

Effectiveness of a 12-Week Telehealth Tai-Chi Intervention on Serum Lipids and Sleep Quality in Type-2 Diabetes Mellitus: A Randomized Control Trail.

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Abstract: **Background:** Telehealth is an exercise program delivered through audio or video conferencing to the individuals. Type-2 diabetes mellitus (T2DM) is generally complemented by dyslipidemia and sleep disturbances, elevating cardiovascular risk and impairing metabolic control. Although Tai Chi has proved progresses in glycemic and lipid profiles, limited data exist on remotely delivered Telehealth Tai-Chi programs targeting both serum lipids and sleep quality in T2DM. Aim of the study is to examine the effects of a 12-week Telehealth-delivered Tai-Chi intervention on serum lipid profiles and subjective sleep quality in adults with T2DM. **Methods:** In this single-center, parallel-group randomised control trial, 40 adults with T2DM (aged 30–75 years) were randomly assigned to a Telehealth Tai-Chi group (n = 20) or a conventional care group (n = 20). The intervention group received supervised Telehealth Tai -Chi sessions (45–60 minutes, 5 days/week) via secure video platform for 12 weeks, while controls group received standard medical care and lifestyle counseling. The primary outcomes included the serum lipid profile, comprising total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C), as well as sleep quality evaluated using the Pittsburgh Sleep Quality Index (PSQI). Secondary outcomes comprised fasting blood glucose, HbA1c, body mass index, and blood pressure. Analyses adhered to the intention-to-treat principle. **Results:** After 12 weeks, of the Telehealth Tai-Chi intervention group showed significant within-group reductions in TC (–53.98 mg/dL), LDL-C (–13.14 mg/dL), TG (–52.87 mg/dL), and PSQI score (–4.71 points; all p < 0.001). HDL-C declined modestly (–8.44 mg/dL). Between-group comparisons revealed greater improvements in PSQI (p < 0.001) and significant additional reductions in TC, LDL-C, and TG versus controls (all p < 0.05). No adverse events occurred. **Conclusions:** A 12-week Telehealth Tai-Chi program is a safe, feasible, and effective adjunct to standard care, producing clinically meaningful reductions in total cholesterol, LDL-C, triglycerides, and enhancing sleep quality in adults with T2DM. Larger multi-center trials with extended follow-up are warranted to confirm durability and clarify long-term effects on HDL-C.

Keywords: Telehealth Tai-Chi, Lipid Profile, Lipid Serum, Pittsburgh Sleep Quality Index, Types-2 Diabetic Mellitus.

INTRODUCTION

Telehealth utilizes advanced computer-based applications to monitor and maintain health effectively [1]. In the contemporary technological landscape, telehealth is utilized effectively, ensuring safety and reducing financial burdens [2]. It is readily accessible for numerous patients who cannot afford in-person visits to medical facilities [3,4].

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by sustained hyperglycemia and recurrent dyslipidemia, impacting over 530 million adults worldwide, with projections indicating an increase to 783 million by 2045 [5]. Abnormal serum lipid

profiles, characterized by elevated triglycerides (TG) and reduced high-density lipoprotein cholesterol (HDL-C), significantly elevate the risk of cardiovascular disease in individuals with type 2 diabetes mellitus (T2DM) [6,7]. Concurrently, sleep disturbances are common in this population and exacerbate metabolic dysregulation and insulin resistance [5,7]. Although pharmacological therapy remains essential, it is often limited by adverse effects, cost, and suboptimal long-term adherence [6], underscoring the need for safe and scalable lifestyle interventions.

Exercise therapy is a cornerstone of diabetes management. Several studies have highlighted the benefits of physical activity in managing chronic

conditions like Type-2 diabetes. One study examined the effectiveness of therapeutic techniques in improving flexibility and balance, which are vital for managing diabetes complications [8]. Another found that structured exercise programs enhanced balance and confidence in post-stroke individuals, a group often affected by diabetes [9]. Research also emphasizes the importance of physical therapy in intensive care settings, supporting its role in diabetes management [10]. Additionally, studies have shown that exercise can improve knee function in osteoarthritis patients, indicating similar benefits for diabetes [11]. Lastly, the use of EMG-guided exercises to enhance functional ability further suggests the potential of interventions like Tai-Chi for people with Type-2 diabetes [12].

