NIECZYPORUK, Mateusz, SIKORA, Aleksandra, SKWERES, Martyna, PUCYŁO, Szymon, CEGLARZ, Katarzyna, PIELACIŃSKI, Jan, RUDNIK, Aleksander, SIKORA, Kinga and PIOTROWSKA, Gabriela. High-intensity interval training in Diabetes Mellitus: A short systematic review. Journal of Education, Health and Sport. 2025;80:58458 eISSN 2391-8306.
https://doi.org/10.12775/JEHS.2025.80.58458
https://apcz.umk.pl/JEHS/article/view/58458

The journal has had 40 points in Minister of Science and Higher Education of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).
Punkty Ministerialne 40 punktów. Załącznik do komunikatu Ministra Nauki i Szkolnictwa Wyższego z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).
The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 02.02.2025. Revised: 03.03.2025. Accepted: 28.03.2025. Published: 10.04.2025.

High-intensity interval training in Diabetes Mellitus: A short systematic review

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Abstract

In recent decades, diabetes has become a prominent health concern in the developed world, with numerous researchers suggesting that it should be designated as the pandemic of the 21st century. Both type 1 and type 2 diabetes are on the rise, yet the latter poses a particularly significant threat. It is important to note that in a substantial number of cases, the underlying risk factors for type 2 diabetes are amenable to modification, highlighting the potential for preventative strategies. A major contributing factor is low physical activity, which significantly impedes disease control once it has developed.HIIT has been identified as a potentially effective and time-saving physical activity alternative for people with and at risk of diabetes. A comprehensive analysis of 12 papers from the 513 papers in the PubMed database was conducted, highlighting the substantial benefits of HIIT, including the immediate reduction in glucose levels post-training and the enhancement of the daily glycaemic profile due to increased insulin sensitivity of tissues. Similar observations were made regarding the reduction in systolic blood pressure and pro-inflammatory cytokines.

Keywords: diabetes; HIIT – high-intensity interval training, glycemic control; insulin resistance; cardiovascular fitness; training

Introduction

In recent decades, a substantial body of research has demonstrated that physical activity and exercise offer significant health benefits. These benefits encompass a reduction in cardiovascular risk, as indicated by a decrease in LDL fraction, an increase in HDL fraction, a reduction in blood pressure, and a decrease in insulin resistance through an increase in tissue demand for glucose. Other notable benefits include weight reduction, improved wellbeing, immune system function, and hormone management[1, 2]. Type 2 diabetes is a growing problem particularly in developed countries becoming a 'pandemic' of the 21st century. Low levels of physical activity are one of the causes leading to obesity and insulin resistance, and consequently constitute a major factor leading to the development of type 2 diabetes[3-7], in addition, low levels of physical fitness are one of the main predictors of mortality among type 2 diabetes patients[8, 9]. Even a single training session has a beneficial effect on glucose metabolism by increasing insulin sensitivity for 12-48h after training[10-12]. The amount and duration of these benefits varies depending on the type of training adopted. In our review, we will focus on the presentation of high-intensity interval training (HIIT) as an effective option for reducing glycaemic levels in patients with diabetes, as well as those at risk of diabetes.

Physical activity in diabetes

Type 2 diabetes is an escalating problem in the developed world. An estimated 10.5% of the world's adult population is affected by the disease, where around half of these people are unaware of their condition[13, 14]. Chronic hyperglycaemia leads to microvascular and macrovascular complications, which are a major cause of reduced quality of life, healthy life expectancy and mortality among diabetic patients [15-19]. Successful management of diabetes should be based on patient-oriented pharmacotherapy, adequate diet and physical activity[20]. Current ADA guidelines recommend 150 min of moderate-intensity exercise per week for patients with type 2 diabetes, or 30 min every day for five days a week. Moderate intensity exercise should be understood as physical activity that increases heart rate by 50% - 60% relative to resting heart rate, such activities may include dancing or walking briskly [21-24]. Of the reasons for low activity, lack of time is cited by diabetes patients as one of the most common barriers against increasing physical activity [25-29].

