GASZYŃSKA, Monika, DRZEWIECKA, Antonina, DRZEWIECKI, Artur, KORCZAK, Wiktor, MADEJSKA, Maria Anna, RUDZKA, Aleksandra, FALKOWSKI, Wojciech, KRYSIŃSKA, Anna, WOŹNIAK, Weronika and MAGIELSKI, Jakub. The role of physical activity in type 1 diabetes: a review of the literature. Journal of Education, Health and Sport. 2025;80:59766. eISSN 2391-8306.
https://doi.org/10.12775/JEHS.2025.80.59766
https://apcz.umk.pl/JEHS/article/view/59766

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: 26.04.2025. Revised: 06.05.2025. Accepted: 06.05.2025. Published: 09.05.2025.

The role of physical activity in type 1 diabetes: a review of the literature

Authors:

Monika Gaszyńska
Provincial Hospital in Bielsko-Biała , Al.Armii Krajowej 101,
43-316 Bielsko-Biała, PL
https://orcid.org/0009-0007-0784-1370
E-mail: Monika.gaszynska20@gmail.com

Antonina Drzewiecka
Jan Biziel University Hospital No. 2 in Bydgoszcz: Bydgoszcz, Kujawsko-Pomorskie, PL
https://orcid.org/0009-0007-1007-2082
E- mail: antmarzec@gmail.com

Artur Drzewiecki
University Hospital A. Jurasz No.1: Bydgoszcz, Kujawsko-Pomorskie, PL
https://orcid.org/0009-0008-1664-1087
E-mail: artur.drzewiecki@o2.pl

Wiktor Korczak
Provincial Specialist Hospital in Włocławek, ul. Wieniecka 49, 87–800 Włocławek; PL
https://orcid.org/0009-0004-2177-7027
E-mail: wiktor.korczak99@gmail.com

Maria Anna Madejska
Masovian Specialist Hospital in Radom, ul. Juliana Aleksandrowicza 5,
26-617 Radom, PL
https://orcid.org/0009-0004-2570-2313
E-mail: mery.madejska@gmail.com

Aleksandra Rudzka
Masovian Specialist Hospital in Radom, ul. Juliana Aleksandrowicza 5,
26-617 Radom, PL
https://orcid.org/0009-0008-6602-5522
E-mail: aleksandra.rudzka98@gmail.com

Wojciech Falkowski
Provincial Hospital in Bielsko-Biała, Al.Armii Krajowej 101,
43-316 Bielsko-Biała, PL
https://orcid.org/0009-0004-7831-2570
E-mail: falwojciech99@gmail.com

Anna Krysińska
Dr. Emil Warmiński Clinical Hospital of the Bydgoszcz University of Technology: Bydgoszcz, PL
https://orcid.org/0009-0001-8633-8410
E-mail: anna.krysinska99@gmail.com

Weronika Woźniak
Independent Public Health Care Facility in Słupca, ul. Traugutta 7 62-400 Słupca, PL
https://orcid.org/0009-0007-4920-4230

E-mail: werkawozniak98@wp.pl

Jakub Magielski
Independent Public Multi-Specialist Health Care Facility of the Ministry of Internal Affairs and Administration in Bydgoszcz; Bydgoszcz, Kujawsko-pomorskie, PL
https://orcid.org/0009-0003-0737-6262
Email: Jakub.magielski@gmail.com

Corresponding author:

Monika Gaszyńska

Email: monika.gaszynska20@gmail.com

Abstract.

Introduction and Purpose: Diabetes is a prevalent metabolic disorder affecting over 530 million people globally, with its incidence increasing alarmingly. Due to the early onset of type 1 diabetes (T1D), treatment and prevention of complications are critical. This study aims to present the safety profile of physical activity, its effects on metabolic processes, and the benefits of exercise in preventing late complications of T1D.

Review methods: Data were collected using databases such as PubMed and Google Scholar. Over 30 studies and scientific publications published in English or Polish were analyzed, considering keywords such as “type 1 diabetes”,“physical activity”, “exercise”, “aerobic exercise”, “anaerobic exercise”.

