Meta-Analysis of the Effect of Physical Exercise on Decrease Blood Sugar Levels in Type-2 Diabetes Mellitus Patients

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ABSTRACT

Background: Diabetes Mellitus is a major health problem worldwide, the number of sufferers is expected to increase rapidly every year. Handling to achieve controlled sugar levels requires the integration of drugs, diet and physical exercise. This study aimed to analyze the effect of physical exercise on reducing blood sugar levels in patients with type 2 diabetes mellitus.

Subjects and Method: This study uses the PRISMA flowchart to perform the meta-analysis. The article review process took place between 2017 and 2022 with PICO as follows, Population: type-2 diabetes mellitus sufferers. Intervention: physical exercise. Comparison: not doing physical exercise. Outcome: decrease in blood sugar levels, articles collected using databases such as PubMed, Google Scholar, and Science Direct. The articles obtained will be filtered using the stages according to the PRISMA flow diagram. The analysis was carried out using RevMan 5.3.

Results: A total of 9 articles reviewed in the meta-analysis showed that physical exercise reduced blood sugar levels in type 2 diabetes mellitus patients with statistical significance (SMD= -0.44; 95% CI= -0.84 to -0.05; p= 0.030).

Conclusion: Physical exercise lowers blood sugar levels in people with type 2 diabetes mellitus..

Keywords: physical exercise, diabetes mellitus type 2, decrease in blood sugar levels.

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BACKGROUND

Diabetes Mellitus is a major health problem that has reached an alarming level. Today, more than half a billion people live with diabetes worldwide. In 2000, the global estimate of the prevalence of diabetes in the 20 to 79 year age group was 537 million (10.5%) of the global population at that time. It is estimated that 643 million people will suffer from diabetes in 2030 (11.3% of the population) and the number will jump to 783 million (12.2%) in 2045. In Indonesia, the number of patients increased from 10.7 million in 2019 to 13.7 million in 2030 (IDF, 2021; PERKENI, 2021).

Diabetes mellitus is a condition of increased blood glucose levels because the body cannot produce the hormone insulin or cannot use insulin effectively. Symptoms that often appear are polyuria, polydipsia and weight loss. The diagnosis can be made on the basis of: random venous plasma glucose concentration of 11.1 mmol/l or asymptomatic by fasting plasma glucose

concentration of 7.0 mmol/l (whole blood 6.1 mmol/l or HbA1c 6.5%) (IDF, 2021).

Scientific and evidence-based management of Diabetes Mellitus is applied to lower blood glucose levels including, through increasing physical activity and diet modification (Ogbu and Musco, 2021). Regular physical activity is considered as one of the cornerstones of lifestyle modification in the prevention and management of Diabetes Mellitus (Fayehun et al., 2018; Heiskanen et al., 2018). Physical activity and exercise are effective means of risk factors for metabolic syndrome in type 2 diabetes mellitus (Azarmehr et al., 2017; Eaglehouse et al., 2017).

Based on the many cases of Diabetes Mellitus that exist in our society and the need to do physical exercise to reduce blood sugar levels in its management, researchers are interested in conducting a meta-analysis on the Effect of Physical Exercise on Reducing Blood Sugar Levels in Type 2 Diabetes Mellitus Patients. This study aimed to analyze the effect of physical exercise on reducing blood sugar levels in patients with type 2 Diabetes Mellitus, with a meta-analysis of previously conducted primary studies.

SUBJECTS AND METHOD

1. Study Design
This research was conducted using a meta-analysis research design with PRISMA flow chart guidelines. Article searches were performed using the following databases: PubMed, Google Scholar and ScienceDirect. Some of the keywords used include: Diabetes Mellitus Type 2" OR "Diabetes Mellitus Type II" AND (Exercise OR "Physical Exercise" OR "Exercise Training" OR "Exercise Trainings" OR "Aerobic Exercise") AND "Blood Glucose".

2. Inclusion Criteria
The inclusion criteria for this research article were articles 2013-2022 that used English, randomized controlled trial study designs, measure the relationship using the Mean and Standard Deviation.

