

INFLUENCE OF A 12-WEEK CARDIOVASCULAR EXERCISE PROGRAM ON GLYCEMIC STATUS AND LIPID REGULATION IN ADULTS WITH TYPE 2 DIABETES MELLITUS: A RANDOMIZED CONTROLLED TRIAL

HUMA KHAN¹, KAMRAN ALI², TABISH FAHIM³, & MUHAMMAD SUFYAN⁴

1. PH.D. SCHOLAR, DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF HEALTHCARE AND ALLIED SCIENCES, GD, GOENKA UNIVERSITY, HARYANA, INDIA.
1. DEPARTMENT OF PHYSIOTHERAPY SNSAH JAMIA HAMDARD, NEW DELHI, INDIA.
EMAIL: humakhan@jamiahamdard.ac.in.
2. DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF ALLIED HEALTH SCIENCES, GALGOTIAS UNIVERSITY, GREATER NOIDA, UTTAR PRADESH, INDIA.
EMAIL: k.alisportsphysio@gmail.com.
3. DEPARTMENT OF PHYSIOTHERAPY SCHOOL OF HEALTHCARE AND ALLIED SCIENCES, GD GOENKA UNIVERSITY, HARYANA, INDIA.
EMAIL: drtabishfahim4u@gmail.com.
4. HIMSR, JAMIA HAMDARD UNIVERSITY, NEW DELHI-110062, INDIA,
EMAIL: muhammadsufyanmame2020@gmail.com.

*CORRESPONDENCE: DR. TABISH FAHIM
ASSOCIATE PROFESSOR,
DEPARTMENT OF PHYSIOTHERAPY SCHOOL OF HEALTHCARE AND ALLIED SCIENCES GD, GOENKA UNIVERSITY, HARYANA, INDIA.
EMAIL: drtabishfahim4u@gmail.com, ORCID :0000-0001-8480-2593

ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) presents a major global health burden due to its progressive metabolic complications and strong association with cardiovascular disease. Exercise therapy is widely recognized as an essential non-pharmacological strategy, yet comprehensive randomized trials comparing cardiovascular-style exercise with standard therapeutic programs that remain limited.

Objectives: To evaluate the impact of a structured 12-week cardiovascular exercise regimen on glycemic markers and lipid parameters in adults with T2DM and compare outcomes with those achieved through conventional therapeutic exercise.

Methods: A single-blind randomized controlled study was carried out at a tertiary care hospital in New Delhi, India. Forty clinically diagnosed adults with T2DM were randomly assigned to either a cardiovascular exercise group (n = 21) or a conventional therapeutic exercise group (n = 19). Both groups participated in supervised exercise sessions three times weekly for 12 weeks. Primary outcomes were glycated hemoglobin (HbA1c) and fasting blood glucose. Secondary variables included lipid profile indices, body mass index (BMI), body weight, random blood sugar, six-minute walk distance (6MWD), and blood pressure. Analysis involved paired tests for within-group changes and changes-score comparisons for between-group differences.

Results: The cardiovascular group demonstrated pronounced improvements across nearly all metabolic and functional parameters, including significant reductions in HbA1c, fasting glucose, random glucose, triglycerides, LDL cholesterol, total cholesterol, weight, and BMI, alongside enhanced functional capacity. The conventional exercise group showed modest improvements in selected metabolic indicators but no significant gains in HbA1c, BMI, or endurance. Change-score comparisons confirmed that cardiovascular training was superior across most outcome domains.

Conclusion: A structured cardiovascular exercise program performed thrice weekly for 12 weeks produced clinically meaningful benefits in metabolic regulation, lipid health, and functional performance in adults with T2DM. These findings highlight cardiovascular-style body-weight training as an accessible and practical addition to diabetes rehabilitation programs.

