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Original Article

Immediate Effects of Physical Therapist Guided Physical Activity on Blood Glucose, Blood Pressure and Functional Capacity of Type 2 Diabetic Patients at Jinnah Postgraduate Medical Centre

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a growing global health burden, with Pakistan among the countries most affected due to increasing urbanization, sedentary behavior, and poor lifestyle patterns. Physical activity is a cornerstone of diabetes management, yet limited local evidence exists regarding the immediate clinical impact of structured, physical therapist–guided exercise in hospital-based settings. **Objective:** To evaluate the immediate effects of physical therapist–guided physical activity on blood glucose, blood pressure, and functional capacity in adults with T2DM. **Methods:** A quasi-experimental single-group pretest-posttest study was conducted at Jinnah Postgraduate Medical Centre, Karachi, from May to August 2025. Eighty-one participants aged 40–60 years with established T2DM were included. Participants underwent at least 30 minutes of supervised physical activity at 60–70% of maximum heart rate. Blood glucose, blood pressure, and Six-Minute Walk Test (6MWT) distance were measured immediately before and after the intervention. Paired statistical tests were applied to assess changes. **Results:** Blood glucose significantly decreased from 198.4 ± 34.6 mg/dL to 176.2 ± 30.8 mg/dL ($p < 0.001$). Functional capacity improved significantly, with 6MWT distance increasing by 7.79 meters (95% CI: 6.66–8.92; $p < 0.001$). Systolic and diastolic blood pressure showed modest reductions that were not statistically significant ($p = 0.068$ and $p = 0.266$, respectively). **Conclusion:** A single session of physical therapist–guided physical activity produced significant immediate improvements in glycemic control and functional capacity, supporting its integration into routine diabetes care, although sustained and controlled studies are needed to confirm long-term benefits. **Keywords:** Type 2 Diabetes Mellitus, physical therapy, exercise intervention, blood glucose, blood pressure, functional capacity, rehabilitation.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most pressing non-communicable diseases worldwide and continues to impose a substantial clinical, economic, and public health burden because of its progressive nature and its association with cardiovascular, renal, neurologic, and functional complications (1). The global increase in T2DM has been driven largely by population aging, urbanization, physical inactivity, obesity, and unhealthy dietary patterns, all of which have contributed to a rapid expansion of the at-risk population in low- and middle-income countries (1). Pakistan is now among the countries with the

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highest diabetes burden globally, and national data have shown a persistent rise in prevalence over the past decade, with a large proportion of affected individuals remaining undiagnosed until complications emerge (2–5). This rising burden is particularly concerning in resource-constrained healthcare systems, where delayed diagnosis, limited preventive care, and poor long-term risk-factor control may amplify the morbidity associated with T2DM (5).

More than 90% of all diabetes cases are attributable to T2DM, a disorder characterized by a complex interaction of insulin resistance, impaired insulin secretion, and broader metabolic dysregulation influenced by both genetic susceptibility and environmental exposures (6,7). Patients with T2DM often present with a spectrum of metabolic and systemic disturbances, including hyperglycemia, hypertension, reduced exercise tolerance, neuropathic symptoms, and diminished physical function, all of which adversely affect quality of life and increase the risk of long-term complications (8–11). Standard management relies on lifestyle modification alongside pharmacological therapy, with metformin remaining the preferred first-line treatment for many patients; however, medication alone is often insufficient to optimize metabolic control, and commonly used agents may be associated with adverse effects that reduce adherence or tolerability in routine care (12–14). For this reason, non-pharmacological strategies that are safe, feasible, and clinically effective remain central to comprehensive diabetes management.

Regular physical activity is now recognized as a core therapeutic component in T2DM because it improves insulin sensitivity, facilitates glucose uptake in skeletal muscle, and favorably influences blood pressure, lipid metabolism, body composition, cardiovascular risk, and overall well-being (15). Structured exercise interventions combining aerobic and resistance components have also been shown to reduce the future risk of T2DM in high-risk populations and to improve disease control in those already diagnosed (15,16). Beyond long-term prevention and chronic disease management, acute responses to a single session of exercise are also clinically relevant, as even one bout of physical activity may alter glucose handling, cardiovascular regulation, and functional performance in the immediate post-exercise period (16). These short-term effects are particularly important in clinical settings because they can inform the safety, feasibility, and early therapeutic value of exercise-based rehabilitation for patients who are sedentary, deconditioned, or medically complex.