What is HIIT?

High-intensity interval training (HIIT) is a form of exercise that involves a series of high-intensity workouts, each lasting a few minutes, interspersed with brief periods of rest. [30-32](Fig. 1).

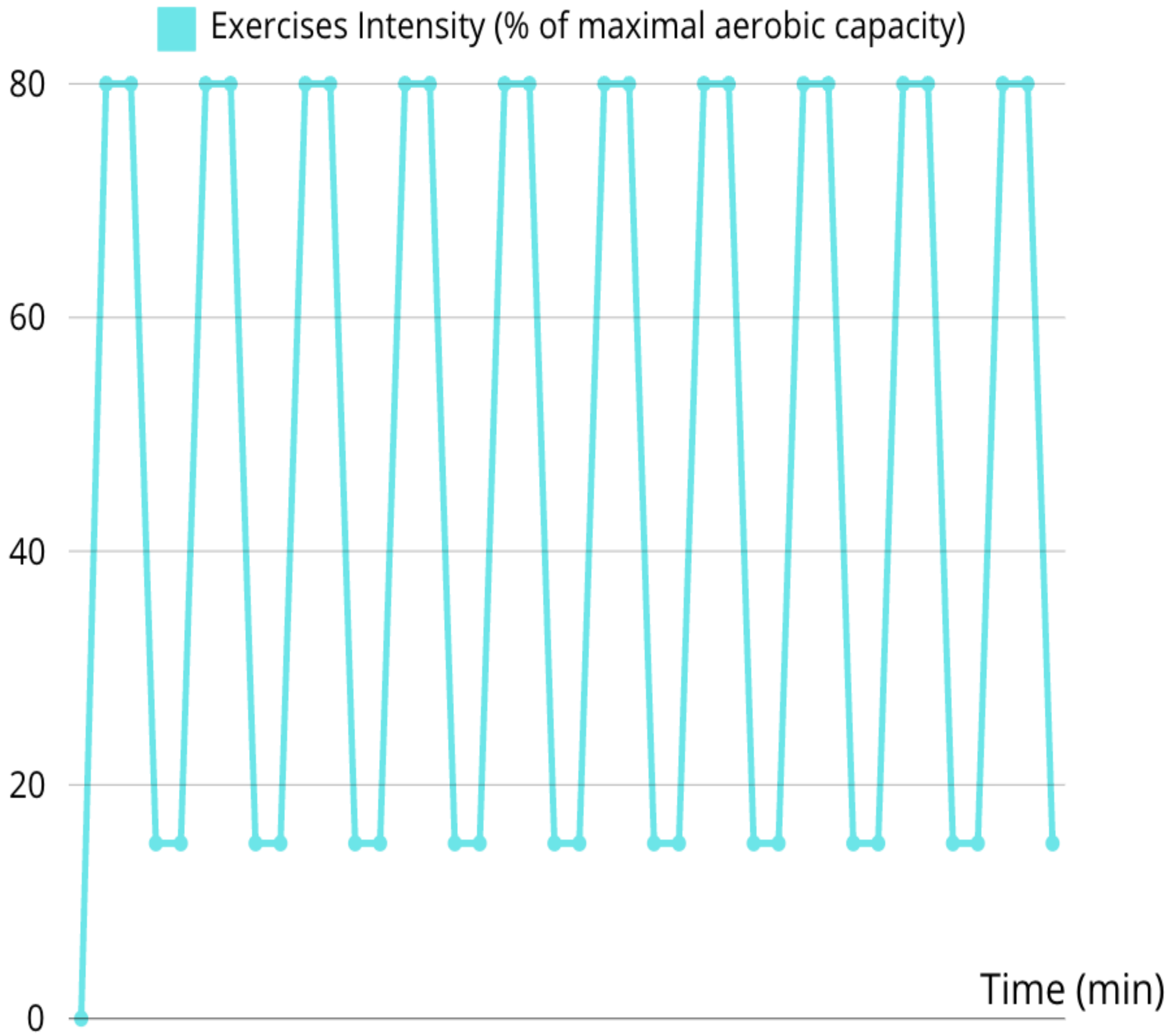

Figure 1. Example of a HIIT training protocol. The horizontal line shows the training intensity as a percentage of maximum aerobic capacity. A sample protocol consisting of a 20 minute session includes 10x 1 minute intense workouts at 80% of maximum aerobic capacity interspersed with 1 minute rest intervals.