Regular physical activity improves glycemic control, optimizes lipid metabolism, and enhances overall metabolic health [13,14]. Tai-Chi is a traditional Chinese mind-body practice integrating controlled movements, breathing, and meditative awareness has gained attention as a feasible, low-impact exercise suitable for diverse populations. Multiple systematic reviews and meta-analyses demonstrate that Tai Chi reduces fasting blood glucose (FBG) and glycated hemoglobin (HbA1c), decreases TG, and raises HDL-C in individuals with T2DM [11-15]. Evidence also shows reductions in total cholesterol (TC) and improvements in body mass index (BMI) following regular Tai Chi practice [10,13,17].

Beyond glycemic and lipid benefits, Tai-Chi may positively influence sleep quality. Mind-body integration, gentle aerobic intensity, and autonomic modulation are thought to promote restorative sleep and reduce stress in individuals with chronic conditions [16]. Trials of 12 -week Tai-Chi programs have reported improvements in both metabolic outcomes and subjective sleep parameters [14,15]. Meta-analytic evidence further suggests that high-frequency (5-7 sessions/week) 45 to 60-minute sessions of 24form simplified Tai-Chi produce ideal effects on glucose and lipid metabolism [13,17].

Despite these promising findings, most prior interventions required in-person classes, limiting accessibility for individuals facing mobility constraints, geographic barriers, or pandemic-related restrictions [10,12]. Telehealth-delivered exercises offer a practical, supervised, and cost-effective alternative that can maintain program fidelity while expanding reach [12,15]. However, rigorous randomized controlled trials (RCTs) evaluating Telehealth Tai-Chi's effects on both serum lipid profiles and sleep quality in adults with T2DM are lacking.

Accordingly, this study was designed as a parallel-group RCT to examine whether a 12-week Telehealth Tai-Chi intervention improves (1) serum lipids total cholesterol, TG, low-density and high-density lipoproteins and (2)

subjective sleep quality compared with usual care in adults with T2DM [18].

In spite of much use of these apps, only few literatures are available to see how effective these Telehealth apps are there on blood biochemistry. To fill this gap authors have used Telehealth Tai-Chi exercises apps for lipid profiles and quality of sleep-in participants. We hypothesize that Telehealth Tai-Chi apps intervention will yield significant improvements in lipid metabolism and sleep outcomes relative to standard management

MATERIALS AND METHODS

Study Design

A parallel group, single-centered randomized controlled trial was performed at Hakeem Abdul Hameed Centenary Hospital, Jamia Hamdard, New Delhi, India from July 2024 to October 2024. Ethical approval was secured 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 adhered to the Declaration of Helsinki guidelines.

Participants

Forty-five participants were recruited for this study, two of them did not match inclusion criteria and three dropped before the first diagnosis. Forty participants diagnosed with Type 2 Diabetes Mellitus (T2DM) were included in this study. The diagnosis was confirmed by an endocrinologist utilizing the International Classification of Diseases, 10th Revision (ICD-10) code E11. Participants were randomly allocated in two groups: Tele-Tai Chi group or the Conventional group (20 participants each), Figure 1. All the adverse effects related to study were explained to the participants prior signing the consent form.

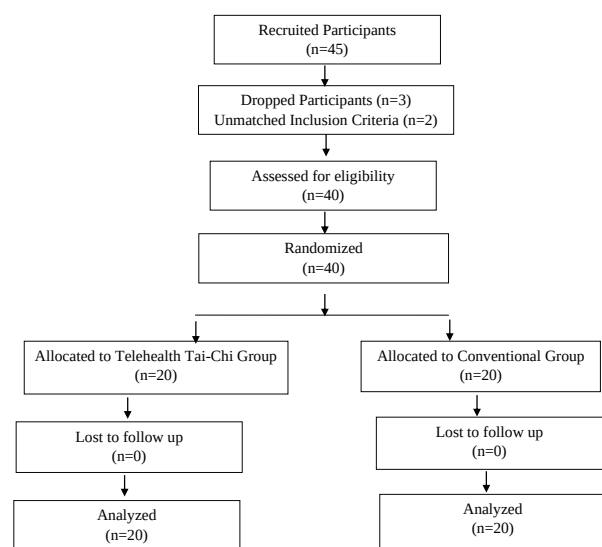


Figure 1 Flow Diagram of participants

Inclusion and Exclusion Criteria

Participants were men and women aged 30–75 years with a established diagnosis of type 2 diabetes mellitus (ICD-10 code E11) by an endocrinologist. All were on stable anti-diabetic medication and presented with at least one comorbidity such as chronic obesity, dyslipidemia, or hypertension. Eligible participants had an ICF score ≥ 10 , were medically cleared to perform moderate-intensity physical activity, and provided written informed consent. Individuals were excluded if they had uncontrolled hypertension, diabetic retinopathy, advanced neuropathy, or chronic kidney disease stage ≥ 3 . Additional exclusions included any recent (within six months) musculoskeletal injuries or cardiovascular events, intolerance to moderate-intensity exercise, or other medical contraindications likely to impair safe participation or affect glycemic outcomes.

