per week showed a low proportion of uncontrolled blood glucose (17.6%, n=3/17) and a high proportion of controlled blood glucose (58.8%, n=10/17). This difference was significant (p=0.034), with an RR of 2.889 (95% CI: 1.024-8.153), indicating a 2.889-fold increased risk of uncontrolled blood glucose in patients engaging in exercise at an intensity of fewer than three times for 30 minutes per week.

Overall, the analysis demonstrates that higher physical activity levels (METs), more frequent exercise, longer durations, and greater intensity are significantly associated with better blood glucose control. These findings underscore the importance of regular physical activity in diabetes management.

Discussion

The study's finding that patients with physical activity levels below 600 METs have a significantly higher proportion of uncontrolled blood glucose (88.2%) aligns with previous research indicating that regular physical activity is crucial for glycemic control. A systematic review highlighted that aerobic and resistance exercises can effectively reduce blood glucose levels and improve HbA1c in individuals with type 2 diabetes (T2DM).[17] Similarly, a meta-analysis found that physically active diabetes patients had controlled blood glucose levels 2.4 times more often than their inactive counterparts.[18] These studies support the notion that increased physical activity is essential for managing diabetes effectively. Moreover, the significant difference in blood glucose control based on exercise frequency—where exercising fewer than three times per week resulted in an 82.4% rate of uncontrolled blood glucose—echoes findings from the American Diabetes Association, which emphasizes the importance of regular exercise (150-300 minutes of moderate-intensity) for optimal glycemic control.[19] The current study's results reinforce these guidelines, suggesting that increasing exercise frequency can substantially reduce the risk of uncontrolled blood glucose.

The analysis also revealed that patients who exercised for less than 30 minutes per session exhibited a high proportion of uncontrolled blood glucose (64.7%). This observation is consistent with literature indicating that longer durations of exercise enhance insulin sensitivity and glycemic control.[20] Studies suggest that regular moderate-intensity exercise can maintain increased insulin sensitivity for up to 48 hours post-exercise, highlighting the importance of both duration and consistency in physical activity.[21,22] Lastly, the impact of exercise intensity on glycemic control is supported by evidence showing that higher intensity workouts can lead to significant improvements in insulin sensitivity and overall metabolic health in T2DM patients.[14,20] The current study’s finding that patients engaging in intense exercise (≥3 times for 30 minutes) had a significantly lower rate of uncontrolled blood glucose further corroborates this.

The implications of these findings are profound for diabetes management strategies. They suggest that healthcare providers should prioritize physical activity as a fundamental component of diabetes care. Tailoring exercise recommendations to individual patient capabilities and preferences may enhance adherence to physical activity regimens. Given the strong association between increased physical activity and improved glycemic control, interventions aimed at promoting regular exercise should be implemented. This may include structured exercise programs, community support initiatives, or personalized fitness plans designed to meet the specific needs of patients with varying levels of fitness and motivation. Furthermore, education on the benefits of both aerobic and resistance training should be emphasized in clinical settings. Patients should be informed not only about the quantity but also the quality and type of exercise necessary for optimal blood glucose management. In conclusion, this study adds to the growing body of evidence supporting the critical role of physical activity in managing diabetes. By fostering an environment that encourages regular exercise, healthcare providers can significantly improve patient outcomes related to blood glucose control.

Conclusion

This study examined the relationship between physical activity and blood glucose control in 34 patients, predominantly aged between 50 and 60 years, with a near-balanced gender distribution. The findings demonstrate that physical activity significantly impacts blood glucose control. Patients with low levels of physical activity, defined as below 600 METs, tended to exhibit uncontrolled blood glucose levels. Furthermore, exercise frequencies of less than three times per week, exercise durations under 30 minutes per session, and inadequate exercise intensity also correlated with poor blood glucose control. Conversely, patients who were physically active—those with activity levels exceeding 600 METs, exercising at least three times per week for a minimum of 30 minutes per session, and maintaining sufficient exercise intensity—demonstrated better blood glucose control. These findings underscore the importance of regular and adequate physical activity in diabetes management. Regular physical activity, characterized by appropriate duration and intensity, proves effective in improving blood glucose control. Therefore, healthcare providers should prioritize tailored physical activity recommendations for each patient while educating them on the benefits of physical activity in diabetes management.