State of Knowledge: Depending on the type of exercise performed, the body of a diabetic behaves somewhat differently. There is a risk of hypoglycemia during or after aerobic exercise, although some studies have not confirmed such a relationship. Systematic aerobic activity has been proven to benefit carbohydrate metabolism, lipid metabolism, blood vessels and overall body condition. Anaerobic exercise may temporarily raise blood glucose levels and introduce additional stress factors. However, combining both types of exercise can effectively stabilize

glycemic levels and improve quality of life. Additionally, exercise has been shown to mitigate long-term diabetes complications.

Conclusion: Historically, diabetes was viewed as a disease that restricted physical activity. However, current evidence supports the recommendation of physical exercise for T1D patients. Proper education, treatment advancements, and self-monitoring allow even high-intensity activities to be safely performed.

Keywords: Type 1 diabetes, physical activity, aerobic exercises, anaerobic exercises

1. Introduction.

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia that results from abnormal insulin production or action. Over time, it can result in damage to numerous organs, primarily the kidneys, eyes, nerves, blood vessels and heart. It is a major global health issue, and the number of affected individuals continues to rise. According to the International Diabetes Federation, 537 million people worldwide had diabetes in 2021, and this number is projected to be 784 million in 2045. In Poland, approximately 3 million people have diabetes, with about 10% being diagnosed with type 1 diabetes [9]. It occurs in genetically predisposed individuals and is typically autoimmune in nature. It involves the destruction of the beta cells of the pancreas, which are responsible for the production of insulin. This leads to a deficiency of the endogenous hormone and requires insulin pharmacotherapy. However, for many years there was a belief that people with type 1 diabetes should avoid excessive physical activity. After the discovery of insulin, it was thought that exercise in type 1 diabetes could pose a risk to patients. The results of a study evaluating the effect of exercise on the development of chronic complications were not published until 1986 [7]. It was concluded that physical activity in people with type 1 diabetes did not appear to have a negative impact on health, and may even have a beneficial effect.

2. Types of physical activity.

Today, physical activity is the foundation of a healthy lifestyle and is recognized by the medical community as an essential component of effective diabetes management [17]. The role of physical activity in type 2 diabetes is well established, and its importance in type 1 diabetes is

still being studied. The many benefits of exercise like increased insulin sensitivity, improved glycemic control, blood pressure, lipid profile and weight reduction are known. It also has a positive effect on mood, even in depressed patients.
However, in patients on insulin therapy, intense exercise carries the risk of rapid changes in the body's carbohydrate metabolism in the form of hypo- or hyperglycemia. There is considerable skepticism regarding the benefits of physical activity among individuals with diabetes.

Physical activity is categorized as:

- **Aerobic Exercise:** Activities such as walking, marching, “Nordic walking”, leisurely cycling, rollerblading, skiing. They are characterized by the work of muscles using oxygen supplied to the body. In this case, burning glucose gives the most favorable energy balance. The level of glucose in the blood decreases, and the sensitivity of tissues to insulin increases and remains high even up to 48h after exercise. However, diabetics are at risk of hypoglycemia after this type of activity.

- **Anaerobic Exercise:** High-intensity activities like weightlifting and sprinting can lead to post-exercise hyperglycemia. They place a heavy burden on the body, and the body's demand for energy exceeds the available glucose in the blood. The body activates additional methods of obtaining energy such as releasing glucose from glycogen in the liver and muscles, through the process of glycogenolysis, which leads to hyperglycemia. Furthermore, with prolonged exercise, the body shifts to utilizing fatty acids as an energy source. This results in the formation of ketone bodies, which impair the action of insulin, leading to hyperglycemia, which is poorly responsive to treatment. Glycemia is also influenced by adrenaline produced during team sports and competitions, which contributes to an increase in its levels.