Randomization and Allocation

Participants were randomly assigned using a computer-generated random sequence with concealed allocation. The allocation ratio was 1:1 and managed by a blind research assistant who was not involved in assessment or intervention. Intervention was given by a qualified physiotherapist. Pre and post data was taken by a blinded investigator.

Interventions

Telehealth Tai-Chi Intervention Group

Participants received supervised Tele-Tai Chi sessions via a secure video platform. Sessions followed a 24-Form Simplified Tai-Chi protocol (by means of an app to exercise Tai-Chi, lasting 45 to 60 minutes, 5 days per week, for 12 weeks). Each session included warm-up, Telehealth Tai-Chi intervention protocol emphasizing

slow, continuous movements with breathing coordination, and cool-down. Qualified Physiotherapist provided live, interactive instruction and monitored participant safety.

Conventional Group

Participants continued standard medical care and received routine lifestyle counseling as per American Diabetes Association recommendations [17]. They did not participate in any supervised exercise programs during the study period.

- Outcome Measures
- Primary outcomes were
- Using a blood sample, determine the serum lipid profile, which includes total cholesterol, triglycerides, LDL, and HDL.
- 2. The PSQI (Pittsburgh Sleep Quality Index) was used to evaluate the quality of sleep.

Secondary measures included fasting blood glucose, HbA1c, body mass index (BMI), and blood pressure. All biochemical assessments were performed at baseline and at 12 weeks using standardized laboratory protocols.

Data Collection and Analysis

Baseline demographic and clinical data were recorded at enrollment. Blood samples were collected in a fasting state at baseline and post-intervention. An intention-to-treat analysis was performed on the data. We will compare continuous variables using independent t-tests, taking baseline values into account, and expressing them as mean $\pm$ SD. A significance level of $p < 0.05$ was used.

RESULT

After 12 weeks, the Telehealth Tai-Chi Intervention Group ($n = 20$) showed marked improvements across all outcomes except HDL-cholesterol (Table 1). Total cholesterol decreased from 228.46 ± 65.74 mg/dL to 174.49 ± 41.87 mg/dL, LDL-cholesterol from 119.59 ± 73.91 mg/dL to 106.45 ± 59.41 mg/dL, triglycerides from 236.55 ± 116.82 mg/dL to 183.68 ± 92.09 mg/dL, and HDL-cholesterol declined modestly from 55.33 ± 11.67 mg/dL to 46.89 ± 10.04 mg/dL. Sleep quality improved substantially, with the Pittsburgh Sleep Quality Index (PSQI) score decreasing from 20.04 ± 1.93 to 15.33 ± 1.56 , (Graph 1).

The Conventional group ($n = 20$) also demonstrated reductions in total cholesterol (243.17 ± 62.84 to 190.47 ± 50.98 mg/dL), LDL Cholesterol (141.33 ± 49.57 to 120.28 ± 37.00 mg/dL), triglycerides (243.17 ± 133.12 to 187.48 ± 109.13 mg/dL), and HDL-cholesterol (58.28 ± 10.32 to 50.35 ± 8.07 mg/dL), but their PSQI score changed only slightly (19.81 ± 1.79 to 19.04 ± 2.41) (Table 2 & Graph 2).

The Telehealth Tai-Chi group showed considerably higher decreases in total cholesterol, LDL-cholesterol, and triglycerides (all $p < 0.05$) and a highly superior improvement in sleep quality ($p < 0.01$), according to the between-group comparison (Table 3). Both the effectiveness and safety of the Telehealth Tai-Chi intervention were demonstrated by the absence of adverse events in either arm. Mean $\pm$ SD is used to display the values.

