South American Publishing

SAP Rehabilitation and Sports Medicine. 2025;5:234
doi: 10.62486/rsm2025234

REVIEW

Effect of Cycling on Blood Glucose Level among Type 2 Diabetes Mellitus: A Systematic Review

Efecto del ciclismo sobre el nivel de glucosa en sangre en personas con diabetes mellitus tipo 2: una revisión sistemática

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Submitted: 27-08-2025 | Revised: 30-11-2025 | Accepted: 28-12-2025 | Published: 30-12-2025

ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and persistent hyperglycemia, leading to complications such as retinopathy, neuropathy, nephropathy, and cardiovascular diseases. Lifestyle modification, particularly physical activity, plays a vital role in glycemic control and the prevention of complications. Cycling, as a form of aerobic exercise, has gained attention for its potential metabolic and functional benefits in individuals with T2DM. Objective: To systematically review the effects of cycling as an aerobic exercise intervention on glycemic control, insulin sensitivity, and quality of life in individuals with T2DM. Methods: A systematic search was conducted across PubMed, Google Scholar, and Web of Science for studies published between 2015 and 2025, following PRISMA guidelines. Keywords included "cycling," "aerobic exercise," "type 2 diabetes," "blood glucose," and "quality of life." Only full-text, English-language studies were included. Methodological quality was assessed using the PEDro scale. Data extraction focused on HbA1c, fasting blood glucose, postprandial glucose, insulin sensitivity, and quality of life outcomes. Results: The included studies consistently demonstrated that cycling significantly improves glycemic control in individuals with T2DM. Notable reductions were observed in HbA1c, fasting blood glucose, and postprandial glucose levels. Cycling also enhanced insulin sensitivity, supported weight management, and improved peripheral circulation and physical fitness. Additionally, participants reported improvements in quality of life and functional capacity following cycling interventions. Conclusion: Cycling is an effective, accessible, and sustainable aerobic exercise for individuals with T2DM. It contributes to improved glycemic control, enhanced insulin sensitivity, better weight management, and overall quality of life. Incorporating cycling into routine care may serve as a valuable non-pharmacological strategy for T2DM management.

Keywords: Aerobic exercise, Blood glucose level, Cycling, Diabetic, Quality of life, Type 2 Diabetic, Weight Control.

RESUMEN

Antecedentes: La diabetes mellitus tipo 2 (DM2) es un trastorno metabólico crónico caracterizado por resistencia a la insulina e hiperglucemia persistente, lo que conduce a complicaciones tales como retinopatía, neuropatía, nefropatía y enfermedades cardiovasculares. La modificación del estilo de vida, particularmente la actividad física, desempeña un papel vital en el control glucémico y en la prevención de complicaciones. El ciclismo, como forma de ejercicio aeróbico, ha captado la atención debido a sus potenciales beneficios metabólicos y funcionales en individuos con DM2. Objetivo: Realizar una revisión sistemática de los efectos del ciclismo, como intervención de ejercicio aeróbico, sobre el control glucémico, la sensibilidad a la insulina y la calidad de vida en individuos con DM2. Métodos: Se llevó a cabo una búsqueda sistemática en PubMed, Google Scholar y Web of Science para identificar estudios publicados entre 2015 y 2025, siguiendo las directrices PRISMA. Las palabras clave incluyeron: «ciclismo», «ejercicio aeróbico», «diabetes tipo 2», «glucosa en sangre» y «calidad de vida». Solo se incluyeron estudios en texto completo y en idioma inglés. La calidad metodológica se evaluó mediante la escala PEDro. La extracción de datos se centró en la HbA1c, la glucosa en ayunas, la glucosa posprandial, la sensibilidad a la insulina y los resultados relacionados con la calidad de vida. Resultados: Los estudios incluidos demostraron de manera consistente que el ciclismo mejora significativamente el control glucémico en individuos con DM2. Se observaron reducciones notables en los niveles de HbA1c, glucosa en ayunas y glucosa posprandial. El ciclismo también potenció la sensibilidad a la insulina, favoreció el control del peso y mejoró la circulación periférica, así como la aptitud física. Además, los participantes informaron mejoras en su calidad de vida y capacidad funcional tras las intervenciones de ciclismo. Conclusión: El ciclismo constituye un ejercicio aeróbico eficaz, accesible y sostenible para las personas con DM2. Contribuye a mejorar el control glucémico, potenciar la sensibilidad a la insulina, facilitar un mejor control del peso y mejorar la calidad de vida en general. La incorporación del ciclismo en la atención habitual puede servir como una valiosa estrategia no farmacológica para el manejo de la DM2.