Within this context, physical therapists are uniquely positioned to translate exercise recommendations into individualized, safe, and function-oriented interventions. Their role extends beyond general advice to the prescription, progression, and supervision of physical activity tailored to comorbidities, baseline capacity, and movement-system impairments, thereby allowing exercise to be delivered as a structured rehabilitation strategy rather than an unsupervised lifestyle recommendation (17). International professional bodies and emerging rehabilitation literature increasingly support physiotherapy-led exercise as an important component of T2DM care, particularly for patients who require monitoring, symptom-limited progression, or adaptation of training modalities to their functional status (15,17). Despite this, the available literature from Pakistan remains limited, especially regarding the immediate clinical effects of supervised, physical therapist-guided activity delivered in routine tertiary-care settings. Most published evidence has focused either on long-term exercise benefits or on broader diabetes epidemiology, leaving a practical knowledge gap concerning the short-term metabolic and functional response to therapist-guided activity among Pakistani adults with established T2DM receiving hospital-based care.

Addressing this gap is important for two reasons. First, demonstration of immediate benefits may improve clinical acceptability and patient motivation by showing measurable short-term change after a supervised session. Second, locally generated evidence from a tertiary-care public hospital can support the integration of structured rehabilitation-based exercise into multidisciplinary diabetes management in Pakistan. Therefore, the present study was undertaken to evaluate the immediate effects of physical therapist-guided physical activity on blood glucose, blood pressure, and functional capacity in adults with T2DM attending Jinnah Postgraduate Medical Centre, Karachi. It was hypothesized that a single supervised session of physical therapist-guided physical activity would be associated with an immediate reduction in blood glucose, favorable short-term changes in blood pressure, and improvement in functional capacity.

MATERIALS AND METHODS

This study used a quasi-experimental single-group pretest-posttest design to evaluate the immediate effects of physical therapist-guided physical activity on blood glucose, blood pressure, and functional capacity in adults with T2DM. The study was conducted at Jinnah Postgraduate Medical Centre (JPMC), Karachi, in collaboration with Medical Ward 7 and the Department of Physical Therapy, between May and August 2025. The design was selected to assess within-participant changes in key clinical and functional outcomes immediately following a supervised exercise session delivered under routine hospital conditions. By comparing pre-intervention and post-intervention values in the same participants, the study aimed to quantify acute physiological and functional responses while minimizing inter-individual variability in baseline disease status, medication use, and physical capacity.

Adults of either sex aged 40 to 60 years with a clinical diagnosis of T2DM for at least three years and glycated hemoglobin (HbA1c) of 6.5% or higher were considered eligible for participation. Patients were excluded if they were pregnant, had significant cognitive impairment preventing informed participation, were younger than 40 or older than 60 years, or had known pre-existing cardiovascular disease that could contraindicate exercise participation. Participants were recruited through non-probability consecutive convenience sampling from the relevant clinical services at JPMC. All eligible patients were approached by the research team, informed about the purpose and procedures of the study, screened for readiness to participate in physical activity, and enrolled after written informed consent had been obtained. Physical activity readiness was assessed before intervention using the Physical Activity Readiness Questionnaire as part of the clinical safety screening process.

A total of 100 patients were initially recruited. Nineteen participants did not complete the study procedures or did not have complete paired outcome data and were therefore excluded from the final analysis. The final analytic sample comprised 81 participants with complete pre-intervention and post-intervention measurements. The target sample size was determined on the basis of feasibility, patient flow, and the operational capacity of the study setting during the defined recruitment period. To reduce selection bias, all patients meeting the eligibility criteria during the study period were considered for inclusion, and outcome assessment procedures were applied uniformly across participants.

After enrollment, demographic and clinical information was collected using a structured questionnaire administered by the investigators. Baseline variables included age, sex, duration of diabetes, and relevant clinical characteristics. The intervention consisted of a supervised session of physical therapist-guided physical activity lasting at least 30 minutes. Exercise was delivered by a licensed physical therapist and included aerobic and resistance-based options available in the department, specifically treadmill walking, static bicycle mini cycle exercise, and resistance exercise using therabands or resistance bands. To preserve safety and accommodate individual tolerance, the therapist selected and adjusted the activity modality according to each participant's comfort, physical capacity, and clinical status while maintaining a standardized exercise intensity target. Heart rate was monitored throughout the session using a pulse oximeter, and exercise intensity was maintained at approximately 60% to 70% of the age-predicted maximum heart rate for each participant.