3. Exclusion Criteria
The exclusion criteria for this research article were article that are not in English, research subjects with pregnancy, the article is not full text.

4. Operational Definition of Variables
The articles included in this study are PICO-adjusted. The article search was carried out by considering the eligibility criteria determined using the PICO model as follows: Population= type 2 Diabetes Mellitus sufferers, Intervention= Physical Exercise, Comparison = not doing physical exercise, Result= Decrease in blood sugar levels.

Diabetes Mellitus is a group of chronic metabolic diseases characterized by hyperglycemia or an increase in blood sugar levels that occurs because the body cannot produce the hormone insulin or cannot use insulin effectively, or both. Symptoms that often appear are polyuria, polydipsia and weight loss. The diagnosis can be made on the basis of a random increase in venous plasma glucose concentration above 11.1 mmol/l or a fasting plasma glucose concentration above 7.0 mmol/l (whole blood 6.1 mmol/l or HbA1c over 6.5%).

Physical exercise is a form of planned, structured, and continuous physical activity that involves repetitive body movements and is aimed at improving physical health and fitness. To achieve optimal results, physical exercise needs to be done at least 3-5 times a week with moderate intensity for 30-60 minutes.

Decrease in Blood Sugar Levels is a decrease in blood sugar levels in mmol/L that occurs after physical exercise. Decrease

in blood sugar levels is categorized as numerical data and the measurement scale is continuous.

5. Instruments

The research was guided by the PRISMA flowchart and assessment of the quality of research articles using the Critic al Assessment Skills Program tool (jbi.global, 2020). The 13 questions used are as follows.

The 13 randomized controlled trial study questions used are as follows:

1. Was true randomization used for assigning participants to treatment groups?
2. Was the allocation to the treatment group hidden?
3. Were the treatment groups similar at baseline?
4. Were participants blind to treatment assignments?
5. Are those administering the treatment blind to the treatment assignment?
6. Are outcome raters blind to treatment assignments?
7. Was the treatment group treated identically other than the intervention of interest?
8. Was follow-up complete and if not, were differences between groups in terms of follow-up adequately explained and analyzed?
9. Were participants analyzed in randomized groups?
10. Were outcomes measured in the same way for the treatment group?
11. Are results measured in a reliable way?
12. Was appropriate statistical analysis used?
13. Was the trial design appropriate, and any deviations from the standard RCT design (randomization of individuals, parallel groups) accounted for in the conduct and analysis of the trial?

6. Data Analysis

Research data were analyzed using the RevMan 5.3 application, to calculate the effect size and heterogeneity of the study. The results of data processing are presented in the form of forest plots and funnel plots.
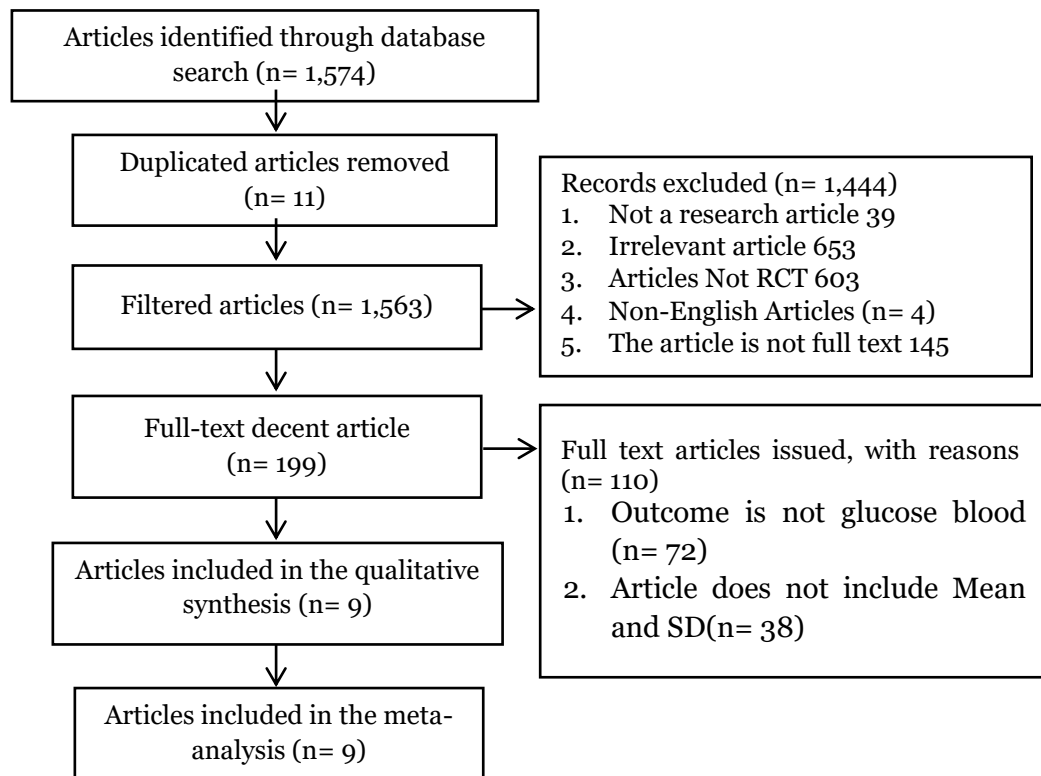
RESULTS