Palabras clave: Ejercicio aeróbico, Nivel de glucosa en sangre, Ciclismo, Diabético, Calidad de vida, Diabético tipo 2, Control del peso.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both. It is strongly associated with pancreatic β-cell dysfunction and reduced glucose uptake in peripheral tissues, leading to long-term metabolic imbalance. Due to its progressive nature and associated complications, diabetes represents a major global public health challenge. (1,2)

According to recent global estimates, approximately 529 million individuals were living with diabetes in 2021, and this number is projected to rise to 1.31 billion by 2050. Type 2 Diabetes Mellitus (T2DM) accounts for the majority of cases and is primarily associated with modifiable risk factors such as physical inactivity, obesity, and sedentary behavior. (1) India is among the most affected countries, with a rapidly increasing prevalence attributed to urbanization, lifestyle transitions, and genetic susceptibility. (3,4)

T2DM is characterized by insulin resistance and relative insulin deficiency, leading to chronic hyperglycemia and multiple complications, including cardiovascular diseases, neuropathy, nephropathy, and retinopathy. (5,6) Effective management requires long-term glycemic control, typically assessed using glycated hemoglobin (HbA1c), fasting blood glucose, and postprandial glucose levels. (6–8)

Lifestyle modification, particularly regular physical activity, plays a critical role in the prevention and management of T2DM. Aerobic exercise enhances insulin sensitivity, improves glucose uptake, and contributes to weight management and cardiovascular health. (8-10) Among various forms of aerobic exercise, cycling has emerged as a practical, low-impact, and accessible intervention suitable for individuals across different age groups and fitness levels.

Cycling offers several physiological benefits, including improved glycemic control, enhanced cardiovascular function, and better body composition. It can be performed as an outdoor activity or through stationary pedaling, making it adaptable for both community and clinical settings. Recent studies have reported that cycling interventions can significantly reduce HbA1c levels, improve fasting and postprandial glucose, and enhance overall physical fitness in individuals with T2DM. (11-14) Additionally, cycling-based interventions have been shown to support adherence due to their feasibility and low joint stress. Despite growing evidence supporting the role of aerobic exercise in diabetes management, the specific effects of cycling as a distinct intervention remain underexplored. Most existing reviews combine multiple forms of exercise, limiting the ability to isolate cycling-specific outcomes. Furthermore, recent randomized controlled trials evaluating cycling interventions have not been comprehensively synthesized. (14-18)

Therefore, no recent systematic review has focused exclusively on cycling as an aerobic intervention in individuals with T2DM using contemporary evidence. Addressing this gap is essential for developing targeted, evidence-based exercise recommendations. Accordingly, this systematic review aims to evaluate the effects of cycling on glycemic control, insulin sensitivity, and quality of life in individuals with Type 2 Diabetes Mellitus.

METHODS

Study Design and Reporting Framework

This systematic review was conducted using a structured and transparent methodology in accordance with the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines. The review followed a predefined systematic approach to ensure methodological rigor, reproducibility, and minimization of bias.

Eligibility Criteria

The eligibility criteria for inclusion and exclusion of studies were defined using the PICOS framework:

Population (P): Adults diagnosed with Type 2 Diabetes Mellitus.

Intervention (I): Cycling or static cycling as an aerobic exercise intervention.

Comparator (C): Conventional care, other forms of exercise, or no intervention.

Outcomes (O): Primary outcomes included glycemic control parameters such as HbA1c, fasting blood glucose (FBG), and postprandial blood glucose (PPBG). Secondary outcomes included insulin sensitivity, body weight, and quality of life.

Study Designs (S): Randomized Controlled Trials (RCTs), pilot studies, and comparative interventional studies.

Inclusion Criteria:

Full-text articles published in English.
Studies published between 2015 and 2025.
Studies evaluating cycling as an aerobic intervention in individuals with T2DM.
Experimental and interventional study designs.
Exclusion Criteria:
Studies not available in full text.
Non-English publications.
Review articles, editorials, case reports, and studies without primary data.
Studies not specifically assessing cycling as a primary intervention.