Keywords: Diabetes Mellitus-Type II, Exercise Therapy, Cardiovascular, Glycated Hemoglobin A, Blood Glucose, Lipid Metabolism.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder involving persistent hyperglycemia due to impaired insulin secretion or insulin resistance. With rising global prevalence, T2DM continues to impose a substantial burden on healthcare systems. Sedentary habits, excessive adiposity, and reduced physical activity contribute to worsening glycemic control and lipid abnormalities, predisposing individuals to severe vascular complications (1,2). Structured exercise has been consistently recommended as an essential non-pharmacological strategy to support metabolic regulation in individuals with T2DM.

Exercise therapy remains a central non-pharmacological strategy for improving metabolic function in T2DM. Cardiovascular-style exercise—consisting of rhythmic, body-weight, multi-joint movements—has gained recognition due to its practicality, low cost, and physiological benefits. Unlike equipment-based resistance training, cardiovascular exercise requires minimal resources and has demonstrated favorable effects on glucose regulation, lipid profiles, and functional capacity. Prior studies report improvements in insulin sensitivity, enhanced GLUT-4 activation, and reductions in visceral adiposity following body-weight-based training programs (3). However, relatively few randomized trials have examined its comparative effects against conventional therapeutic exercise across a comprehensive range of metabolic and functional indicators (4).

Similarly, Kamat et al. demonstrated that 12 weeks of cardiovascular resulted in greater reductions in HbA1c, postprandial glucose, and body-fat percentage compared with Pilates training in overweight adults with T2DM (5). Even though a retracted study by Wu and Qu had initially suggested improvements in hypoglycemia parameters with cardiovascular, subsequent investigations with stronger methodology have validated these outcomes (6).

Cardiovascular exercise studies further support this physiological mechanism. Amini-Najafabadi et al. showed significant reductions in fasting blood sugar, HbA1c, and total cholesterol after 8 weeks of moderate-intensity Cardiovascular training among women with T2DM (1). Likewise, Ghalavand et al. demonstrated improvements in glycemic markers and HDL following structured Cardiovascular sessions in diabetic men (2). Collectively, these findings indicate that resistance-based cardiovascular and traditional Cardiovascular training both contribute to improved metabolic control through enhanced glucose transport, improved insulin action, and favorable lipid modulation.

Despite these promising findings, gaps remain. Few randomized controlled trials have compared cardiovascular directly with conventional exercise programs in adults aged 30 to 65 years with established T2DM. Moreover, limited studies have evaluated comprehensive metabolic outcomes including fasting blood sugar, random blood sugar, HbA1c, total lipid profile, blood pressure, anthropometry, and functional capacity in a single 12-week Cardiovascular protocol. The existing literature often focuses on single outcomes or specific subgroups, leaving uncertainty about the holistic cardiometabolic effects of Cardiovascular training in clinically diagnosed adults.

Therefore, the present study was designed to address this gap by evaluating glycemic, lipid, anthropometric, cardiovascular, and functional changes following 12 weeks of structured cardiovascular exercise in adults with T2DM.

METHODOLOGY

Study Design: This study employed a single-blind, randomized controlled trial with two parallel groups: an A single-blind, parallel-group randomized controlled trial was conducted between July and October 2025 at Hakeem Abdul Hameed Centenary Hospital, Jamia Hamdard, New Delhi. Participants were randomly allocated to either a cardiovascular exercise group or a conventional exercise group. Baseline and follow-up assessments were performed by an outcome assessor blinded to group allocation.

Participants: Adults aged between 30 and 65 years with clinically confirmed T2DM for at least one year and medically cleared for moderate-intensity physical activity were recruited. Exclusion criteria included uncontrolled hypertension, diabetic complications limiting exercise capacity, musculoskeletal disorders restricting movement, and recent cardiovascular events. Ethical approval was obtained, and all participants provided written informed consent. Ethical approval was obtained from the Institutional Ethics Committee (Ref. No. 14/23/12/2023), and the trial was prospectively registered with the Clinical Trial Registry of India (CTRI/REF/2024/02/079131). All procedures followed institutional and international ethical guidelines.