3. The role of aerobic exercise in T1D.

The presence of post-exercise hypoglycemia in people with type 1 diabetes is controversial. Some studies indicate an increased risk of glucose decline after aerobic exercise, while others show no such association. Untrained individuals and those who engage in physical activity unsystematically are at greater risk for late hypoglycemia, occurring up to 24 hours after exercise. A study conducted by researchers from Silesian Medical University in Katowice,

Poland, found that people with type 1 diabetes are particularly at risk for developing post-exercise hypoglycemia. Of great importance is the level of physical activity. The incidence of hypoglycemia significantly increases in people who train intensively compared to patients with low activity [2]. It is recommended to perform aerobic exercise in the morning due to the increase in blood glucose levels at this time. This provides additional protection against an episode of hypoglycemia [19]. Nevertheless, aerobic exercise is considered a safe form of physical activity in type 1 diabetes, and it is recommended to undertake exercise of at least 150 minutes per week. Systematic aerobic exercise training increases cardiorespiratory fitness, has beneficial effects on lipid levels, endothelial function and reduces insulin resistance. It can also help improve glycated hemoglobin levels.

4. The role of anaerobic exercise in T1D.

In 2021, researchers from Spain conducted a study in which they evaluated the effects of high-intensity interval training (HIIT) on the metabolism and mental state of people with type 1 diabetes. The results of the study showed that several seconds of intense exercise, interspersed with moderate intensity activity, produced beneficial effects in patients. No significant drops in glycemia were observed during or after exercise. The subjects also did not experience episodes of hyperglycemia. In addition, improvements in quality of life, sleep, increased enjoyment and motivation to exercise were observed in previously inactive subjects with type 1 diabetes [4].

The study conducted by Cuenca-García et al. [8] confirmed that physical activity is associated with improved glycemic control. A total of 97 young individuals were examined. The findings demonstrated that regular moderate-to-vigorous physical activity may enhance glycemic control in young individuals with type 1 diabetes, as indicated by lower HbA1c levels in the study group.

Researchers from Portland demonstrated that aerobic exercise led to a greater decrease in glucose levels during the workout, while resistance exercise had a better impact on long-term glycemic control (24 hours post-exercise). Resistance training has been shown to help participants maintain glucose levels within a more stable range for a longer period following exercise [6]. Another study confirmed that adding short bursts of high-intensity, sprint-type exercise to aerobic exercise can minimize the risk of a hypoglycemic episode and help stabilize

values [11][17][18]. Anaerobic exercise is best performed during the time of day when a person is most at risk for hypoglycemia (i.e., afternoon/evening) [19].

Diabetes can lead to muscle weakness through nerve damage (diabetic neuropathy) and disturbances in protein and carbohydrate metabolism. Additionally, improper glucose control and reduced insulin production may hinder the effective use of glucose by muscles, leading to their weakness. Resistance training contributes to increased muscle strength and mass, enhances bone mineral density, and improves body composition. It is an important factor in improving physical fitness [17][19].

5. Exercise and Diabetes Complications.

In 2015, German and Austrian researchers confirmed the beneficial effect of physical activity on late complications of hyperglycemia in type 1 diabetes [5]. They noted that physically active patients appear to be more educated about their disease and control systems. In addition, activity forces increased frequency of glucose measurements which affects early capture of abnormal blood glucose and faster response. A lower incidence of retinopathy and microalbuminuria has been shown in active patients compared to inactive patients. Systematic exercise is associated with weight reduction, positive effects on diastolic blood pressure and hypertension. Exercise has also been shown to be associated with beneficial effects on LDL cholesterol, triglycerides and HDL cholesterol [7]. All of these components contribute to reducing the risk of cardiovascular incidents in patients with type 1 diabetes.

6. Safety of training in diabetics.

6.1 Evaluation of Exercise Capacity.

According to the Polish Society of Diabetology, the patient's capacity for physical activity should be evaluated by a diabetologist. He or she takes into account the activity of the disease, the type, duration, intensity of exercise, any contraindications, the likelihood of compliance with the recommendations and the patient's training. The diabetologist's decisions may require consultation with other specialists, including an ophthalmologist, cardiologist, nephrologist and

neurologist. For younger people with diabetes (without significant contraindications), daily vigorous exercise, including active sports, is recommended.