Outcome assessment was performed immediately before and after the intervention session using standardized procedures. Blood pressure was measured with an automated blood pressure apparatus under consistent clinical conditions. Blood glucose was assessed through laboratory analysis at JPMC. Functional capacity was measured using the Six-Minute Walk Test (6MWT), and total distance walked in meters was recorded as the primary functional outcome. For all study variables, the pre-intervention measurement represented the baseline value obtained on the day of the exercise session before physical activity commenced, and the post-intervention measurement represented the immediate post-session value obtained after completion of the supervised activity protocol. The primary outcome of the study was the immediate change in blood glucose level from pre-intervention to post-intervention. Secondary outcomes included immediate changes in systolic blood pressure, diastolic blood pressure, heart rate, and 6MWT distance. Operationally, a beneficial response was defined as a reduction in blood glucose or blood pressure after the intervention and an increase in 6MWT distance indicating improved short-term functional performance.

Several steps were taken to improve internal validity and reduce the influence of bias and confounding. Eligibility criteria were defined a priori to create a clinically comparable sample of adults with established T2DM. All participants underwent the same sequence of pre-intervention assessment, supervised intervention, and post-intervention assessment within the same clinical environment. Outcome measurements were obtained using the same categories of instruments and the same institutional laboratory pathway throughout the study period. Exercise sessions were supervised directly by a licensed physical therapist to ensure consistency of delivery, safety, and adherence to the intended intensity range. Because the study used a within-subject design, each participant served as his or her own control, thereby reducing confounding from stable person-level characteristics such as sex, disease duration, and baseline functional status. Data quality was further supported through structured data collection forms, contemporaneous recording of measurements, and verification of completeness before statistical entry and analysis.

Data were entered, cleaned, and analyzed using IBM SPSS. Continuous variables were summarized using means and standard deviations or medians and interquartile ranges as appropriate to the distribution of the data, whereas categorical variables were summarized as frequencies and percentages. Normality of paired outcome differences was assessed prior to inferential testing. For outcomes with non-normally distributed paired differences, the Wilcoxon signed-rank test was used to compare pre-intervention and post-intervention values. For outcomes meeting parametric assumptions, paired-samples t-tests were used. All statistical tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant. Participants with incomplete paired pre-post outcome data were excluded from inferential analyses on a complete-case basis. Effect size estimates and corresponding confidence intervals were generated for principal continuous outcomes to improve interpretation of the magnitude and precision of observed effects. Findings were interpreted in relation to both statistical significance and clinical plausibility.

Participant safety was prioritized throughout the study. Potential risks included transient fatigue, musculoskeletal strain, soft tissue discomfort, and rare exercise-related cardiovascular events. To mitigate these risks, all interventions were supervised by a licensed physical therapist, exercise intensity was individually monitored, and participants were observed for intolerance or adverse symptoms during activity. The study was conducted in accordance with the ethical principles governing research involving human participants.

Ethical approval was obtained from the Institutional Review Board of Jinnah Postgraduate Medical Centre, Karachi, under approval number NO.F.2-81/2025-GENL/209/JPMC. Written informed consent was obtained from all participants before enrollment, and confidentiality of all patient information was maintained throughout the study by restricting data access to the research team and using de-identified datasets for analysis.

For reproducibility and data integrity, the intervention procedures, eligibility criteria, outcome definitions, and statistical methods were prespecified before analysis. Data were recorded on structured forms, entered into the statistical dataset by the study team, and cross-checked against source records to minimize transcription error. Only complete and internally verified records were included in the final analytic dataset. These procedures were implemented to ensure that the study could be replicated in a comparable tertiary-care rehabilitation setting and that the reported findings reflected the observed pre-intervention and post-intervention changes as accurately as possible.