Process of searching article wascarried out by searching several journal databases PubMed, Sciencedirect, and Googlescholar. it can be seen using the PRISMA FLOW flowchart shown in Figure 1.

Table 1. Assessment of the Quality Studies by Joanna Briggs Institute

Primary Study	Criteria													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Mendes et al (2019)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Metcalfe et al (2018)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Li et al (2020)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
MacDonald et al (2020)	2	2	2	2	2	2	2	2	2	2	1	2	2	25
Li et al (2018)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Mensberg et al (2017)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Duvivier et al (2017)	2	2	2	2	2	2	2	2	2	2	2	1	2	25
Karstoft et al (2013)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Tabari et al (2014)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Note: Answer: Yes=2, No =1, Can't tell=0														

Figure 1. Results of Prisma Flow Diagrams

Figure 2. Resarch Distribution Map

**Table 2. Description of Primary Research included in the Meta-Analysis**

| Author (Year) | Country | Study Design | Sample | | P | I | C | O | Mean | | SD | |
			I (PE)	C (Not PE)					PE	Non-PE	PE	Non-PE
Mendes et al (2019)	Portugal	RCT	15	15	Patients with type 2 DM (HbA1c) less than 10%; stable 3 months non-smoker in the last 6 months and without complications	Treadmill walking with HIIT (high-intensity interval training) 40 min for 3 weeks	No Treadmill, CON (control session of rest)	Average value of by measuring Capillary blood glucose in values (mg/dL)	4.54	6.89	0.80	1.66
Metcalfe et al (2018)	UK	RCT	11	11	Type 2 DM No history of cerebrovascular cardiovas-cular disease, impaired kidney or liver function, uncontrolled hypertension	REHIT, do a sprint done at 2 minutes 40 seconds and 6 minutes 40 seconds into a 10 minute training session	Control session of rest (CON) perform daily activities	Average value of blood glucose 24 hours measuring blood sugar levels in mmol/L	7.74	8.11	0.59	1.05
Li et al (2020)	China	RCT	34	29	Type 2 diabetes is three months old, is not involved in moderate or strenuous activities, can ambulate independently	Gigong Fitness, 60 min for 12 weeks. The qigong fit-ness training program in this study was con-ducted and	Control stretching, instructor-supervised stretching, consisted of 20 minutes of health education and 40	Average blood value by measurement of fasting Plasma Glucose (FPG) in mmol/L	8.78	6.83	3.46	2.80