Randomization: A computer-generated allocation sequence was used to assign participants in a 1:1 ratio. Sequentially numbered, sealed opaque envelopes ensure allocation concealment. Therapists supervising interventions were not blinded, whereas assessors and data analysts remained blinded.

Intervention Protocol:

Cardiovascular Exercise Group: Participants completed structured body-weight exercise sessions lasting 45–60 minutes, three times weekly. Sessions included warm-up mobility exercises, multi-joint cardiovascular movements (squats, lunges, step sequences, modified push-ups, hip-stabilizing drills), and cool-down stretching.

Exercise intensity was regulated using Borg's RPE scale (11–14), with gradual progression introduced throughout the 12-week program.

Conventional Exercise Group: Participants engaged in standard therapeutic exercise that included warm-up walking, moderate aerobic activity, basic strengthening and mobility routines, and flexibility training. Intensity and session duration were matched to the cardiovascular group.

Outcome Measures:

Primary outcome:

- Glycated hemoglobin (HbA1c)
- Fasting blood glucose (FBG)

Secondary outcomes:

- Lipid profile (total cholesterol, LDL-C, HDL-C, triglycerides)
- Body weight and BMI
- Systolic and diastolic blood pressure
- Six-minute walk distance (6MWD)
- Random blood sugar

All biochemical measurements were performed at baseline and after 12 weeks using standard laboratory protocols.

Statistical Analysis:

Data were analyzed using SPSS version XX. Within-group differences were assessed using paired tests, while between-group differences were analyzed using independent t-tests on change scores. Statistical significance was set at $p < 0.05$.

RESULTS

Forty participants (21 cardiovascular; 19 conventional) completed the intervention. Baseline characteristics were comparable. Baseline demographic and clinical variables were broadly comparable between the groups, although minor differences in certain metabolic values were present. These variations were statistically adjusted using change-score analyses to ensure an unbiased comparison of outcomes.

The cardiovascular exercise group experienced significant reductions across all major metabolic markers, including HbA1c, fasting glucose, random glucose, triglycerides, LDL cholesterol, and total cholesterol. Weight and BMI declined meaningfully, and functional capacity improved markedly, as demonstrated by substantial increases in 6MWD. Blood pressure values also showed notable improvements (Table-1).

The conventional exercise group demonstrated smaller improvements in certain biochemical measures but no substantial changes in HbA1c, BMI, or endurance capacity. Functional performance decreased slightly in this group (Table-1).

Between-group comparisons based on change scores revealed that cardiovascular training was significantly more effective than conventional exercise across nearly all outcome categories, except for fasting glucose, which improved similarly in both groups. Overall, the Cardiovascular intervention demonstrated superior effectiveness compared to conventional exercise in improving cardiometabolic health and functional capacity in adults with Type 2 Diabetes Mellitus (Table-1).

Table 1. Comparison of clinical and biochemical variables within and between groups at baseline and after 12 weeks.