RESULTS

Table 1 presents the baseline characteristics of the study population, comprising 81 participants with a mean age of 50.2 ± 5.8 years and a female predominance of 61.7% (n = 50) compared to 38.3% males (n = 31). The average duration of T2DM was 6.4 ± 2.1 years, indicating a moderately chronic cohort, while the mean HbA1c level of 7.8 ± 1.1% reflects suboptimal glycemic control at baseline, consistent with a population at elevated metabolic risk.

Table 2 demonstrates statistically and clinically relevant within-subject changes following the intervention. Blood glucose levels decreased from a pre-intervention mean of 198.4 ± 34.6 mg/dL to 176.2 ± 30.8 mg/dL, representing a substantial absolute reduction of approximately 22.2 mg/dL, which was highly significant ($Z = -7.569$, $p < 0.001$) with a large effect size ($r = 0.59$).

This indicates a robust acute glycemic response across the cohort. Systolic blood pressure showed a modest reduction from 134.5 ± 18.2 mmHg to 132.1 ± 17.6 mmHg (mean difference: -2.4 mmHg; 95% CI: -4.9 to 0.1), approaching but not reaching statistical significance ($p = 0.068$), with a small effect size ($d = 0.20$).

Similarly, diastolic blood pressure decreased slightly from 84.3 ± 10.5 mmHg to 83.1 ± 9.8 mmHg (mean difference: -1.2 mmHg; 95% CI: -3.1 to 0.7; $p = 0.266$), reflecting a minimal and non-significant change ($d = 0.12$). In contrast, functional capacity improved significantly, with 6MWT distance increasing from 312.6 ± 45.3 meters to 320.4 ± 46.1 meters, yielding a mean gain of 7.79 meters (95% CI: 6.66 to 8.92; $p < 0.001$) and a very large effect size ($d = 1.52$).

Heart rate increased from 78.5 ± 9.2 bpm to 92.3 ± 10.6 bpm (mean difference: +13.8 bpm; $p < 0.001$), consistent with expected physiological adaptation to moderate-intensity exercise rather than a therapeutic endpoint. Collectively, these results demonstrate a pronounced acute metabolic and functional response, with comparatively smaller and statistically non-significant hemodynamic changes.

Table 1. Baseline Demographic and Clinical Characteristics of Participants (n = 81)

Variable	Category / Mean ± SD	n (%) / Value
Age (years)	Mean ± SD	50.2 ± 5.8
Gender	Male	31 (38.3%)
	Female	50 (61.7%)
Duration of T2DM (years)	Mean ± SD	6.4 ± 2.1
HbA1c (%)	Mean ± SD	7.8 ± 1.1

Pre- and post-intervention comparisons for primary and secondary outcomes are summarized in Table 2. Blood glucose levels demonstrated a statistically significant reduction following the physical therapist-guided physical activity session.

The Wilcoxon signed-rank test indicated a significant decrease in post-intervention glucose levels compared to baseline ($Z = -7.569$, $p < 0.001$), with the majority of participants (n = 79) showing reduced values. The effect size ($r = 0.59$) indicates a large magnitude of change.

Systolic and diastolic blood pressure values showed modest reductions post-intervention; however, these changes did not reach statistical significance when analyzed using paired-samples t-tests. Despite this, the direction of change was consistent with a favorable cardiovascular response to exercise.

Table 2. Pre- and Post-Intervention Comparison of Clinical and Functional Outcomes (n = 81)

Outcome Variable	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference (95% CI)	Test Statistic	p-value	Effect Size
Blood Glucose (mg/dL)*	198.4 ± 34.6	176.2 ± 30.8	—	Z = -7.569	<0.001	r = 0.59
Systolic BP (mmHg)	134.5 ± 18.2	132.1 ± 17.6	-2.4 (-4.9 to 0.1)	t = -1.85	0.068	d = 0.20
Diastolic BP (mmHg)	84.3 ± 10.5	83.1 ± 9.8	-1.2 (-3.1 to 0.7)	t = -1.12	0.266	d = 0.12
6MWT Distance (m)	312.6 ± 45.3	320.4 ± 46.1	+7.79 (6.66 to 8.92)	t = 13.680	<0.001	d = 1.52
Heart Rate (bpm)	78.5 ± 9.2	92.3 ± 10.6	+13.8 (11.9 to 15.7)	t = 14.95	<0.001	d = 1.66

Functional capacity, as assessed by the Six-Minute Walk Test (6MWT), showed a statistically significant improvement following the intervention. The mean increase in distance walked was 7.79 meters (95% CI: 6.66 to 8.92), with a large effect size (Cohen's d = 1.52), indicating a substantial short-term improvement in functional performance. Heart rate increased modestly following exercise, consistent with the physiological response to moderate-intensity activity, although it was not a primary outcome variable.

