

The Effect of High-Intensity Interval Training on Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus: A Literature Review

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ABSTRACT

Diabetes Mellitus (DM) is a chronic and progressive disease characterized by elevated blood glucose levels. This study aims to investigate the effect of High-Intensity Interval Training on blood glucose levels in patients with type 2 diabetes mellitus through a literature review. The comprehensive search in the database resulted in 7,737 articles: Pubmed (2,610), Science Direct (4,724), Scopus (282), and Springer (121), and only 11 articles met the criteria for further review. A comprehensive analysis of the included studies reveals the effect of HIIT on blood glucose levels in type 2 DM patients, which can be observed through changes in blood glucose levels and HbA1c following exercise. In conclusion, our findings suggest that HIIT could be an essential intervention for managing blood glucose in Type 2 DM patients.

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1. INTRODUCTION

Diabetes Mellitus is a metabolic disorder distinguished by symptoms such as high blood glucose levels, which can affect the breakdown of food substances, especially carbohydrates (Moini *et al.*, 2022, p. 2). The International Diabetes Federation (IDF) reports an improvement in the occurrence of Diabetes Mellitus each year, attributed to changes in unhealthy lifestyles. Indonesia, categorized as one of the countries with the highest number of Diabetes Mellitus cases in the Southeast Asia region, has a total of 10 million cases, with type 2 DM being the most common (Kementrian Kesehatan, 2020).

Type 2 Diabetes Mellitus arises from disorders of the pancreas gland, which affect insulin production and lead to an imbalance between insulin levels and blood glucose. This condition is characterized by high blood glucose levels or hyperglycemia. It is crucial to monitor glycemic status by measuring hemoglobin A1c (HbA1c) and examining blood glucose levels manually (Alam *et al.*, 2014). Treatment options for Type 2 Diabetes Mellitus include pharmacological and non-pharmacological approaches (Putera, 2020). In pharmacological treatments, individuals may be prescribed metformin, biguanide, or tolbutamide to control blood sugar levels. Non-pharmacological treatments, on the other hand, may involve physical exercise to regulate blood sugar levels, promote muscle glucose metabolism, and prevent complications, disability, and death due to type 2 DM (Mirnawati, 2019).

It has been found that High-Intensity Interval Training (HIIT) is a beneficial physical activity for those with type 2 Diabetes Mellitus, as it helps to maintain blood sugar levels. HIIT involves a workout program consisting of high-intensity repetitions or interval designs with short durations. This increases the work of the heart and metabolism, leading to an increase in VO2max (Kravitz, 2014). The program comprises three phases: a warm-up phase, core training with maximum intensity, and a cool-down phase. In adults with type 2 DM, these phases can enhance skeletal muscle oxidative capacity, glycemic control, and insulin sensitivity (Nugraha & Berawi, 2017).

Previous research has suggested that a combination of exercises, including HIIT training, can help manage blood sugar levels in individuals with type 2 DM (Sheikh, 2020). However, further investigation



is needed to fully understand the impact of High-Intensity Interval Training on patients with Type 2 Diabetes Mellitus. In addition, many individuals solely rely on medication to control blood sugar levels and do not engage in physical activity. Given this information, researchers are eager to delve deeper into the potential benefits of High-Intensity Interval Training for blood glucose control in Type 2 Diabetes Mellitus.

2. METHOD

2.1. Research Design

The proposed methodology for research involves a comprehensive literature review. This type of research entails an in-depth analysis of previously published studies, evaluations, and analytical findings from a central viewpoint. It is a data-oriented research approach that does not rely on speculation or debate (Hidayatullah, 2022, pp. 1–2).

2.2. Research Strategy

The research has utilized databases such as Pubmed, Science Direct, Scopus, and Springer by employing the keywords “High-Intensity Interval Training” OR “HIIT” AND “Diabetes Mellitus Type 2” OR “DM 2” AND “Blood Glucose” OR “Glycemic Control.”

The inclusion criteria carried out in this study are as follows: (1) international journals or research articles relating to the effects of High-Intensity Interval Training on blood glucose levels in Type 2 Diabetes Mellitus patients, (2) journals or articles that utilize a Randomized Control Trial research design (RCT), (3) articles published within the last 5–10 years, (4) articles that are available in full text, (5) contains PICO (Population, Intervention, Comparison, Outcome) information, (6) international journal or research article included in Quartile 1 (Q1) to Quartile 4 (Q4). As for the exclusion criteria of this study, they comprise the following: (1) the title of the article does not align with the research title, (2) the article is not written in English, (3) the article does not encompass the complete text, (4) the research abstract contained in the article is not relevant.