6.2 Monitoring During Exercise.

During activity, continuous glucose monitoring (CGM) systems are recommended. They allow continuous glycemic control and rapid response to health-threatening glucose values. In the situation of self-measurement with a glucometer, it is advisable to take measurements at least 3 times - up to 15 minutes before the start of the activity, during the activity and after the cessation of the activity.

6.3 Contraindications for Physical Activity.

Severe hypoglycemia is a contraindication for engaging in physical activity for at least 24 hours. When the glucose level falls below 70 mg/dl, simple carbohydrates (preferably in liquid form) should be consumed. Once symptoms of hypoglycemia subside, physical activity can be resumed. With glycemic values >250 mg/dl and the presence of ketone bodies in the blood or urine ≥ 1,5 mmol/L, exercise is contraindicated. Adjustments to insulin dosage depend on several factors, including the type and duration of exercise, prior insulin therapy, carbohydrate intake, and individual body weight and composition. The treatment regimen is individualized and tailored to the patient's specific needs.

6.4 Special Considerations for Long-Term Diabetes.

People with a history of long-term diabetes complications should take special care. Complications of the disease lead to impairment of the functioning of important organs of the body. Moderate and intense exercise in certain clinical situations has a negative impact on the patient's condition. It can lead to an increase in the incidence of myocardial ischemia and orthostatic hypotonia. In proliferative diabetic retinopathy, the growth of abnormal blood vessels in the retina increases the risk of retinal detachment and vitreous hemorrhage during intense physical activity. In diabetic kidney disease, there may be an increase in albumin excretion and proteinuria.

6.5 Foot Care and Injury Prevention.

Active people are advised to wear comfortable shoes, care for their feet, and be especially careful of injuries, as peripheral neuropathy impairs pain sensation. The risk of microtrauma and the development of diabetic foot then increases. The indicated dangers are a threat in people with already made organ changes. In the early stages of diabetes, training slows its course and reduces the risk of late complications.

7. Conclusion.

Physical activity plays a crucial role in the management of type 1 diabetes, offering a range of benefits from improved glycemic control to a reduction in the risk of late-stage complications such as retinopathy, cardiovascular diseases, and kidney damage. Both aerobic and anaerobic exercises have proven positive effects on insulin sensitivity, blood pressure regulation, lipid profiles, and overall physical fitness.

While aerobic exercises can reduce blood glucose levels and improve insulin sensitivity, they also carry the risk of hypoglycemia, especially in individuals who are less physically active or untrained. Anaerobic exercises, while sometimes leading to temporary hyperglycemia, can help stabilize glucose levels over the long term and contribute to increased muscle mass and strength. High-intensity interval training (HIIT) also shows promise in improving both metabolism and mental health.

Safety during physical activity for individuals with type 1 diabetes requires careful monitoring and individualized adjustments to insulin therapy. Continuous glucose monitoring (CGM) systems and regular blood glucose checks before, during, and after exercise are essential for preventing adverse outcomes. Special precautions must be taken for those with long-term diabetes complications, particularly in relation to the eyes, kidneys, and cardiovascular system.

Overall, current evidence supports the inclusion of physical activity as a vital part of diabetes management. With proper education, monitoring, and individualized treatment plans, exercise can be safely incorporated into the lives of individuals with type 1 diabetes, improving their health outcomes and quality of life.

Disclosure

Authors do not report any disclosures.

Authors' contribution:

Conceptualization: Monika Gaszyńska, Artur Drzewiecki

Methodology: Aleksandra Rudzka, Maria Anna Madejska, Weronika Woźniak, Monika Gaszyńska

Investigation: Anna Krysińska,, Antonina Drzewiecka, Monika Gaszyńska

Software: Maria Anna Madejska, Wiktor Korczak, Wojciech Falkowski

Formal analysis: Wiktor Korczak, Weronika Woźniak, Antonina Drzewiecka

Writing: Artur Drzewiecki, Wojciech Falkowski, Aleksandra Rudzka

Resources: Jakub Magielski, Monika Gaszyńska, Anna Krysińska

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

Funding statement:

The study did not receive special funding.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest Statement:

The authors declare no conflict of interest.