Table 1. Telehealth Tai-Chi Group: Baseline vs post-intervention ($n = 20$)

Parameter	Minimum Value $\pm$ Standard Deviation	Post-12-Week Mean $\pm$ SD	Mean Variation	p (within-group)
Total Cholesterol (mg/dL)	228.46 ± 65.74	174.49 ± 41.87	-53.98	<0.001

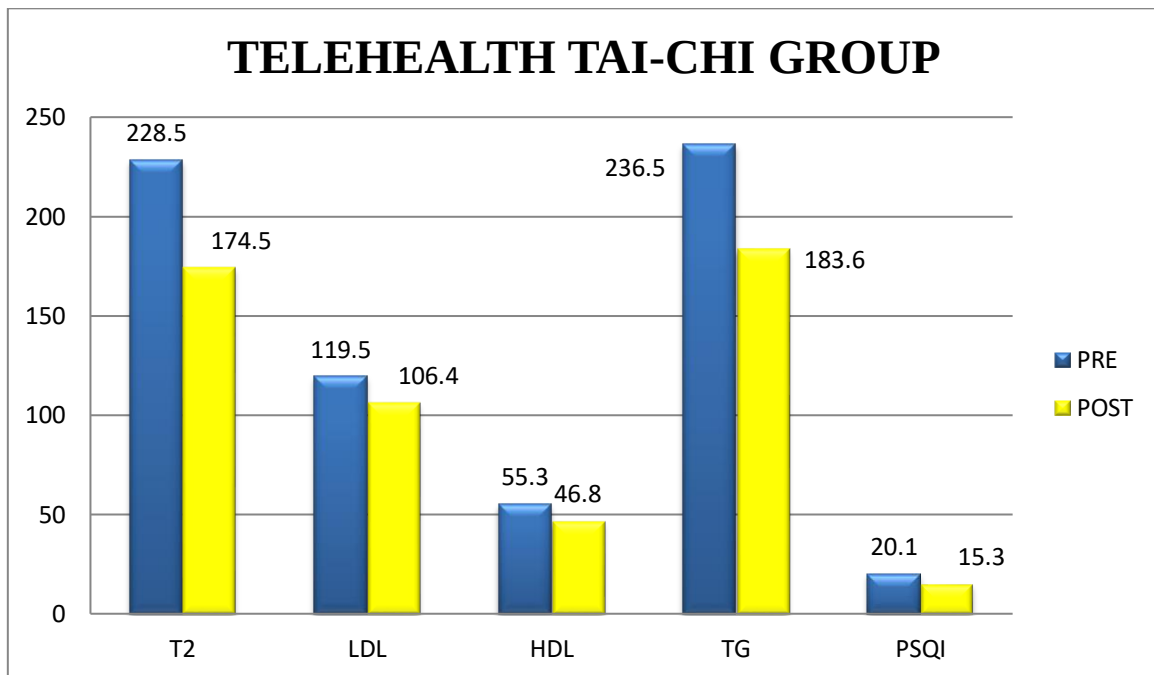
LDL-C (mg/dL)	119.59 ± 73.91	106.45 ± 59.41	-13.14	0.001
HDL-C (mg/dL)	55.33 ± 11.67	46.89 ± 10.04	-8.44	<0.001
Triglycerides (mg/dL)	236.55 ± 116.82	183.68 ± 92.09	-52.87	<0.001
PSQI score	20.04 ± 1.93	15.33 ± 1.56	-4.71	<0.001

Table 2. Conventional Group: Baseline vs post-intervention (n = 20)