2.3. Research Instrument

The research employs the Physiotherapy Evidence Database (PEDro Scale), which serves as a tool for evaluating the quality of Randomized Controlled Trial studies used in literature reviews and systematic analyses. The PEDro Scale is designed to assist with determining the credibility and relevance of trial results published in journals. Points are given based on meeting specific criteria. Each criterion is assigned a value of 1 if present in the article or journal, and 0 if not present.

3. RESULTS

Utilizing a search strategy, a total of 7,737 articles were gathered and screened to finally identify 11 articles that meet the inclusion criteria for analysis. The PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) diagram below provides a concise summary of the article screening process (Fig. 1).

Assessment of journal quality using the PEDro Scale resulted in two articles with fair quality, eight articles deemed good, and the remaining articles considered excellent quality. An outline of the PEDro Scale results, along with journal rankings, are provided in Table I.

The following table provides summary of each article being reviewed including authors, year of publication, population, intervention, and result (Table II).

4. DISCUSSION

This research aims to assess the impact of High-Intensity Interval Training on the blood glucose levels of individuals with Type 2 Diabetes Mellitus. The findings of the research encompassed a total of 746 participants who were categorized into various intervention groups, including HIIT, MICT, or other interventions, as well as a control group. After examining the included study, it is evident that HIIT is beneficial for managing blood glucose levels in individuals with type 2 diabetes through monitoring of HbA1c and blood glucose measurements. Furthermore, it was found that HIIT produced notable improvements compared to other interventions, such as MICT or the control group.

The HIIT approach seeks to optimize the body's metabolic processes by combining high and moderate-intensity training that targets both the aerobic and anaerobic systems (Trisandi *et al.*, 2017). Engaging in more intense physical activity helps in the oxidation of glycogen and triacylglycerol stored in muscle fibers. Eventually, these carbohydrate and fat stores within the muscles serve as the primary

substrate for the increase in oxidative capacity and performance brought about by the resistance training-induced increase in muscle mitochondrial density.

High-Intensity Interval Training (HIIT) can lead to an acute increase in non-oxidative glucose elimination or a decrease in chronic preference for intra-abdominal fat tissue, thereby increasing insulin sensitivity (Liu & Wang, 2021). As glucose is converted into energy beyond regular muscle contractions, muscle glucose deficiency can occur, which triggers the use of glucose in the bloodstream. This mechanism improves blood glucose transmission, leading to better control of blood glucose levels (Putro et al., 2023).