| Author (Year) | Country | Study Design | Sample | | P | I | C | O | Mean | | SD | |
			I (PE)	C (Not PE)					PE	Non-PE	PE	Non-PE
					, and has no cognitive impairment	choreographed by the qigong research team,	minutes of exercise five times per week for 12 weeks.					
MacDonald et al (2020)	Mayo Clinic	RCT	61	31	DM type 2 intensive lifestyle intervention (U-TURN). Both groups received lifestyle advice and medical regulations	UTURN 12 months aerobic and resistance training .supervised counseling	Standard Care (StC), with lifestyle interventions and without aerobic exercise	Average blood value by measuring blood glucose in mmol/L	7.38	7.40	0.45	1.10
Li et al(2018)	China	RCT	29	29	Uncomplicated type 2 diabetes is contraindicated for physical activity	MIE (moderate-intensity exercise, exercise, participants walked on a treadmill for 20 minutes after dinner, with a heart rate reserve of 40%.	CON, non-exercise control, patients with normal daily activities but refrain from strenuous physical activity	Average blood value 2jpp with continous glucose monitoring system measurement in mmol/L	8.20	8.90	1.30	2.00

| Author (Year) | Country | Study Design | Sample | | P | I | C | O | Mean | | SD | |
			I (PE)	C (Not PE)					PE	Non-PE	PE	Non-PE
Mensberg et al (2017)	Denmark	RCT	36	34	DM type 2 is overweight, disorganized and doesn't move much	Exercise compliance and physical fitness 16 weeks, 60 minutes 2x a week	CON (control session of rest)	Average blood value by measuring blood glucose in mmol/L	7.00	9.80	1.60	3.70
Duvivier et al (2017)	Netherland	RCT	20	19	Type 2 diabetes without disease that interferes with participation in physical activity, and alcohol abuse	Moderate-vigorous intensity exercise (Breaking sitting) 150 minutes per week for 14 days. Physical activity was measured 24 hours/day using the activPAL3 monitor (PAL Tech-nologies, Glasgow, Scotland).	Sitless regimen. Performing daily activities Physical activity was measured 24 hours/day using the activPAL 3 monitor (PAL Technologies, Glasgow, Scotland).	Average value of blood 24h by measuring glucose levels in mmol/L	7.29	7.35	0.24	0.19
Karstoft et al (2013)	Denmark	RCT	24	22	DM type 2, recruit volunteers with medical	CWT 60 minutes 5 sessions per week for 4	CON performs daily activities and	Average blood glucose by measuring fasting glucose	7.70	8.20	0.70	0.90

| Author (Year) | Country | Study Design | Sample | | P | I | C | O | Mean | | SD | |
			I (PE)	C (Not PE)					PE	Non-PE	PE	Non-PE
					examination, physical, blood chemistry analysis, and oral glucose tolerance test	months accelerometer and heart rate monitor	is still measured with an accelerometer and heart rate monitor	in mmol/L				
Tabari et al(2014)	Iran	RCT	27	26	Type 2 DM based on age (>40 and <40) and Body Mass Index (BMI) (≥25 and <25	Aerobic exercise 8-week 3x a week, measuring heart rate and blood glucose levels	CON control group without intervention, heart rate and blood sugar levels are still being measured	Average blood glucose by measuring fasting plasma glucose in mg/dl (7mmol/L)	7.48	9.03	4.39	0.09
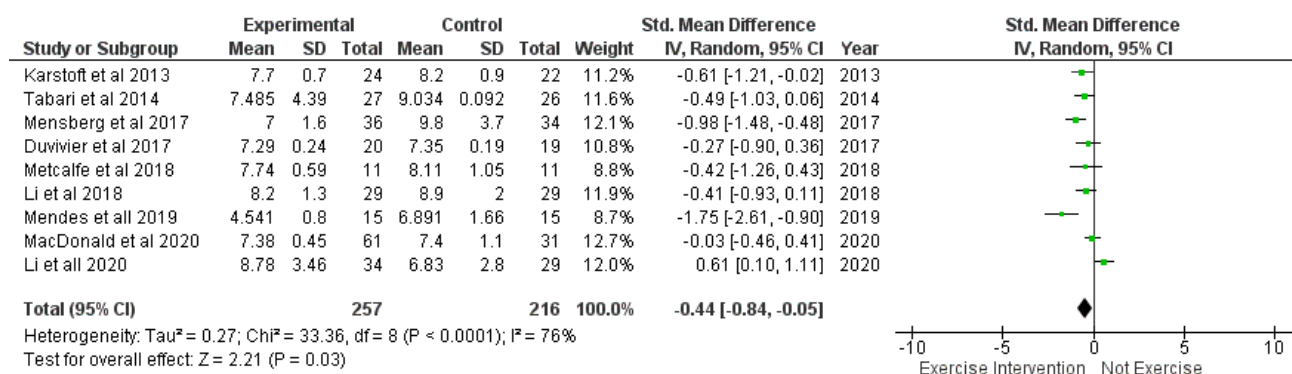
Figure 3. Forest plot the Effect of Physical Exercise on Decline Blood Sugar Levels for Type-2 Diabetes Mellitus Patients