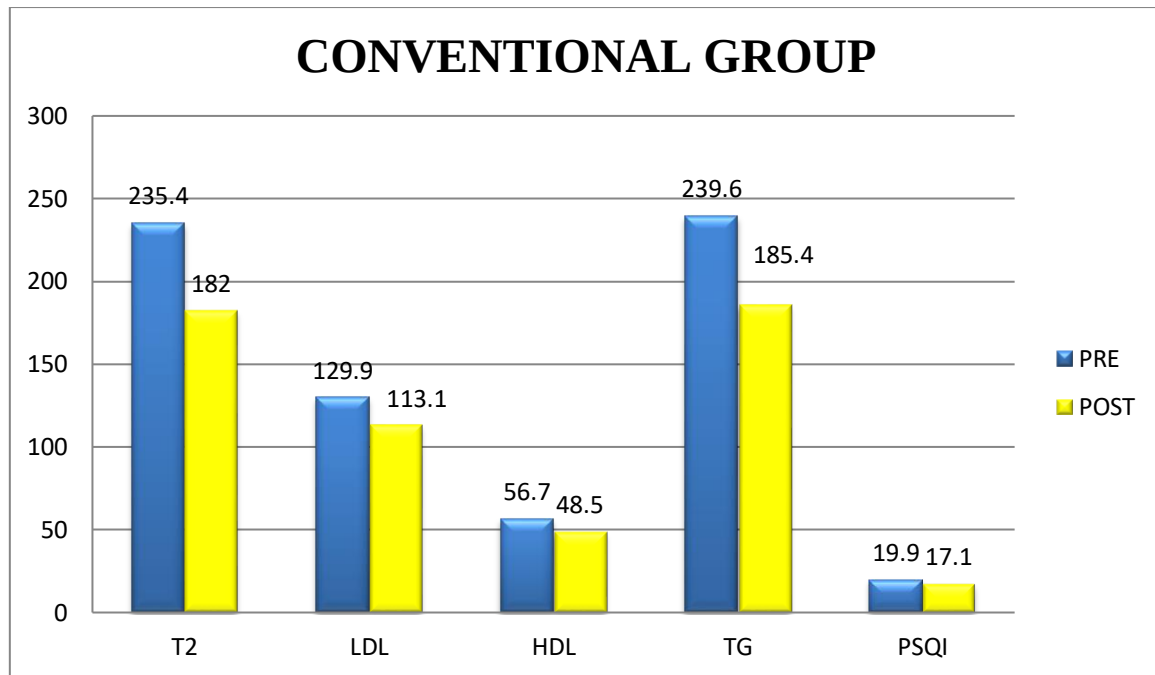
Parameter	Minimum Value ± Standard Deviation	Post 12-Week Mean ± SD	Mean Variation	p (within-group)
Total Cholesterol (mg/dL)	243.17 ± 62.84	190.47 ± 50.98	-52.70	<0.001
LDL-C (mg/dL)	141.33 ± 49.57	120.28 ± 37.00	-21.05	0.001
HDL-C (mg/dL)	58.28 ± 10.32	50.35 ± 8.07	-7.94	<0.001
Triglycerides (mg/dL)	243.17 ± 133.12	187.48 ± 109.13	-55.69	<0.001
PSQI score	19.81 ± 1.79	19.04 ± 2.41	-0.77	0.69

Table 3. Between-Group Comparison of Post-Intervention Outcomes

Parameter	p (between groups)
Total-Cholesterol (mg/dL)	0.283
LDL-C (mg/dL)	0.388
HDL-C (mg/dL)	0.241
Triglycerides (mg/dL)	0.906
PSQI score	<0.001



Graph 1: Pre-Post Mean Analysis of Telehealth Tai-Chi Group



Graph 2: Pre-Post Mean Analysis of Conventional Group

DISCUSSION

Telehealth Tai-Chi is the delivery of Tai-Chi exercise regimens using digital health platforms such as video conferencing, mobile applications, or virtual reality, allowing patients to participate remotely and under professional supervision [19]. It mixes Tai-Chi, a traditional mind-body activity that emphasizes slow, controlled motions, balance, breathing, and relaxation, with telehealth technologies to increase accessibility, safety, and continuity of care [20]. Telehealth Tai-Chi is particularly useful in physical therapy, geriatrics, neurology, cardiac rehabilitation, and chronic disease management, as it promotes balance, mobility, fall prevention, stress reduction, and overall wellness in groups that may be unable to attend in-person sessions [21]. In current technology-era many popular apps are used for health disease monitoring, prevention, maintenance and health promotion.

This randomized controlled trial demonstrated that a 12-weeks Telehealth Tai-Chi program led to greater progress in serum lipid profile and sleep quality than conventional care in adults with type-2 diabetes-mellitus (T2DM). Participants practicing Telehealth Tai-Chi achieved mean reductions of approximately 54 mg/dL in total cholesterol, 13 mg/dL in LDL cholesterol, and 53 mg/dL in triglycerides, together with a 5-point decrease in Pittsburgh Sleep Quality Index (PSQI) scores, while the control group showed smaller lipid reductions and almost no change in sleep quality. These findings confirm that Telehealth Tai-Chi intervention is both effective and safe as an adjunct to routine diabetes management [18].

Our findings align with a rising body of evidence that Tai-Chi improves lipid metabolism in T2DM and other

metabolic conditions. Pan et al. found significant reductions in total cholesterol and triglycerides in a meta-analysis of randomised control trials [18], and Alenazi et al. confirmed pooled reductions in TC, LDL-C, and TG across 15 studies [17]. Zhao et al. demonstrated that high-frequency, 24-form Tai Chi programs of at least 12 weeks optimize glucose and lipid outcomes in T2DM [7].