It is important to note that the intensity of exertion during HIIT training is not standardised and is instead dependent on the individual participant's level of physical fitness. This implies that activities such as running or sprinting on a bicycle, which for healthy individuals would be considered equivalent to high-intensity physical activity, for patients suffering from obesity and other co-morbidities would be activities such as brisk walking, where for the former group, they would not exceed medium intensity.

Materials and Methods

We used the Pubmed database, considering all papers from 2014-2024 that contained in the 'all-fields' section words such as: 'diabetes', 'HIIT', 'interval training' and 'high-intensity training' obtaining 513 results. Publications from non-human models, publications that did not contain information about the subjects such as sex, age, BMI, no study group with HIIT training and publications that included healthy participants alone were excluded, ultimately only 12 of the selected papers were qualified for further analysis (Figure 2).

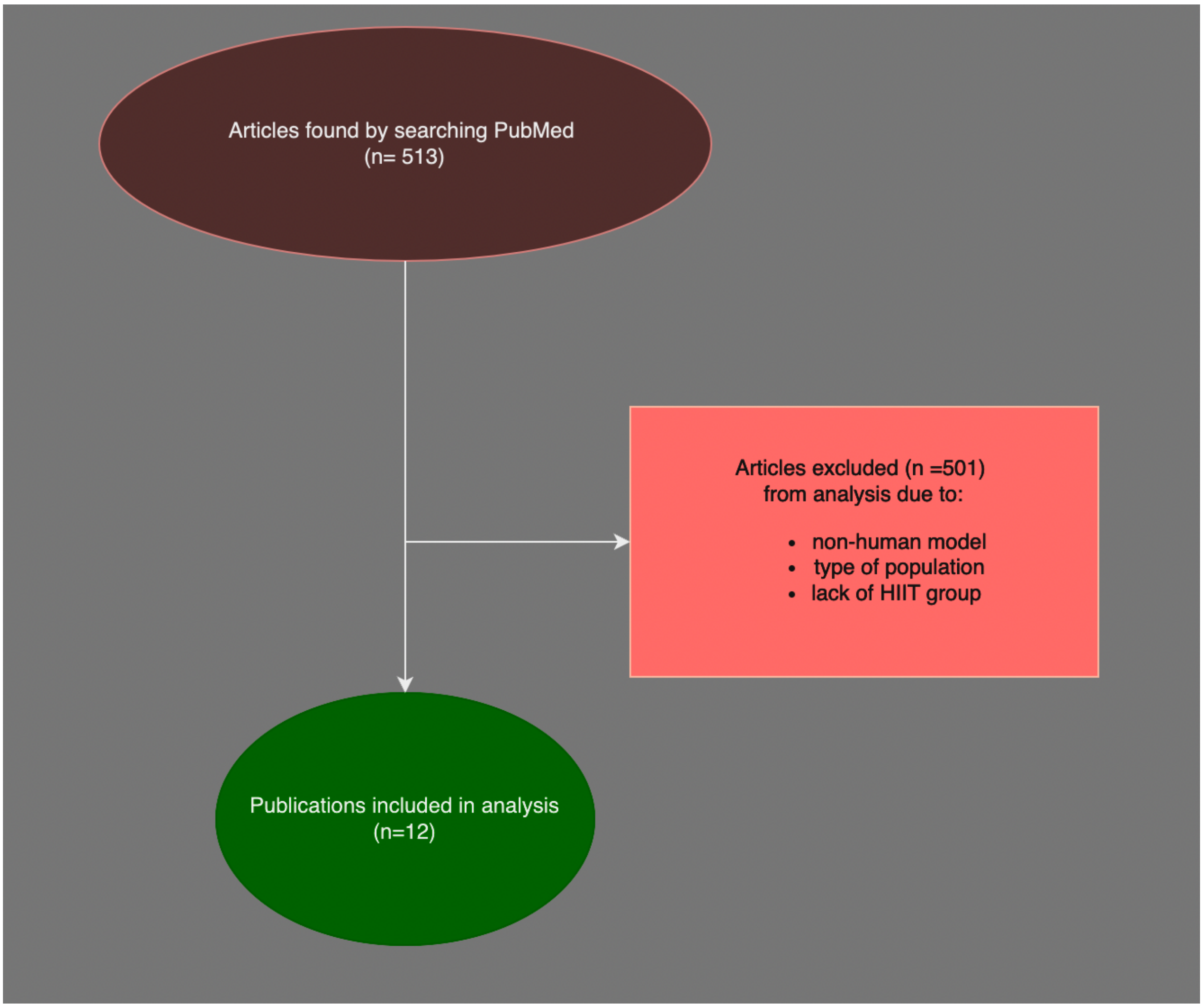

Figure 2. Following the application of the predetermined criteria in the PubMed database, 513 papers were identified as relevant to the subject of investigation. Of these, 12 were selected for further analysis. The remaining results were disqualified on the basis of various criteria, including the absence of a study group receiving HIIT training, use of a non-human model, or the paucity of basic information regarding the number of participants, age, and BMI of the study population.

Results