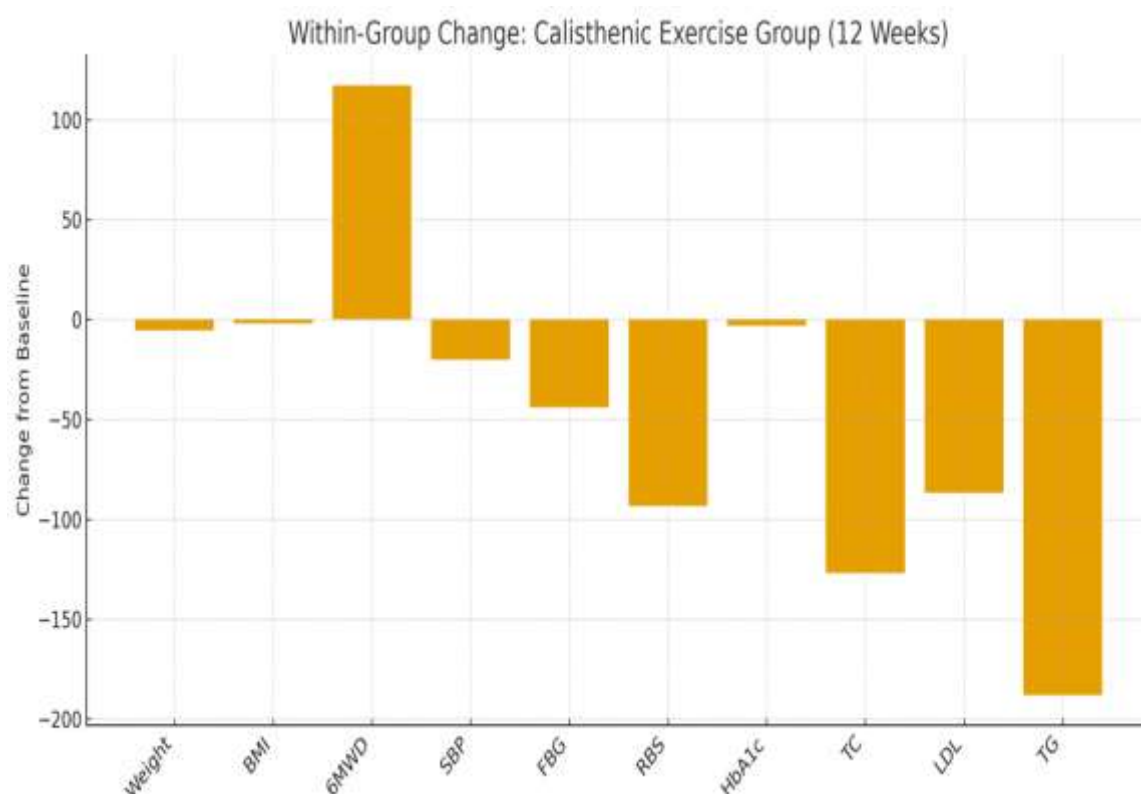
Variable	Cardiovascular group Pre (Mean $\pm$ SD)	Cardiovascular group Post (Mean $\pm$ SD)	p (within Cardiovascular)	Conventional group Pre (Mean $\pm$ SD)	Conventional group Post (Mean $\pm$ SD)	p (within Conventional)	p (between groups, change)
Weight (kg)	71.10 $\pm$ 10.07	65.67 $\pm$ 9.75	<0.001	69.37 $\pm$ 11.50	69.84 $\pm$ 11.35	0.359	<0.001
BMI (kg/m ²)	26.51 $\pm$ 4.22	24.45 $\pm$ 3.97	<0.001	27.28 $\pm$ 2.85	27.53 $\pm$ 2.67	0.246	<0.001
6MWD (m)	400.00 $\pm$ 93.49	517.14 $\pm$ 89.23	<0.001	456.58 $\pm$ 115.83	365.00 $\pm$ 102.10	0.001	<0.001
SBP (mmHg)	136.38 $\pm$ 9.27	116.29 $\pm$ 7.11	<0.001	133.63 $\pm$ 12.64	125.95 $\pm$ 9.61	0.001	<0.001
DBP (mmHg)	91.81 $\pm$ 7.15	76.14 $\pm$ 6.41	<0.001	80.47 $\pm$ 7.95	79.95 $\pm$ 6.95	0.682	<0.001