In preparing this work, the author(s) used perplexity.ai for the purpose of improve language and readability, text formatting, verification of bibliographic styles,. After using this tool/service, the author(s) have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

References

1. Czenczek-Lewandowska E, Grzegorczyk J, Mazur A. Physical activity in children and adolescents with type 1 diabetes and contemporary methods of its assessment. *Pediatr Endocrinol Diabetes Metab*. 2018;24(4):179-184. doi:10.5114/pedm.2018.83364.

2. Zielińska K, Bysiak-Korus D, Sosna-Kondera A, Banaś E, Bosowska J, Strojek K. Impact of physical activity on hypoglycaemia in patients with diabetes. *Clin Diabetol*. 2018;7(2):108-113. doi:10.5603/DK.2018.0005.

3. Skorupska S, Chomiuk T, Mamcarz A. Is sport healthy for patients with diabetes? *Cardio-Diabetol Rev*. 2008:232-236.

4. Alarcón-Gómez J, Chulvi-Medrano I, Martin-Rivera F, Calatayud J. Effect of high-intensity interval training on quality of life, sleep quality, exercise motivation and enjoyment in sedentary people with type 1 diabetes mellitus. *Int J Environ Res Public Health*. 2021;18(23):12612. doi:10.3390/ijerph182312612.

5. Bohn B, Herbst A, Pfeifer M, et al. Impact of physical activity on glycemic control and prevalence of cardiovascular risk factors in adults with type 1 diabetes: a cross-sectional multicenter study of 18,028 patients. *Diabetes Care*. 2015;38(8):1536-1543. doi:10.2337/dc15-0030.

6. Reddy R, Wittenberg A, Castle JR, et al. Effect of aerobic and resistance exercise on glycemic control in adults with type 1 diabetes. *Can J Diabetes*. 2019;43(6):406-414.e1. doi:10.1016/j.jcjd.2018.08.193.

7. Chimen M, Kennedy A, Nirantharakumar K, Pang TT, Andrews R, Narendran P. What are the health benefits of physical activity in type 1 diabetes mellitus? A literature review. *Diabetologia*. 2012;55(3):542-551. doi:10.1007/s00125-011-2403-2.

8. Cuenca-García M, Jago R, Shield JP, Burren CP. How does physical activity and fitness influence glycaemic control in young people with Type 1 diabetes? *Diabet Med*. 2012;29(10):e369-e376. doi:10.1111/j.1464-5491.2012.03740.x.

9. Clinical recommendations for the management of people with diabetes 2024. Position statement of the Polish Diabetes Association. Accessed March 19, 2025. https://ptdiab.pl/zalecenia-ptd/zalecania-aktywni-czlonkowie-2024.

10. WHO guidelines on physical activity and sedentary lifestyles: a discussion. Published 2021. https://iris.who.int/handle/10665/341120.

11. Tonoli C, Heyman E, Roelands B, et al. Effects of different types of acute and chronic (training) exercise on glycaemic control in type 1 diabetes mellitus: a meta-analysis. *Sports Med*. 2012;42(12):1059-1080. doi:10.1007/BF03262312.

12. Dubé MC, Lavoie C, Weisnagel SJ. Glucose or intermittent high-intensity exercise in glargine/glulisine users with T1DM. *Med Sci Sports Exerc*. 2013;45(1):3-7. doi:10.1249/MSS.0b013e31826c6ad3.

13. Sluik D, Buijsse B, Muckelbauer R, et al. Physical activity and mortality in individuals with diabetes mellitus: a prospective study and meta-analysis. *Arch Intern Med*. 2012;172(17):1285-1295. doi:10.1001/archinternmed.2012.3130.

14. Kania L. Hypoglycemia in type 1 diabetes. *Borgis Sp. z o.o.* Published January 25, 2017. https://www.czytelniamedyczna.pl/5890.