In review of the 12 publications incorporated into the meta-analysis that satisfied the established methodology criteria, the characteristics of the participants within each study are presented below, including the specific type of diabetes or its absence, age, and BMI. (Table 1).

Author	Type of participants	No.	Age (years ± SD)	BMI (kg/m^2 ± SD)
Francois, et al. [33]	DM2 ND untrained ND trained	12 DM2 11 ND untrained 12 ND trained	57.5 ± 5.0 55.1 ± 7.0 55.3 ± 9.1	35.0 ± 7.0 23.0 ± 3.0 26.0 ± 5.0
Karstoft, et al. [34]	DM2	10 DM2	60.3 ± 2.3	28.3 ± 1.1
Terada, et al. [35]	DM2	10 DM2	60.0 ± 6.0	30.8 ± 5.4
Al-Rawaf, et al. [36]	DM2 ND	30 DM2 20 ND	46.1 ± 3.1 46.3 ± 2.8	31.8 ± 3.96 24.5 ± 2.85
Durrer, et al. [37]	DM2 ND	10 DM2 9 ND	57.9 ± 5.4 55.8 ± 9.0	34.8 ± 5.9 24.8 ± 3.6
Metcalfe, et al. [38]	DM2	11 DM2	52.0 ± 6.0	29.7 ± 3.1
Santiago, et al. [39]	DM2	14 DM2	63.6 ± 9.8	30.3 ± 4.4
Minnebeck, et al. [40]	DM 1	11 DM1 OW 11 DM1 NW	40.7 ± 14.3 42.2 ± 15.5	28.6 ± 2.1 23.2 ± 1.4

Mendes, et al. [41]	DM2	15 DM2	60.2 ± 3.1	29.6 ± 4.61
Scott, et al. [42]	DM1	14 DM1	26.0 ± 3.0	27.6 ± 13.0
Viana, et al. [43]	DM2	11 DM2	52.3 ± 3.0	28.4 ± 1.5
Baker, et al. [44]	DM2 pDM ND	26 DM2 60 pDM ND 76	58.2 ± 12.2	32.0 ± 5.2

Table 1. Informations about participants in each study included in review. DM2, type 2 diabetes mellitus; DM1, type 1 diabetes mellitus; BMI, body mass index; SD, standard deviation; ND, non-diabetic; pDM, prediabetic; OW – overweight; NW – normal weight.

Significant benefits of HIIT were observed in all studies regardless of the type of diabetes, same observations applied to healthy volunteers as well as those at risk of developing diabetes. The main conclusions of each study are presented below (Table 2).