Fasting sugar (mg/dL)	144.32 ± 47.98	100.38 ± 7.88	<0.001	148.04 ± 48.58	120.37 ± 24.31	0.002	0.193
Total cholesterol (mg/dL)	270.12 ± 55.47	143.15 ± 16.04	<0.001	243.17 ± 62.84	190.47 ± 50.98	<0.001	<0.001
LDL (mg/dL)	164.60 ± 55.08	77.86 ± 29.87	<0.001	141.33 ± 49.57	120.28 ± 37.00	0.001	<0.001
HDL (mg/dL)	100.98 ± 23.27	42.12 ± 7.53	<0.001	58.28 ± 10.32	50.35 ± 8.07	0.016	<0.001
Triglycerides (mg/dL)	328.94 ± 77.19	141.06 ± 19.26	<0.001	243.17 ± 133.12	187.48 ± 109.13	<0.001	<0.001
HbA1c (%)	9.60 ± 2.00	6.54 ± 0.80	<0.001	8.85 ± 1.62	8.81 ± 1.49	0.694	<0.001
Random sugar (mg/dL)	242.62 ± 23.85	149.24 ± 22.14	<0.001	258.47 ± 19.31	242.42 ± 28.05	<0.001	<0.001

*p (between groups, change) = Independent-samples t-test on change scores (Post & Pre) for Cardiovascular vs. Conventional group.

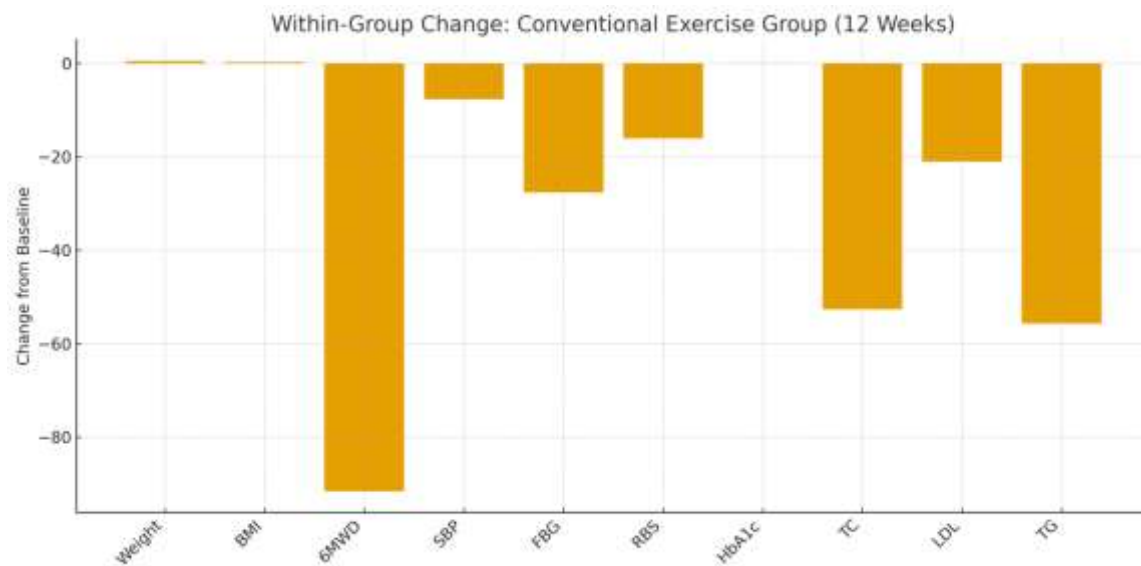
GRAPH 1

Within-group changes in clinical and biochemical variables following 12 weeks of Cardiovascular exercise. This figure illustrates the pre-to-post intervention change scores for the Cardiovascular Exercise Group across all measured outcomes, including weight, BMI, 6-minute walk distance (6MWD), systolic blood pressure (SBP), fasting blood glucose (FBG), random blood sugar (RBS), HbA1c, total cholesterol (TC), low-density lipoprotein (LDL), and triglycerides (TG). Negative values indicate reductions, while positive values reflect improvements.