References

1. Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqi H, Uribe KB, et al. Pathophysiology of Type 2 Diabetes Mellitus. Int J Mol Sci. 2020 Aug 30;21(17):6275.
2. DeFronzo RA, Ferrannini E, Groop L, Henry RR, Herman WH, Holst JJ, et al. Type 2 diabetes mellitus. Nat Rev Dis Prim. 2015 Jul 23;1(1):15019.
3. Sami W, Ansari T, Butt NS, Hamid MRA. Effect of diet on type 2 diabetes mellitus: A review. Int J Health Sci (Qassim). 2017;11(2):65–71.
4. Lu Y, Wang W, Liu J, Xie M, Liu Q, Li S. Vascular complications of diabetes: A narrative review. Medicine (Baltimore). 2023 Oct 6;102(40):e35285.
5. Cade WT. Diabetes-Related Microvascular and Macrovascular Diseases in the Physical Therapy Setting. Phys Ther. 2008 Nov 1;88(11):1322–35.
6. Zakir M, Ahuja N, Surksha MA, Sachdev R, Kalariya Y, Nasir M, et al. Cardiovascular Complications of Diabetes: From Microvascular to Macrovascular Pathways. Cureus. 2023 Sep 24;15(9).
7. Raghav A, Ahmad J, Noor S, Ozair M, Alam K, Mishra BK, et al. Updates of Diabetes Mellitus: A Concern for Public Health. J Res Diabetes Metab. 2017;3(1).
8. Khan MAB, Hashim MJ, King JK, Govender RD, Mustafa H, Al Kaabi J. Epidemiology of Type 2 Diabetes – Global Burden of Disease and Forecasted Trends. J Epidemiol Glob Health. 2019;10(1):107.
9. Ratre B, Patel D, Patel D, Patel H, Patel S, Singh D. Review Paper for Diabetes Mellitus. Int J Adv Multidiscip Res Stud. 2024 Dec 13;4(6):927–31.
10. Wahidin M, Achadi A, Besral B, Kosen S, Nadjib M, Nurwahyuni A, et al. Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs. Sci Rep. 2024 Mar 5;14(1):5424.
11. Dinas Kesehatan Provinsi Sumatera Utara. Profil Kesehatan Provinsi Sumatera Utara Tahun 2018. Medan; 2019.
12. Sugandh F, Chandio M, Raveena F, Kumar L, Karishma F, Khuwaja S, et al. Advances in the Management of Diabetes Mellitus: A Focus on Personalized Medicine. Cureus. 2023 Aug 18;15(8).
13. Zahalka SJ, Abushamat LA, Scalzo RL, Reusch JEB. The Role of Exercise in Diabetes. Treasure Island (FL): StatPearls Publishing; 2023.
14. Kirwan JP, Sacks J, Nieuwoudt S. The essential role of exercise in the management of type 2 diabetes. Cleve Clin J Med. 2017 Jul;84(7 suppl 1):S15–21.
15. van Dijk JW, van Loon LJC. Exercise Strategies to Optimize Glycemic Control in Type 2 Diabetes: A Continuing Glucose Monitoring Perspective. Diabetes Spectr. 2015 Feb 1;28(1):24–31.
16. Lee J, Kim D, Kim C. Resistance Training for Glycemic Control, Muscular Strength, and Lean Body Mass in Old Type 2 Diabetic Patients: A Meta-Analysis. Diabetes Ther. 2017 Jun 5;8(3):459–73.
17. Fajriyah N, Sudiana IK, Dwi Wahyuni E. The Effects from Physical Exercise on the Blood Glucose Levels, HbA1c and Quality of Life of Type 2 Diabetes Mellitus Patients: A Systematic Review. J Ners. 2020 Jul 7;15(1):486–96.
18. Asfaw MS, Dagne WK. Physical activity can improve diabetes patients' glucose control; A systematic review and meta-analysis. Heliyon. 2022 Dec;8(12):e12267.
19. Zhang C, Yang J. Personalizing Physical Activity for Glucose Control Among Individuals With Type 2 Diabetes: Are We There Yet? Diabetes Care. 2024 Feb 1;47(2):196–8.
20. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. Diabetes Care. 2016 Nov 1;39(11):2065–79.
21. Syeda USA, Battillo D, Visaria A, Malin SK. The importance of exercise for glycemic control in type 2 diabetes. Am J Med Open. 2023 Jun;9:100031.
22. Hawley JA, Lessard SJ. Exercise training-induced improvements in insulin action. Acta Physiol. 2008 Jan 29;192(1):127–35.