The forest plot in Figure 3. shows that physical exercise reduces blood sugar levels of people with diabetes mellitus 0.44 times compared to patients with diabetes mellitus who do not do physical exercise, and the results are statistically significant. (SMD= -0.44; 95% CI= -0.84 to -0.05; p = 0.030).
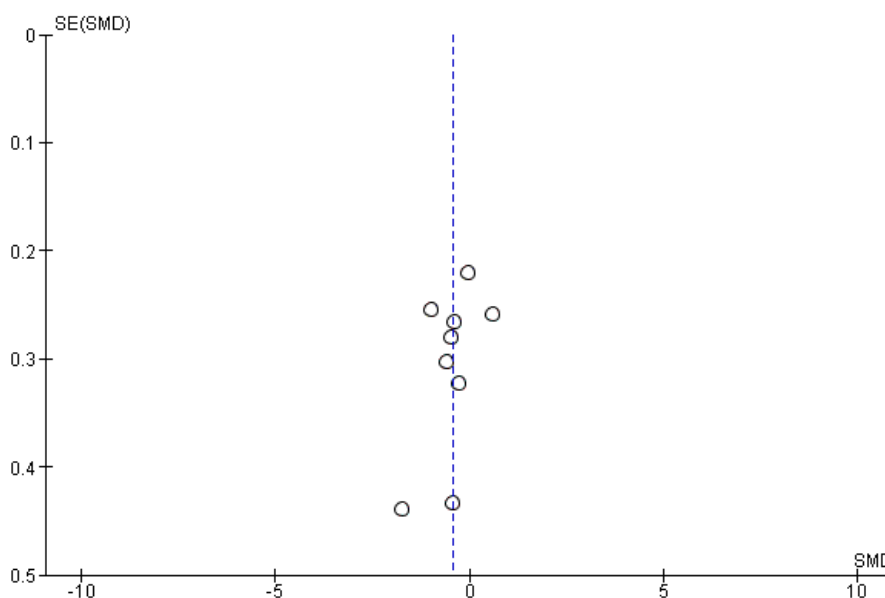
Figure 4. Funnel plot the Effect of Physical Exercise on Decline Blood Sugar Levels for Type 2 Diabetes Mellitus Patients

The funnel plot in Figure 4 showed there is not publication bias characterized by an symmetrical distribution between the right and left plots.

DISCUSSION

This systematic review and meta-analysis research raised the theme of the effect of physical exercise on reducing blood sugar levels in patients with type 2 diabetes mellitus. This study discusses physical exercise, this is considered important in the management of people with diabetes mellitus. Because physical exercise can reduce blood sugar levels of people with diabetes mellitus, support in controlling blood sugar levels (Wang et al., 2021).

The Main Study that met the criteria were 9 articles, spread across several countries. The results of the Florest plot showed the magnitude of the effect of physical exercise on reducing blood sugar levels in patients with diabetes mellitus and was statistically significant (SMD= -0.44; 95% CI= -0.84 to -0.05; p= 0.030). The heterogeneity of the research data showed I^2= 76% so that the distribution of the data was declared heterogeneous (random effect model). The symmetrical distribution of the funnel plot indicates that there is no publication bias.