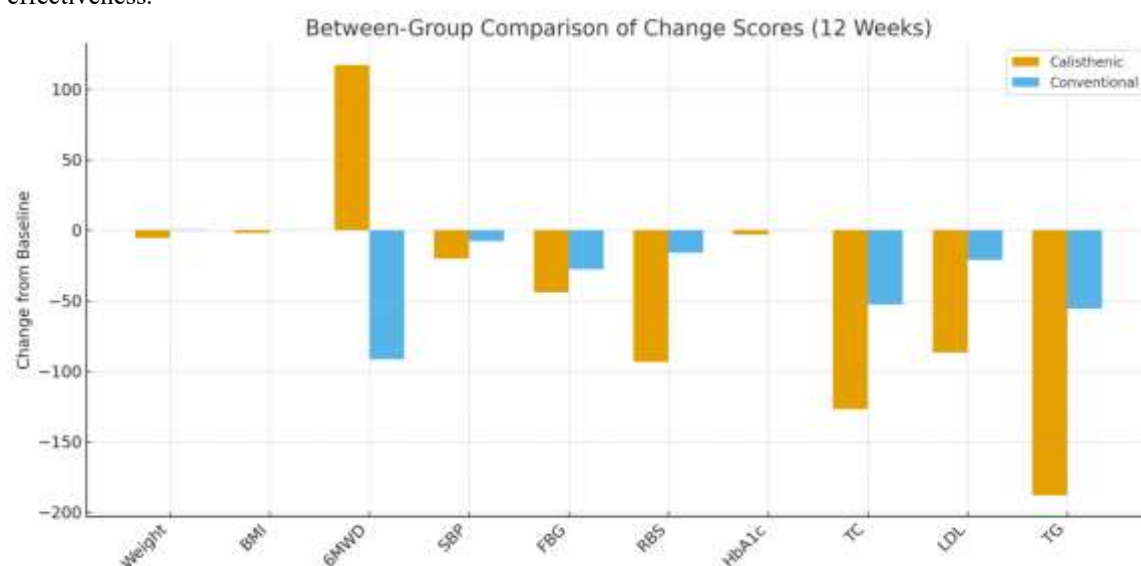
GRAPH 2

Within-group changes in clinical and biochemical variables following 12 weeks of conventional exercise. This figure presents the change scores for the Conventional Exercise Group across all variables. Moderate improvements were observed in some metabolic markers, while weight, BMI, and HbA1c remained largely unchanged, and functional capacity (6MWD) declined.



GRAPH 3

Between-group comparison of change scores after 12 weeks of intervention. Side-by-side bars represent the Cardiovascular Exercise Group and Conventional Exercise Group for each variable. The Cardiovascular group demonstrated significantly greater improvements across most outcomes, indicating superior intervention effectiveness.



DISCUSSION

This randomized controlled study demonstrated that a 12-week structured cardiovascular exercise regimen can produce meaningful improvements in essential metabolic parameters among adults with T2DM. The pronounced reductions in HbA1c and lipid abnormalities suggest enhanced insulin action, improved energy metabolism, and favorable modulation of lipid transport mechanisms. The substantial gain in 6MWD reflects improvements in aerobic tolerance and cardiovascular efficiency.

Our results are in line with the Cardiovascular-specific trial by Kong et al., who reported that a structured Cardiovascular program in middle-aged individuals with obesity and T2DM led to significant reductions in visceral fat and improvements in glycemic markers, confirming that body-weight Cardiovascular-style Cardiovascular can be an effective metabolic intervention in this population (4). Similarly, Elfaki found that a structured exercise training program improved both HbA1c and lipid profile in adults with T2DM (6). The pattern of HbA1c reduction and lipid improvements observed in our Cardiovascular group fits well within the effect sizes reported by these earlier intervention trials.

The present findings also agree with several recent resistance-training and combined-exercise meta-analyses. Bärge et al. demonstrated that resistance training (RT) significantly reduces HbA1c in people with T2DM, with gym-based, supervised RT protocols being more effective than unsupervised home programs (7). Su et al. further clarified dose-response relationships, showing that higher training frequency and sufficient duration of RT are associated with larger reductions in HbA1c and fasting glucose (8). Our 12-week, thrice-weekly Cardiovascular protocol, which combines elements of Cardiovascular and resistance loading via repetitive body-weight

movements, is consistent with these optimized RT “doses” and may explain the clinically relevant reductions in HbA1c observed in the experimental group.