Publication	Results
Francois, et al. [33]	Improvement of endothelial function in all group (normoglycemic and DM2), especially in DM2 group. Additionally, improvement of diastolic blood pressure and MAP.
Karstoft, et al. [34]	HIIT improves postprandial glycemic control in type 2 diabetes mellitus subjects when compared with an oxygen consumption- and time duration-matched continuous exercise session.
Terada, et al. [35]	HIIT significantly improved glycemic control compared to other groups without increasing risk of hypoglycemia.

Al-Rawaf, et al. [36]	12-week HIIT program significantly improves diabetes by reducing insulin resistance; regulating mitochondrial biogenesis; and decreasing oxidative stress capacity among patients and healthy controls. Additionally, p53 protein expression; COX; 8-OhdG; and TAC and mt-DNA content were shown to be associated with T2DM before and after exercise training
Durrer, et al. [37]	Reduction of TLR2 expression in both groups (including DM2 group) post and 1h post-exercise.
Metcalfe, et al. [38]	Significant improvment of glycemic parametres in all exercise groups. However, CMIT showed better beneficial effect on 24h glycemic profile.
Santiago, et al. [39]	HIIT presented improvement in glycemic control, reduction of systolic blood pressure with greatest reduction within 30 min of recovery in DM2 group.
Minnebeck, et al. [40]	HIIT improves metabolic parameters and physical fitness and help to prevent the development of diabetes-related complications. However, blood glucose levels need to be monitored to prevent hypoglycaemia in T1DM patients performing this type of activity.
Mendes, et al. [41]	HIIT showed better blood glucose reduction during exercise and within 50 min of recovery than CMIT.
Scott, et al. [42]	Study showed no difference between HIIT and CMIT group in the daily glycemic profile.
Viana, et al. [43]	HIIT presented better results in lowering blood glucose than CMIT.
Baker, et al. [44]	Findings show that low-volume HIIT yields improvements in muscle strength and cardiorespiratory fitness and may have a small effect on hepatic steatosis.

Table 2. Main results and conclusions of the use of HIIT in a sample of subjects with diabetes.

Discussion

This study systematically reviewed the extant literature on the acute effects of HIIT on biochemical, cardiovascular, and metabolic parameters in patients with diabetes. The findings indicated that HIIT enhances capillary blood glucose levels and factors associated with cardiovascular risk in people with diabetes. This is particularly evident in the glycemic profile, blood pressure, vascular function, and inflammatory indicators when compared to control groups.

There appears to be a consensus on the potential benefits of exercise for glycaemic control in people with diabetes. It has been suggested that various mechanisms associated with exercise-induced glycaemic control, generate several adaptations. These include increased concentration and translocation of GLUT-4 in the plasma membrane, increased glucose uptake by muscle and increased sensitivity of muscle fibres to insulin.

Conclusions

A significant body of evidence demonstrates that HIIT confers a wide range of benefits, particularly for individuals with diabetes. These benefits include a reduction in glycaemia immediately after training, as well as many hours thereafter due to increased insulin sensitivity of the tissues. Moreover, long-term benefits include a reduction in unhealthy cholesterol fractions, improved endothelial function and enhanced blood pressure control, in addition to the regulation of pro-inflammatory cytokines.

Author Contribution

Conceptualization, Mateusz Nieczyporuk, and Aleksandra Sikora; methodology, Szymon Pucyło; software, Martyna Skweres; check, Katarzyna Ceglarz, Jan Pielaciński and Aleksander Rudnik; formal analysis, Kinga Sikora; investigation, Gabriela Piotrowska; resources, Mateusz Nieczyporuk; data curation, Mateusz Nieczyporuk and Aleksandra Sikora; writing - rough preparation, Mateusz Nieczyporuk; writing - review and editing, Aleksandra Sikora;

visualization, Mateusz Nieczyporuk; supervision, Mateusz Nieczyporuk; project administration, Mateusz Nieczyporuk;

All authors have read and agreed with the published version of the manuscript.

Funding Statement: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflict of Interest Statement: All authors declare no conflict of interest.

Acknowledgments: None.

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