Information Sources and Search Strategy

A comprehensive literature search was conducted across multiple electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, to identify relevant studies. The search strategy was designed to be comprehensive and reproducible using Boolean operators (AND, OR) and keyword combinations. The following search terms were used: “Type 2 Diabetes Mellitus” OR “T2DM” AND “Cycling” OR “Static Cycling” AND “Aerobic Exercise” AND “HbA1c” OR “Blood Glucose” OR “Glycemic Control”. The search was restricted to studies published between January 2015 and December 2025. Additionally, reference lists of included studies were manually screened to identify any additional relevant articles.

Study Selection Process

All retrieved records were imported into reference management software, and duplicates were removed. Study selection was conducted in two phases: Title and abstract screening and full-text review. Screening was performed independently by two reviewers to minimize selection bias. Any disagreements were resolved through discussion or consultation with a third reviewer. A PRISMA flow diagram was used to illustrate the study selection process.

Data Extraction, Quality Assessment, and Data Synthesis

Data extraction was performed using a standardized and pilot-tested data extraction form to ensure uniformity across studies. Two independent reviewers conducted the data extraction process to enhance accuracy and minimize bias, and any discrepancies were resolved through discussion and consensus. The extracted data included study characteristics (author and year of publication), study design, sample size and participant characteristics, intervention details (type, duration, and frequency of cycling), comparator details, outcome measures such as HbA1c, fasting blood glucose (FBG), postprandial blood glucose (PPBG), insulin sensitivity, and quality of life (QoL), as well as key findings. Additionally, information on funding sources and potential conflicts of interest was collected where available.

The methodological quality of the included studies was assessed using the Physiotherapy Evidence Database (PEDro) scale. This validated tool evaluates internal validity based on criteria such as random allocation, concealed allocation, blinding, adequacy of follow-up, and intention-to-treat analysis. Quality assessment was independently performed by two reviewers, and disagreements were resolved through consensus. Based on PEDro scores, studies were categorized as high, moderate, or low quality to facilitate interpretation of evidence strength.

Due to heterogeneity in study designs, intervention protocols, and outcome measures, a quantitative meta-analysis was not feasible. Therefore, a narrative synthesis approach was adopted, in which findings were systematically summarized and grouped according to key outcome domains, including glycemic control, insulin sensitivity, and quality of life. Data were organized in tabular form to enable comparison across studies, and patterns, trends, and consistencies in findings were critically analyzed.

This systematic review was not registered in PROSPERO or any other registry; however, all methodological steps were predefined to ensure transparency and reproducibility. All records were managed using reference management software, and extracted data were stored in structured spreadsheets to maintain accuracy and traceability. No major deviations from the predefined protocol were observed during the conduct of this review.

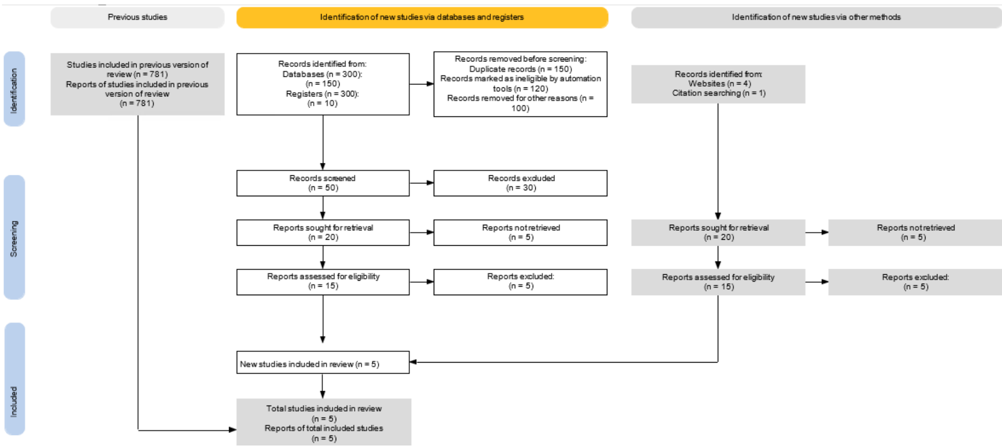

Figure 1: PRISMA Flow chart

Table 1: PEDro Scale Evaluation of Cycling Interventions in Type 2 Diabetes Mellitus