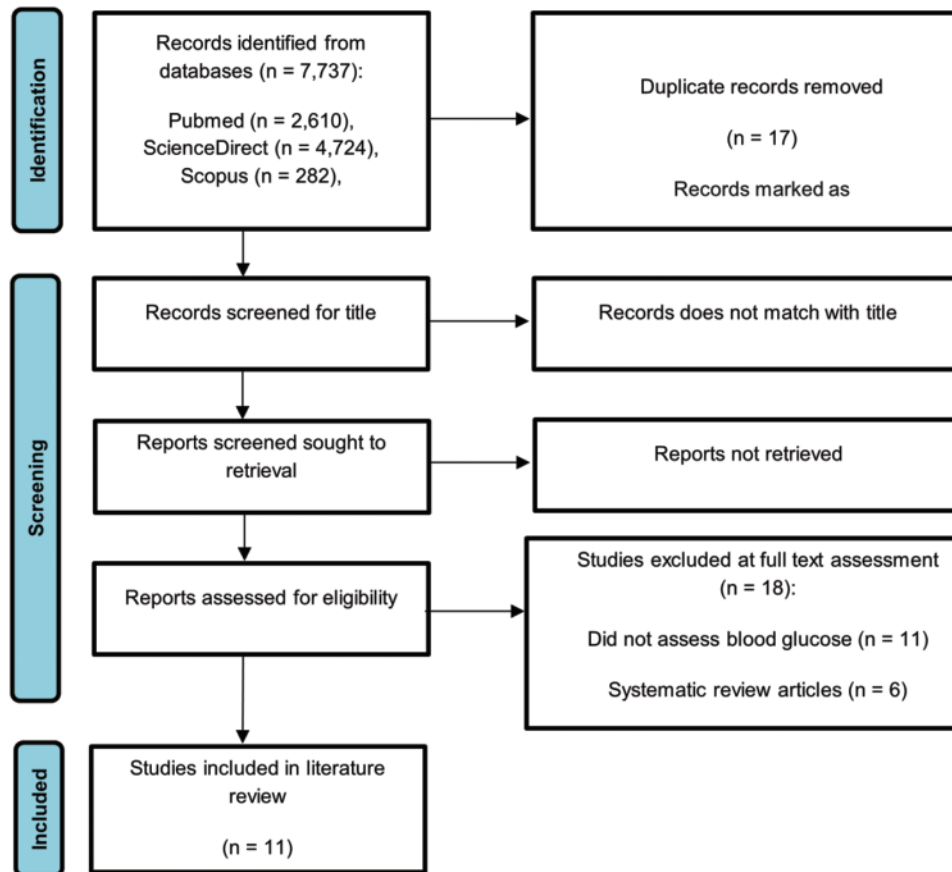


Fig. 1. Search results with PRISMA flowchart.

TABLE I: PEDRO ASSESSMENT AND JOURNAL RANKING

Ranking	Authors (year)	PEDro score	Interpretation of study quality
Q1	Madsen et al. (2015)	5/11	Fair
Q1	Alvarez et al. (2016)	6/11	Good
Q1	Maillard et al. (2016)	7/11	Good
Q1	Støa et al. (2017)	6/11	Good
Q1	Winding et al. (2018)	7/11	Good
Q1	Baasch-Skytte et al. (2020)	6/11	Good
Q1	Gentil et al. (2023)	6/11	Good
Q1	Ahmad et al. (2023)	9/11	Excellent
Q2	Ghardashi Afousi et al. (2018)	6/11	Good
Q2	Liu and Wang (2021)	7/11	Good
Q3	Putro et al. (2023)	5/11	Fair

TABLE II: SUMMARY OF INCLUDED STUDIES

Authors (year)	Population	Intervention	Result
Madsen <i>et al.</i> (2015)	10 non-active Type 2 DM patients and 13 healthy controls	1. HIIT (cycling ergometer 10×1 min intervals with 1 minute of recovery (Cadence: 70 RPM); three times per week over 8 weeks) 2. Healthy controls given the same HIIT	HIIT improves overall glycemic control (average fasting venous glucose concentration ($p = 0.01$), endpoint 2-hour OGTT ($p = 0.04$) and glycosylated haemoglobin ($p = 0.04$)) as well as pancreatic β cell function (insulin resistance (HOMA-IR) ($p = 0.03$) and HOMA β cell function (HOMA-% β) ($p = 0.03$)) in T2 DM patients.
Alvarez <i>et al.</i> (2016)	28 patients with type 2 diabetes	1. Low-volume HIT (progressive running; tri-weekly program for 16 weeks) 2. Control (non-exercise)	The low-volume HIT program has proven effective to improve glycemic control (fasting glucose $p < 0.001$) and HbA1c ($p < 0.001$), lipid (HDL cholesterol $p < 0.001$ and triglyceride $p = 0.001$) and blood pressure levels ($p = 0.002$), endurance performance ($p < 0.001$), and anthropometry (waist circumference $p < 0.001$ in T2 DM women).
Maillard <i>et al.</i> (2016)	17 post-menopausal women with T2 DM	1. HIIT (cycling program (60 × (8 sec at 77%–85% HRmax, 12 sec of active recovery); for 16 weeks, 2 days/week) 2. MICT (cycling program (40 min at 55%–60% of their individual HRR); for 16 weeks, 2 days/week)	HIIT reduces greater total abdominal ($p = 0.03$) and visceral FM ($p = 0.02$) in postmenopausal women with T2D more effectively than MCIT. In Addition, HbA1c and TC-to-HDL ratio both decreased after the intervention ($p = 0.80$)
Støa <i>et al.</i> (2017)	38 individuals with T2D	1. HAIT (4 × 4 min of walking or running uphill at 85%–95% of HRmax; for 12 weeks) 2. MIT (continuous walking at 70%–75% HRmax; for 12 weeks)	HAIT is an effective strategy for improving important risk factors associated with T2D. It is more effective than moderate continuous exercise in improving VO2max ($p < 0.001$) and lowering HbA1c ($p < 0.001$).
Winding <i>et al.</i> (2018)	29 individuals with T2D	1. Low-volume HIIT (20 minutes of cycling: 1 min at 95% Wpeak and 1 min of active recovery (20% Wpeak); 3days/week for 11 weeks) 2. Moderate-intensity Endurance Training (40 minutes of cycling at 50% of Wpeak); 3days/week for 11 weeks) 3. Control (no exercise)	Low-volume HIIT can improve glycemic control ($p < 0.05$), aerobic fitness ($p < 0.05$), and body composition ($p < 0.05$) compared to Moderate-intensity Endurance Training and control group in individuals with T2 DM.
Baasch-Skytte <i>et al.</i> (2020)	51 male participants with T2D	1. HIIT (10-20-30 training (cycling; 3 times weekly for 10 weeks lasting 29 min)) 2. MICT (50 min of continuous cycling: 60%–75% of HRreserve (HRpeak–HRrest); 3x/week for 10 weeks)	HIIT revealed better results than MICT in reducing HbA1c levels ($p < 0.001$) in male patients with Type 2 Diabetes. Additionally, only HIIT showed a decrease in visceral fat mass ($p < 0.05$), while both groups experienced a decrease in total fat mass ($p < 0.01$) and an increase in ViO2max ($p < 0.01$). The results were similar within and between the groups.