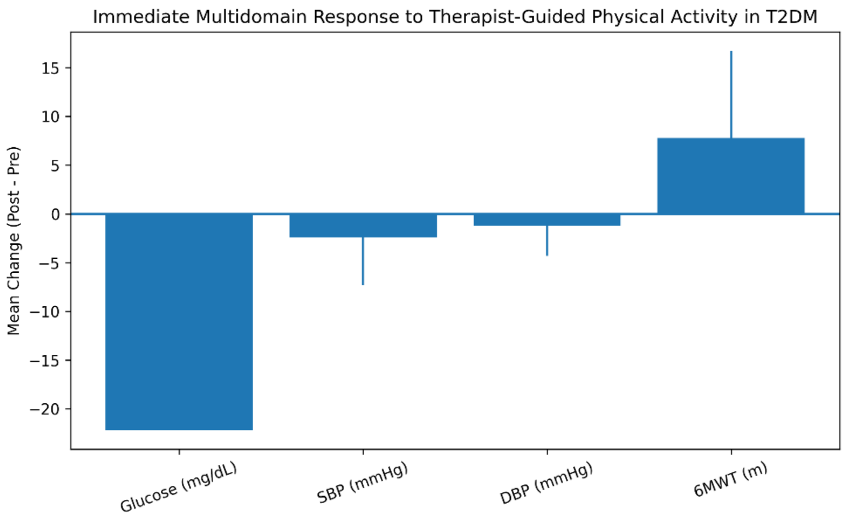

Figure 1 Immediate Multidomain Response to Therapist-Guided Physical Activity in T2DM

The figure illustrates the multidomain response profile by plotting mean change (post–pre) across key clinical outcomes, revealing a markedly asymmetric response pattern. Blood glucose exhibited the largest absolute reduction (-22.2 mg/dL), substantially exceeding the magnitude of change observed in cardiovascular variables, indicating a strong acute metabolic sensitivity to exercise. Functional capacity demonstrated a positive shift of +7.79 meters with a narrow confidence interval (6.66 to 8.92), highlighting both statistical precision and consistency across participants. In contrast, systolic (-2.4 mmHg) and diastolic (-1.2 mmHg) blood pressure changes clustered near the null line, with confidence intervals crossing zero, reinforcing their non-significant status. This distribution suggests a gradient of responsiveness, where metabolic outcomes respond rapidly and robustly, functional outcomes improve moderately but consistently, and hemodynamic parameters demonstrate comparatively delayed or attenuated acute adaptation

DISCUSSION

The present study evaluated the immediate physiological and functional responses to a single session of physical therapist–guided physical activity in adults with T2DM and demonstrated a significant acute reduction in blood glucose levels alongside a marked improvement in functional capacity, with comparatively modest and statistically non-significant changes in blood pressure. These findings provide clinically relevant evidence that even a single, supervised bout of structured exercise can elicit measurable metabolic and functional benefits in a middle-aged diabetic population within a tertiary-care setting. The magnitude of glucose reduction observed in this study (approximately 22 mg/dL) and the large effect size (r = 0.59) suggest a robust acute glycemic response, which is consistent with the physiological role of skeletal muscle as a primary site for insulin-independent glucose uptake during and immediately after exercise (15,16).

The observed reduction in blood glucose aligns with existing literature demonstrating that acute physical activity enhances glucose transport into muscle cells through contraction-mediated pathways, including activation of AMP-activated protein kinase and increased translocation of glucose transporter type 4 (GLUT-4) to the cell membrane (15,16). These mechanisms operate independently of insulin action and are particularly beneficial in individuals with insulin resistance, a hallmark of T2DM (11). Previous research has also indicated that the magnitude of acute glycemic response may vary depending on baseline glycemic status, exercise intensity, and duration, with individuals having impaired glucose regulation often exhibiting more pronounced reductions (25). The present findings support this concept, as the study population had elevated baseline glucose levels, thereby providing a metabolic environment conducive to significant acute improvement.