PEDro Criteria	Su C,et al.(2024)(19)	Bourne JE, et al. (2023) (20)	Li J, et al. (2022) (8)	Haryono I, et al. (2022)(21)	Jhingan A, et al. (2017)(15)
*EC (not scored)	✓	✓	✗	✓	✓
Criteria 1.	✓	✓	✓	✓	✗
Criteria 2.	✓	✓	✗	✗	✗
Criteria 3.	✓	✓	✓	✓	✓
Criteria 4.	✗	✗	✗	✗	✗
Criteria 5.	✗	✗	✗	✗	✗
Criteria 6.	✓	✓	✗	✓	✗
Criteria 7.	✓	✓	✓	✓	✓
Criteria 8.	✓	✗	✗	✓	✗
Criteria 9.	✓	✓	✓	✓	✓
Criteria 10.	✓	✓	✓	✓	✓
Total PEDro Score (/10)	8/10	7/10	5/10	7/10	5/10

*Eligibility criteria; 1 – Random allocation; 2 – Concealed allocation; 3 – Baseline comparability; 4 – Blind subjects; 5 – Blind therapists; 6 – Blind assessors; 7 – Adequate follow-up; 8 – Intention-to-treat analysis; 9 – Between-group comparisons; 10 – Point estimates and variability

Table 2: Summary of Included Studies Based on Focus Area, Study Population, Intervention Duration/ Protocol, and Key Findings.

Author (Year)	Focus Area	Population	Duration	Key Points
Su C,et al.(2024) (19)	Aerobic training intensities (low/moderate) and joint pain	T2DM patients with knee osteoarthritis	12 weeks	Compared the effects of aerobic training on glucose and joint function
Bourne JE, et al.(2023) (20)	Electrically assisted cycling (e-bike) pilot RCT	T2DM individuals	12 weeks	Improved activity levels, HbA1c, fitness
Li J, et al.(2022) (8)	Aerobic dance vs static cycling	T2DM adults	4 weeks	Both improved glucose and lipid profile; cycling had more BMI effect
Haryono I, et al. (2022) (21)	HIIT vs moderate continuous power cycling	Subjects with T2DM	12 weeks	Both improved HbA1c, weight, and fitness
Jhingan A, et al. (2017) (15)	Daily cycling effects	Young T2DM individuals (India)	6months (observational)	Lowered HbA1c, BP, and weight

RESULTS

The tables below summarize the findings of the five articles included in this systematic review. These studies examined the effects of different cycling interventions, such as static cycling (SC) and electric cycling, on glycemic control in individuals with Type 2 Diabetes Mellitus. The primary outcomes assessed in these studies included HbA1c levels, fasting blood glucose (FBG), and 2-hour postprandial blood glucose (PPBG). In addition to glycemic parameters, several studies also evaluated the impact of cycling interventions on other health-related outcomes such as body weight and body mass index (BMI). The results of the review process are presented in Tables 2, 3, and 4, which provide a concise overview of the study characteristics, intervention protocols, and key findings.

Table 3 shows the results of the review process, including the focus area, equipment used, study population, outcome measures, and main findings of the included studies.

Knee Injury and Osteoarthritis Outcome Score (KOOS), quality of life(QOL), higher intensity stationary cycling(HISC), moderate intensity stationary cycling(MISC), fasting blood glucose (FBG), 2-hour postprandial blood glucose(2 hr PPBG), high intensity interval training (HIIT), moderate-intensity continuous training(MICT)

Table 3: Summary of Review Findings

Author	Device Used	Focus Area	Population	Outcome Measure	Findings
Su C,et al.(2024) (19)	Stationary Cycle Ergometer	Different intensities of aerobic training in T2DM with knee OA	Patients with T2DM and Knee OA	Glucose levels, HbA1c, KOOS, QOL, BMI,	HbA1c level improves more in the HISC group than the MISC group, KOOS and QoL improve in both the intervention group than control group, and BMI control in each group.
Bourne JE, et al. (2023) (20)	Electrically Assisted Cycle	Feasibility and effectiveness of e-cycling	T2DM individuals	Adherence, glucose control	Safe, improved engagement and glycaemia control
Li J, et al. (2022) (8)	Static Cycle vs Aerobic Dance	Effect of different aerobic modalities	T2DM Elder Women (60 to 70 years)	FBG, 2hr PPBG, Blood pressure, and BMI level	FBG,2hr PPBG level, BMI, and Systolic BP go down more in cycling compared to aerobic dance
Haryono I, et al.(2022)(21)	Power Cycle	HIIT vs MICT using cycling	Subjects with T2DM	BP, glucose, insulin sensitivity, BMI,	↓ Weight and BMI are higher in MICT than in HIIT. BP ↓ in both intervention groups. HbA1c goes down in HIIT.
Jhingan A, et al. (2017) (15)	Conventional Cycle	Cycling impact on young diabetic adults	T2DM Young (<40 years)	Glycaemia HbA1c, BP, weight,	Significant improvement in all parameters without any supervised instruction session.