Sun et al. similarly reported favorable changes in total cholesterol and HDL-C with Tai Chi related to usual care and showed significant declines in fasting glucose, HbA1c, triglycerides, and LDL-C in T2DM after ≥12 weeks of Tai-Chi practice [23]. Complementing these findings, Chao et al. reported consistent reductions in TC, LDL-C and TG in cardiometabolic populations, including diabetes, in their large meta-analysis [13]. Tsai et al. documented improvements in both glucose and lipid metabolism following Tai Chi in adults with T2DM [15], and another recent trial confirmed reductions in FBG, HbA1c and serum lipids after 12-weeks of structured Telehealth Tai-Chi [21]. The magnitude of lipid reduction in our Telehealth Tai-Chi group is comparable to these pooled estimates, reinforcing the biological plausibility of our results.

Interestingly, HDL-cholesterol declined slightly in our participants despite improvements in other lipid fractions. Although aerobic exercise is generally associated with HDL-C elevation, transient reductions have been observed during early weight-loss or lifestyle interventions and may represent temporary shifts in lipid transport before longer-term rises occur. Future research should examine whether extended or higher-intensity

Tai-Chi programs eventually produce sustained HDL-C increases.

Sleep quality improved markedly, with a 5-point PSQI reduction that is clinically meaningful. Telehealth Tai-Chi's slow, rhythmic movements and coordinated breathing are thought to enhance parasympathetic activity and reduce sympathetic tone, thereby promoting restorative sleep a mechanism supported by Sun *et al.* and Chao *et al.*, who observed better subjective sleep and reduced insomnia symptoms in Tai-Chi participants [23,24].

Remote delivery was well accepted, with full adherence and no adverse events, supporting prior evidence that Telehealth exercise programs are feasible and yield outcomes comparable to in-person sessions [17,19]. Telehealth Tai-Chi therefore represents a scalable, low-cost lifestyle intervention for individuals with T2DM who face geographic or mobility barriers. No harm or post exercise adverse effects were reported by any participant during the study, which is also a beneficial psychological parameter.

Strengths and Limitations

Key strengths include randomized design, complete follow-up, and evaluation of both metabolic and sleep outcomes. Limitations include the modest sample size, single-center setting, absence of long-term follow-up, and the unexpected decrease in HDL cholesterol despite regular moderate exercise. This HDL finding warrants future mechanistic and longitudinal research to explore whether longer duration or different Tai-Chi intensities can produce the expected rise in HDL.

CONCLUSION

A 12-week Telehealth Tai-Chi program produced clinically meaningful decreases in total-cholesterol, LDL-C, & triglycerides, along with significant improvements in sleep quality among adults with type 2 diabetes mellitus but no significant result were observed for HDL level. These findings support Telehealth Tai-Chi as a feasible, low-cost adjunct to standard diabetes care for improving cardiometabolic risk and enhancing sleep. Larger, multi-center trials with longer follow-up are acceptable to confirm these benefits and to explore their durability and impact on long-term diabetes outcomes.

Author Contributions

“Conceptualization, H.K.; K.A.; T.F.; R.M.G., S.A., M.S., O.I.A., and I.A.; methodology, H.K.; K.A.; T.F.; S.A.; I.A.; software, R.M.G., S.A., N.M., M.S., O.I.A., validation, R.M.G., S.A., M.S., O.I.A., and I.A.; formal analysis, H.K., N.M., T.F.; S.K.; investigation, H.K.; K.A.; T.F.; resources, R.M.G., S.A., M.S., O.I.A. data curation R.M.G., S.A., M.S., N.M., writing—original draft preparation, H.K.; K.A.; T.F.; R.M.G., S.A., M.S., N.M., O.I.A. and I.A., writing—review and editing, H.K.; K.A.; T.F.; R.M.G., S.A., N.M., I.A.; visualization,

R.M.G., S.A.; supervision, R.M.G., S.A., project administration, R.M.G., S.A. funding acquisition, R.M.G., S.A., M.S., N.M., O.I.A. and I.A.,

Ethical Approval & Clinical Trial Registry

The study protocol received approval from the Institutional Ethics Committee of Jamia Hamdard, New Delhi, India from July 2024 to October 2024. Ethical approval was secured 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 adhered to the Declaration of Helsinki guidelines. All participants were informed about the study's objectives, risks, and benefits. Informed written consent was secured from each participant before data collection commenced. Data confidentiality and participant rights were upheld throughout the research

Consent for publication

We ensured that patients were fully aware that the results and data collected during the study might be used for publication purposes. This consent process involved providing detailed information about the nature of the publication, including potential outlets (such as scientific journals or conferences) and the level of anonymity or confidentiality that would be maintained in the published materials.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Disclosure statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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