The exercise group carried out five sessions per week (60 minutes/session) walking training with moderate intensity, continuous-walking training (CWT) for 4 months (Karstoft et al., 2013). The exercise protocol consisted of warming up, stretching and flexibility exercises for 10 minutes, followed by walking for 30 minutes with a maximum intensity of 60% increase in heart rate and then stretching in a sitting position for 10 minutes, 3 times a week for 8 weeks (Motahari-Tabari et al., 2014). Other researchers used the 40-minute high-intensity interval training (HIIT) method every day for 3 weeks (Mendes et al., 2019).

In another study, intensive lifestyle intervention (U-TURN) by doing aerobic exercise and resistance training for 12 months under supervision of counseling could reduce blood glucose levels (Mac-Donald et al., 2020). Duvivier et al. (2017) mentioned that sitting rest by standing and walking with light intensity can be an alternative structured exercise to improve glycemic control in type 2 diabetes patients. The qigong fitness training program choreographed by the qigong research team with 60 minutes of exercise every week for 12 weeks was able to lower blood sugar levels. blood (Li et al., 2020). Reduced-exertion high-intensity interval training

(REHIT) is a truly time-efficient exercise intervention to control blood sugar levels in patients with type 2 diabetes mellitus (Metcalfe et al., 2018).

Physical exercise can reduce blood sugar levels in people with type 2 Diabetes Mellitus, the results are in accordance with the hypothesis. According to Metcalfe et al, (2018) emphasized the importance of a multi-component treatment approach in type 2 diabetes, incorporating regular exercise, which is an effective strategy to lower the patient's blood sugar level. Physical activity is a major modifiable risk factor that has been shown to improve glucose tolerance (Temple et al., 2019). According to Cox et al. (2020) states the American Diabetes Association concludes: 'Reducing overall carbohydrate intake for individuals with diabetes has shown the best evidence of lowering glycemia.

This study investigates a diabetes mellitus management program by reducing postprandial glucose through reducing carbohydrate consumption and increasing routine physical activity. Other investigators have also shown that exercise, drugs and diet have altered the profile of liver fat in individuals at risk for type 2 diabetes mellitus. In particular, exercise has been used as an important management strategy in the management of patients with diabetes mellitus. Several studies have reported a strong effect of exercise training intervention in reducing fatty liver and hepatic steatosis in patients with diabetes mellitus.

The results of this study are in line with research conducted by Yao et al., (2021) evaluating the effects of physical activity on people with diabetes mellitus in China. Self-management behaviors such as diet control, physical activity, medical compliance, and glucose monitoring alone have been suggested to achieve better

glycemic control status and clinical outcomes and thereby reduce the substantial physical, psychological, and socioeconomic burden of disease at the family and community levels. With exercise 3-5 times a week, 30-40 minutes at a time can lower blood sugar levels. Diabetic patients are usually encouraged to engage in active exercise, which is beneficial for regular glycemic control.

Other researchers also support this research. Physiological indicators, such as body mass index (BMI), waist circumference, triglycerides, low density lipoprotein, systolic and diastolic blood pressure, and blood glucose were significantly reduced plus graded diagnosis and treatment strategy groups. Management indicators (such as compliance with blood glucose monitoring, level of adherence to diet control, and level of exercise adherence) also improved substantially (Liang et al., 2020). With the results of fasting plasma glucose intervention (Mean= 6.10; SD= 1.13) vs control (Mean= 7.84; SD= 1.07), with $p < 0.001$.

The combination of diet and exercise is the cornerstone of treatment in type 2 diabetes mellitus because it improves glycemic control, improves insulin sensitivity, reduces fat mass (including visceral fat), and lowers serum triglycerides (Otten et al., 2019).

AUTHOR CONTRIBUTION
Tri Nyantosani Widyawardani is the main researcher who selects the topic, searches for and collects research data. Diyanti Safitri analyzes data and reviews research documents.

FUNDING AND SPONSORSHIP

CONFLICT OF INTEREST
There is no conflict of interest in this study.

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