Table II (continued)

<i>Gentil et al.</i> (2023)	52 men and women with T2DM	1. Short Interval HIIT (consisted of 20 bouts of 30 sec at 100% of V'O₂max with 30 seconds passive recovery) 2. Long Interval HIIT (consisted of 5 bouts of 2 min at 100% of VO₂max with 2 min passive recovery) 3. MICT (involved 14 minutes at 70% of V O₂max)	Low-volume HIIT promoted more significant improvements in cardiorespiratory capacity ($p = 0.04$) compared to low-volume MICT, as well as a significant reduction in HbA _{1c} levels for L-HIIT ($p < 0.05$).
<i>Ahmad et al.</i> (2023)	72 obese women with type 2 diabetes	1. Low-volume HIIT (2 × 4 min treadmill exercise at 85%–90% of peak heart rate, with a 3-min active recovery interval in between) 2. High-volume HIIT (4 × 4 min treadmill exercise at 85%–90% of peak heart rate, with three 3-min active recovery intervals in between) 3. Non-exercising control group	High-volume HIIT may improve glycemic control, TG and LDL control, and cardiorespiratory fitness in patients ($p < 0.05$) better than low-volume HIIT. Meanwhile, The non-exercising group did not show significant changes in any outcome measures ($p > 0.05$).
<i>Ghardashi Afousi et al.</i> (2018)	75 patients with type 2 diabetes and untreated pre- or stage I hypertension	1. Low volume HIIT (12 intervals of 1.5 min at 85–90% maximal heart rate (HR_{max}) and 2 min at 55%–60% HR_{max}; 3x/week for 12 weeks) 2. CMIT (42min of exercise at 70% HR_{max}; for three sessions per week for 12 weeks) 3. Control group without exercise training	High-intensity interval training decrease the oscillatory shear-induced improvement ($p = 0.029$) in FMD, as well as outward artery remodeling. Furthermore, both training groups saw significant reductions in fasting plasma glucose ($p < 0.001$), insulin ($p < 0.0001$), and HOMA-IR ($p = 0.005$) levels, as compared to the control group.
<i>Liu and Wang</i> (2021)	145 patients with pre-diabetes and 196 with type 2 diabetes	1. HIIT (progressing to twelve 1-min bouts at 90% maximal aerobic capacity (1 min recovery)) 2. MICT (progressing to 20 min at 65% maximal aerobic capacity)	Both HIIT and MICT training have been found to significantly reduce the serum levels of ficolin-3 in individuals with pre-diabetes ($p = 0.003$) and diabetes ($p = 0.007$). They also lead to a decrease in Fasting Plasma Glucose (FPG) levels in pre-diabetic individuals ($p = 0.004$) and diabetic individuals ($p = 0.037$). Additionally, the study found that the reductions in the HIIT group were more significant than those in the MICT group.
<i>Putro et al.</i> (2023)	20 people diagnosed with Type 2 DM	HIIT (outdoor running, treadmill exercise, bike exercise with 1:3 work to rest ratio)	High-Intensity Interval Training (HIIT) has been found to be effective in reducing blood sugar levels ($p = 0.001$) in people with type 2 diabetes mellitus.

Note: High-Intensity Interval Training (HIIT), High-Intensity Aerobic Interval Training (HAIT), Moderate-Intensity Continuous Training (MICT), Moderate Intensity Training (MIT).

5. CONCLUSION

The primary findings of this study indicate that High-Intensity Interval Training (HIIT) significantly influences blood glucose levels in individuals with Type 2 Diabetes Mellitus. This effect can be assessed by monitoring blood glucose levels or analyzing HbA_{1c} levels following exercise. However, it is crucial to note that HIIT programs must be tailored to each individual and supervised by a qualified professional. Thus, HIIT presents a valuable intervention in managing glycemic control in Type 2 DM patients.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

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