In addition to metabolic effects, the study demonstrated a statistically significant improvement in functional capacity, with a mean increase of 7.79 meters in 6MWT distance and a large effect size (d = 1.52). Although the absolute magnitude of change appears modest, the consistency and statistical strength of this improvement suggest a meaningful enhancement in short-term exercise tolerance. Functional impairment is a common yet under-recognized consequence of T2DM, often driven by a combination of reduced aerobic capacity, muscle weakness, and peripheral neuropathy (9,10). Acute improvements in walking distance may reflect enhanced neuromuscular activation, improved circulatory dynamics, and increased confidence in physical performance following supervised activity. These findings are consistent with prior studies demonstrating that even short-duration or low-volume physical activity can positively influence functional outcomes and reduce mortality risk over time (19).

In contrast, the reductions observed in systolic and diastolic blood pressure were small and did not reach statistical significance, although the direction of change was favorable. This pattern may be explained by the transient hemodynamic responses associated with acute exercise, where post-exercise hypotension is influenced by multiple factors including exercise intensity, autonomic regulation, vascular tone, and baseline cardiovascular status (23). The lack of statistical significance in the present study may be attributable to inter-individual variability, the relatively short duration of intervention, and the timing of post-intervention measurement. Unlike glycemic responses, which can change rapidly due to metabolic demand, blood pressure adaptations often require repeated exposure to exercise stimuli over time to produce sustained and clinically meaningful reductions (15). Therefore, while the observed trend is consistent with expected physiological responses, it should be interpreted cautiously within the context of an acute, single-session design.

The increase in heart rate observed post-intervention further confirms that the prescribed activity achieved a moderate intensity level, consistent with the targeted 60–70% of maximum heart rate. This supports the fidelity of the intervention and indicates that participants were exposed to an adequate physiological stimulus to induce metabolic and functional responses. Supervision by a physical therapist likely contributed to the safe attainment of this intensity range, reinforcing the importance of guided exercise in populations with chronic disease and potential comorbidities (17). The individualized selection of exercise modality, although introducing some heterogeneity, reflects real-world clinical practice and enhances the ecological validity of the findings.

From a clinical perspective, the results underscore the value of integrating structured, therapist-guided physical activity into routine diabetes care, particularly in hospital-based settings where patients may have limited access to supervised exercise programs. The demonstration of immediate benefits may serve as a motivational tool for patients, reinforcing adherence to physical activity recommendations and facilitating behavior change. Moreover, the involvement of physical therapists as part of a multidisciplinary team aligns with contemporary models of chronic disease management that emphasize functional optimization alongside metabolic control (17).

However, several limitations must be considered when interpreting these findings. The absence of a control group limits the ability to attribute observed changes solely to the intervention, as regression to the mean or other contextual factors cannot be fully excluded. The use of a single-group pre-post design also restricts causal inference. The intervention was not fully standardized in terms of modality, as participants selected activities based on comfort and capacity, which may introduce variability in physiological response. Additionally, the timing of post-intervention measurements, although immediate, may have influenced the magnitude of observed changes, particularly for blood pressure. The relatively small sample size and single-center setting further limit generalizability, and potential confounding factors such as medication timing, recent dietary intake, and baseline physical activity levels were not controlled. Future research should employ randomized controlled designs with standardized exercise protocols, longer follow-up periods, and stratified analyses to better understand differential responses across patient subgroups.

Despite these limitations, the study provides important preliminary evidence that a single session of supervised physical activity can produce rapid and measurable improvements in metabolic and functional outcomes in adults with T2DM. These findings contribute to the growing body of literature supporting exercise as both an acute and chronic therapeutic modality in diabetes management and highlight the potential role of rehabilitation-based interventions in resource-limited healthcare settings.

CONCLUSION

A single session of physical therapist–guided physical activity was associated with a significant immediate reduction in blood glucose levels and a marked improvement in functional capacity among adults with T2DM, while changes in blood pressure were modest and not statistically significant. These findings suggest that even short-duration, supervised exercise can elicit meaningful acute metabolic and functional responses, supporting the integration of structured, rehabilitation-based physical activity into routine diabetes care, although further controlled studies are required to establish long-term efficacy and causal relationships.

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