Systematic reviews focused specifically on resistance training reinforce this interpretation. Dadzie et al. showed that RT significantly reduces HbA1c and BMI while increasing muscle strength in people with diabetes across middle-aged and older cohorts (10). Our finding of reductions in BMI and improvements in glycemic indices after Cardiovascular training parallels these observations and suggests that a carefully progressed Cardiovascular protocol can function physiologically as a form of resistance training.

Importantly, our results are also compatible with evidence on combined Cardiovascular–resistance interventions. Zhang et al. demonstrated that combined Cardiovascular and resistance exercise improves HbA1c, lipid profile, BMI, Cardiovascular capacity, and quality of life in middle-aged and older adults with T2DM (9). The present Cardiovascular protocol which naturally blends rhythmic Cardiovascular components with repeated body-weight loading may therefore provide benefits comparable to structured combined-training programs.

Mechanistically, the improvements in glycemic control and lipid levels are supported by established position statements. The American Diabetes Association (ADA) position statement highlights that regular Cardiovascular and resistance exercise enhances insulin sensitivity, promotes GLUT-4 translocation, improves mitochondrial function, and reduces cardiovascular risk factors in T2DM (11). The joint ACSM/ADA position statement further emphasizes that structured exercise programs combining endurance and resistance yield the greatest benefits in HbA1c, lipids, blood pressure, and overall cardiometabolic risk (12). Our Cardiovascular program aligns with these evidence-based recommendations.

The broader exercise literature in T2DM provides additional support. Garcia et al. concluded that structured exercise training and physical-activity advice are effective in lowering HbA1c in people with T2DM, with supervised programs showing the strongest results (13). Several Current studies reported that a combination of Cardiovascular and long term resistance training produced greater HbA1c reductions than either modality alone, improvement in the thyroid functions and improve sleep quality (14, 15,16 & 17).

The superiority of cardiovascular exercise over conventional therapy may be attributed to its incorporation of continuous, rhythmic, multi-joint movements that simultaneously engage multiple muscle groups, increase metabolic demand, and enhance glucose uptake. These physiological mechanisms align with established evidence showing that regular body-weight training can effectively reduce metabolic risk factors in individuals with T2DM

Limitation:

The study sample was limited to a single clinical setting with moderate sample size. Dietary patterns and medication adherence were not objectively monitored. Long-term follow-up was not performed, limiting insight into sustained metabolic benefits.

CONCLUSION

A 12-week cardiovascular body-weight exercise program administered three times weekly significantly improved glycemic control, lipid profile, body composition, blood pressure, and functional endurance in adults with T2DM. The intervention produced superior outcomes compared with conventional therapeutic exercise and may serve as a scalable, low-cost strategy for diabetes rehabilitation programs.