Table 4 presents the results of the review process in a structured format. It includes key study characteristics such as focus area, equipment used, study population, outcome measures, and major findings of the included articles. This table provides a concise overview of how different cycling interventions were utilized and their observed effects in the selected studies.

Table 4: Summary of Outcome Measures and Statistical Results

Author(s) and Years	Outcome Measures	Changes (%)	P-Value
Su C,et al.(2024)(19)	- Blood glucose control -Knee osteoarthritis symptoms KOOS and QoL	-Glucose ↓ ~12% - Both intensity groups compared with the control group difference 0.5%. Average based on 6-month KOOS QoL score -High intersity group 6.0% -Moderate intensity group 4.7% -Control group 2.5% - KOA symptom score ↓ ~18% BMI↓ in all groups	-P < 0.05
Bourne JE, et al.(2023) (20)	- Blood glucose control -VO2max - Fitness level - Quality of life	-HbA1c↓0.5% - VO2 max ↑ ~10%	-P < 0.05
Li J, et al. (2022) (8)	Blood glucose -FBG -PPBG Compare static cycling V/s Aerobic dance -Blood Pressure -Weight	-FBGpost < FBG pre -2hr PPBG post<2hr PPBG pre -2hr PPBG post SC < AD -Systolic BP SC<AD -Weight ↓ 4.2 %	-P =0.04 - p=0.02 -p=0.04 -p= 0.04
Haryono I, et al. (2022) (21)	-HbA1c -Blood Pressure Bodyweight↓ - BMI	(HbA1c↓) -HIIT > MICT BP -HIIT V/S CON -MICT V/S CON (MICT lead result) -Body weight ↓ -BMI	-p < 0.01 -p = 0.018 -p= 0.02 -p = 0.001 -p = 0.001
Jhingan A, et al. (2017) (15)	-HbA1c -Blood pressure - Body weight	- HbA1c ↓ 1.1% - BP ↓ 7–10 mmHg - Weight ↓ 5%	P < 0.05 Mean reduction 1.18%

DISCUSSION

This systematic review evaluated the effects of cycling as a specific aerobic exercise intervention on glycemic control and related outcomes in individuals with T2DM. Overall, the included studies consistently demonstrated that cycling across different modalities, such as stationary cycling, high-intensity interval training (HIIT), moderate-intensity continuous training (MICT), and e-cycling, contributes to improvements in glycemic parameters, including HbA1c, fasting blood glucose (FBG), and postprandial blood glucose (PPBG), along with secondary benefits in body composition, cardiovascular fitness, and quality of life. (19-21)

Cycling intensity appears to play an important role in metabolic outcomes. Evidence from recent randomized controlled trials indicates that both moderate- and high-intensity cycling improve glycemic control; however, high-intensity protocols may produce slightly greater reductions in HbA1c and improvements in insulin sensitivity. (19) Similarly, comparisons between HIIT and MICT suggest that while HIIT is more effective for improving VO_2 max and insulin dynamics, MICT may be more sustainable and beneficial for weight reduction. (21) These findings reinforce the importance of individualized exercise prescription based on patient tolerance, comorbidities, and adherence potential.

Alternative modalities such as e-cycling further expand the applicability of cycling interventions. E-cycling has demonstrated good feasibility and adherence, particularly among sedentary individuals or those with physical limitations, as it allows adjustable intensity and reduces physical strain. (20) This is clinically relevant for long-term behavior change, which is a critical factor in diabetes management. Additionally, evidence comparing static cycling with other aerobic modalities (e.g., aerobic dance) suggests that cycling may offer superior improvements in glycemic and cardiovascular parameters, although such findings should be interpreted cautiously due to small sample sizes. (8)

Evidence from observational and retrospective studies also supports the role of cycling in improving metabolic outcomes, particularly in younger populations with early-onset T2DM. Regular cycling performed over longer durations has been associated with clinically meaningful reductions in HbA1c, blood pressure, and body weight, highlighting its potential as a practical and scalable lifestyle intervention. (15)

Comparison with Existing Reviews

Previous systematic reviews have broadly examined the role of aerobic exercise, resistance training, or combined exercise programs in T2DM management, consistently reporting improvements in glycemic control and insulin sensitivity. For example, meta-analyses on structured exercise interventions have shown average HbA1c reductions of approximately 0.5–0.7%, irrespective of exercise modality. (22,23) However, these reviews typically group multiple forms of aerobic exercise (e.g., walking, jogging, cycling), limiting the ability to isolate the specific effects of cycling.