15. Szczeklik-Kumala Z, Czech A, Tatoń J. Exercise tolerance as a determinant of the use of physical training treatment in people with diabetes mellitus. *New Med*. 2000;6. https://www.czytelniamedyczna.pl/1389.

16. Imperatore G, Boyle JP, Thompson TJ, et al. Projections of type 1 and type 2 diabetes burden in the U.S. population aged <20 years through 2050. *Diabetes Care*. 2012;35(12):2515-2520. doi:10.2337/dc12-0669.

17. Colberg SR, Sigal RJ, Yardley JE, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care*. 2016;39(11):2065-2079. doi:10.2337/dc16-1728.

18. Yardley JE, Kenny GP, Perkins BA, et al. Effects of performing resistance exercise before versus after aerobic exercise on glycemia in type 1 diabetes. *Diabetes Care*. 2012;35(4):669-675. doi:10.2337/dc11-1844.

19. Fitzpatrick R, Davison G, Wilson JJ, McMahon G, McClean C. Exercise, type 1 diabetes mellitus and blood glucose: the implications of exercise timing. *Front Endocrinol (Lausanne)*. 2022;13:1021800. doi:10.3389/fendo.2022.1021800.

20. Riddell MC, Li Z, Gal RL, et al. Examining the acute glycemic effects of different types of structured exercise sessions in type 1 diabetes. *Diabetes Care*. 2023;46(4):704-713. doi:10.2337/dc22-1721.

21. Pitt JP, McCarthy OM, Hoeg-Jensen T, Wellman BM, Bracken RM. Factors influencing insulin absorption around exercise in type 1 diabetes. *Front Endocrinol (Lausanne)*. 2020;11:573275. doi:10.3389/fendo.2020.573275.

22. Samora M, Grotle AK, Stone AJ. Altered cardiovascular responses to exercise in type 1 diabetes. *Exerc Sport Sci Rev*. 2023;51(2):65-72. doi:10.1249/JES.0000000000000314.

23. Dorman JS, Laporte RE, Kuller LH, et al. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study. *Diabetes*. 1984;33(3):271-276. doi:10.2337/diab.33.3.271.

24. Alobaid AM, Zulyniak MA, Ajjan RA, et al. Barriers to exercise in adults with type 1 diabetes and insulin resistance. *Can J Diabetes*. 2023;47(6):503-508. doi:10.1016/j.jcjd.2023.04.016.

25. García-Hermoso A, Ezzatvar Y, Huerta-Uribe N, et al. Effects of exercise training on glycaemic control in youths with type 1 diabetes. *Eur J Sport Sci*. 2023;23(6):1056-1067. doi:10.1080/17461391.2022.2086489.

26. Moser O, Zaharieva DP, Adolfsson P, et al. The use of automated insulin delivery around physical activity and exercise in type 1 diabetes: a position statement of the European Association for the Study of Diabetes (EASD) and the International Society for Pediatric and Adolescent Diabetes (ISPAD). *Diabetologia*. 2025;68(2):255-280.

doi:10.1007/s00125-024-06308-z.

27. Wagenmakers AJM. The clinical and metabolic benefits of exercise for people with type 1 diabetes. *Exp Physiol*. 2020;105(4):562-564. doi:10.1113/EP088493.

28. Gawrecki A. Evaluation of the effect of maximal exercise on metabolic status in men with type 1 diabetes mellitus. Doctoral dissertation. Department of Internal Medicine and Diabetology, Faculty of Medicine, 2nd Medical University of Karol Marcinkowski, Poznań; 2014.

29. Hawke TJ. Do those with type 1 diabetes need more exercise to maintain skeletal muscle health? *J Physiol*. 2022;600(6):1281-1282. doi:10.1113/JP282800.

30. Groele L, Szypowska A. Type 1 diabetes mellitus prevention. *Pediatr Endocrinol Diabetes Metab*. 2023;29(4):209-213. doi:10.5114/pedm.2023.134130.