REFERENCE

1. Amini-Najafabadi B, Keshavarz S, Asgary S, Azarbarzin M. The 8-week Cardiovascular exercise reduces blood sugar, HbA1c and cholesterol levels in women with type 2 diabetes. *Jorjani Biomed J.* 2020;8(3):44–56. doi:10.29252/jorjanibiomedj.8.3.44.
2. Ghalavand A, Rezaee R, Gholami A, Mahmood khanikoo shkaki R, Mahmoudnejad MH. Effects of Cardiovascular training on fasting blood sugar, HbA1c and lipid profile in men with type 2 diabetes. *Int J Med Res Health Sci.* 2016;5(6):27–33.
3. Kamat K, Kage V, Sequeira S. Cardiovasculars versus Pilates training on glycemic control and body fat in overweight individuals with type 2 diabetes mellitus. *Physiother Pract Res.* 2023;44(3):99–108. doi:10.3233/PPR-220688.
4. Kong N, Yang G, Wang L, Li Y. Cardiovasculars exercises to intervene in obesity and diabetes in middle-aged people. *Rev Bras Med Esporte.* 2022;28(2):85–90. doi:10.1590/1517-8692202228022021_0457.
5. Wu G, Qu H. The effect of Cardiovasculars on hypoglycemic control of diabetic patients. *Biomed Res Int.* 2022;2022:7737626. doi:10.1155/2022/7737626. Retracted 2024.
6. Elfaki NK. Effect of exercise training on Type 2 diabetes management and lipid profile. *Rawal Med J.* 2024;49(1):20–23. doi:10.5455/rmj.20231119011058.
7. Bärge M, Idiart-Borda Polotto V, Geiger S, Held S, Brinkmann C. Effects of home- and gym-based resistance training on glycemic control in patients with type 2 diabetes mellitus: a systematic review and meta-analysis. *Diabetol Metab Syndr.* 2025;17(1):228. doi:10.1186/s13098-025-01793-7.
8. Su W, Tao M, Ma L, Tang K, Xiong F, Dai X, Qin Y. Dose-response relationships of resistance training in type 2 diabetes mellitus: a meta-analysis of randomized controlled trials. *Front Endocrinol (Lausanne).* 2023;14:1224161. doi:10.3389/fendo.2023.1224161.

9. Zhang J, Tam WWS, Hounsri K, Kusuyama J, Wu VX. Effectiveness of combined Cardiovascular and resistance exercise on cognition, metabolic health, physical function, and quality of life in adults with type 2 diabetes mellitus: a systematic review and meta-analysis. *Arch Phys Med Rehabil.* 2024;105(8):1585–1599. doi:10.1016/j.apmr.2023.10.005.
10. Dadzie AQ, Babae PMN, Ruku DM. Effects of resistance training on hemoglobin A1c, body mass index, and muscle strength in diabetic patients based on age group: a systematic review and meta-analysis. *Osong Public Health Res Perspect.* 2025. doi:10.24171/j.phrp.2025.0268.
11. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, 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.
12. Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, et al. Exercise and type 2 diabetes: joint position statement of the ACSM and ADA. *Diabetes Care.* 2010;33(12):e147–e167. doi:10.2337/dc10-9990.
13. Garcia SP, Cureau FV, Iorra FQ, Bottino LG, Monteiro LER, Leivas G, et al. Effects of exercise training and physical activity advice on HbA1c in people with type 2 diabetes: a network meta-analysis. *Diabetes Res Clin Pract.* 2025;221:112027. doi:10.1016/j.diabres.2025.112027.
14. Church TS, Blair SN, Cocroham S, Johannsen N, Johnson W, Kramer K, et al. Effects of Cardiovascular and resistance training on HbA1c levels in patients with type 2 diabetes: a randomized controlled trial. *JAMA.* 2010;304(20):2253–2262. doi:10.1001/jama.2010.1710.
15. Sundus H, Khan SA, Zaidi S, Chhabra C, Ahmad I, Khan H. Effect of long-term exercise-based interventions on thyroid function in hypothyroidism: a systematic review and meta-analysis of randomized controlled trials. *Complement Ther Med.* 2025;92:103196. doi:10.1016/j.ctim.2025.103196.
16. Huma Khan, Kamran Ali, Tabish Fahim, Reem M. Gahtani, Sameer Alqassimi, Irshad Ahmad, Nasrin Mansuri, Muhammad Sufyan, Omar Irshad Ahmad. Effectiveness of a 12-Week Telehealth Tai-Chi Intervention on Serum Lipids and Sleep Quality in Type-2 Diabetes Mellitus: A Randomized Control Trail. *J Rare Cardiovasc Dis.* 2025;5(S1):1029–1036.
17. Huma Khan, Kamran Ali, Tabish Fahim, Ifra Aman, Muhammad Sufyan, (2025) Literature Analysis on The Prevalence of Type 2 Diabetes Mellitus in Adolescents and Young Adults. A review study, *Vascular and Endovascular Review*, Vol.8, No.10s, 184-.194.