In contrast, the present review uniquely focuses on cycling as a standalone intervention. This distinction is important because cycling offers specific biomechanical and physiological advantages, including low joint impact, scalability of intensity, and suitability for both clinical and community settings. Despite these advantages, the current evidence base remains limited compared to broader exercise literature. Therefore, while the findings of this review align with existing evidence supporting aerobic exercise in T2DM, they also highlight a critical gap: the lack of high-quality, cycling-specific systematic investigations. This supports the need for more targeted research in this domain. (22-23)

Limitations

This review has several important limitations that must be acknowledged. First, the number of included studies was small (n = 5), which limits the generalizability of the findings. Additionally, there was considerable heterogeneity in cycling interventions, including variations in intensity (HIIT vs MICT), type (stationary, outdoor, and e-cycling), and duration of interventions, which reduces comparability across studies. Blinding was largely absent in the included studies, an inherent limitation in exercise-based research that may introduce performance bias. Furthermore, most studies had short follow-up durations (≤12 weeks), restricting conclusions regarding the long-term sustainability and clinical impact of cycling interventions. The relatively small sample sizes in individual studies also increase the risk of type II error and potential overestimation of treatment effects. Moreover, publication bias was not formally assessed, which may influence the overall interpretation of the predominantly positive findings. Given these limitations, the results of this review should be interpreted with caution, and overgeneralization should be avoided.

Future Directions

Future research should prioritize large-scale, high-quality randomized controlled trials focusing exclusively on cycling interventions in T2DM. Standardization of intervention protocols (intensity, duration, frequency) is essential to improve comparability across studies. Long-term follow-up studies are needed to evaluate sustainability and clinical outcomes beyond glycemic control, including cardiovascular risk and complication prevention. Additionally, research should explore accessible formats such as home-based or low-cost cycling interventions, particularly for resource-limited settings. Investigating subgroup responses (e.g., older adults, individuals with comorbidities) will further strengthen the clinical applicability of cycling-based exercise programs.

CONCLUSION

The findings of this systematic review highlight the potential therapeutic benefits of cycling as an aerobic exercise for individuals with Type 2 Diabetes Mellitus. Both static cycling and electrically assisted cycling demonstrated positive effects on glycemic control, particularly in reducing HbA1c levels, fasting blood glucose, and postprandial blood glucose levels. Cycling interventions were also associated with improvements in blood pressure, body weight, BMI, and overall physical fitness. High-intensity cycling appears to produce greater improvements in glycemic control, particularly among individuals with coexisting conditions such as knee osteoarthritis. E-cycling can serve as a motivating and accessible option for previously inactive individuals, while static cycling has demonstrated stronger effects on blood pressure and glucose regulation compared with some other aerobic activities. In younger individuals with T2DM, regular cycling was associated with clinically significant improvements in metabolic health and physical fitness. Overall, cycling represents a safe, accessible, and effective lifestyle intervention that can contribute to better diabetes management and improved quality of life.

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FUNDING

No financing

CONFLICT OF INTEREST

None

AUTHORSHIP CONTRIBUTIONS

Conceptualization: AA, SG, NS, SS, and AF Data curation: AA, SG, NS, SS, and AF Formal analysis: AA, SG, NS, SS, and AF

Funding acquisition; AA, NS, and SS Investigation: AA, SG, NS, SS, and AF

Methodology: AA, SG, NS, SS, and AF Project administration: AA, SG, NS, SS, and AF Resources: AA, SG, NS, SS, and AF Software: AA, SG, NS, SS, and AF Supervision: AA, SG, NS, SS, and AF

Validation: AA, SG, NS, SS, and AF Visualization: AA, SG, NS, SS, and AF Roles/Writing – original draft; AA, SG, NS, SS, AF, and AF Writing – review & editing. AA, SG, NS, SS, AF, and AF