ORIGINAL RESEARCH ARTICLE

Walking-Induced Metabolic Interventions in Adults with Type 2 Diabetes Mellitus: An Experimental Study in Odisha

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ABSTRACT

Background: Walking is a simple, accessible form of physical activity recommended for glycemic control in type 2 diabetes mellitus (T2DM). Evidence on its immediate metabolic effects in community settings remains limited. The study was conducted to assess the immediate effects of a single walking session on anthropometric, physiological, and biochemical parameters among adults with T2DM.

Methods: A community-based quasi-experimental pre–post study was conducted among 108 adults with T2DM in Puri district, Odisha, India. Participants completed a supervised 1.2-km moderate-intensity walk after overnight fasting. Body weight, blood pressure, fasting blood glucose, and lipid profile were measured before and after the intervention. Paired and independent sample t-tests were used for analysis at a 5% significance level.

Results: Following walking, significant reductions were observed in body weight, systolic and diastolic blood pressure, blood glucose, total cholesterol, triglycerides, LDL, and VLDL levels, while HDL increased significantly (all $p<0.05$). Blood glucose declined from 180.2±45.0 to 168.6±41.8 mg/dL. Improvements were comparable across sex and age groups, with no significant between-group differences. Effect sizes were generally small, indicating modest but consistent acute benefits.

Conclusions: A single session of moderate-intensity walking produced immediate improvements in glycemic, cardiovascular, and lipid parameters among adults with T2DM. Walking represents a practical, low-cost strategy that can support diabetes self-management and cardiometabolic health.

Keywords: Glycemic control, Lifestyle-based interventions, Immediate metabolic effects, Preventive healthcare, Community health outcomes

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INTRODUCTION

Diabetes is exponentially rising as a significant public health issue. According to the 11th edition of the International Diabetes Federation Diabetes Atlas, diabetes affected approximately 589 million adults worldwide in 2024 and is projected to rise to 853 million by 2050. India accounted for nearly 90 million adults with diabetes, ranking second globally after China.[1] A chronic metabolic disorder, diabetes results from insulin deficiency or resistance, affecting glucose metabolism, which triggers chronic oxidative stress and low-grade inflammation.[2] Sedentary lifestyle and stress tend to increase the complications, leading to type 2 diabetes mellitus (T2DM). Serious health consequences such as renal failure, vision loss and increased cardiovascular risks are associated with T2DM which may even lead to risk of mortality. This further creates a burden on financial resources, mental, emotional and psycho-social well-being, impairing the quality of life.[3-5]

Consistent exercise and simple lifestyle changes optimize fasting glucose, boost insulin sensitivity and improve glycemic control in individuals with T2DM.[6]

Exercise and Blood Glucose: Regular resistance and aerobic exercise are emphasized by Indian Council of Medical Research (ICMR) and the Research Society for the Study of Diabetes in India (RSSDI), American Diabetes Association (ADA) and European Association for the Study of Diabetes (EASD). Incorporating simple physical activities including walking, gardening, yoga, household activities into daily routines reduce sedentary behaviour and improve glycemic control.[7] Beyond improving insulin sensitivity, physical activities independently increase glucose uptake and utilization, resulting in coordinated improvements in metabolic function across key organ systems.[2]

Regular physical activity enhances glucose uptake from the bloodstream and improves insulin sensitivity.[8] Blood glucose levels instantly drop when circulating glucose is utilized by muscles as fuel with enhanced mitochondrial function during moderate and high-intensity exercises and helps long-term glycemic control.[9] Glucose uptake can increase even up to 100-fold, increasing insulin sensitivity lasting for up to 24 hours or more post-exercise.[10]

Insulin sensitivity is predictably enhanced by combining moderate aerobic activities with resistance training.[11] Resistance training can reduce the incidence of T2DM in high-risk individuals by up to 58%, while moderate aerobic exercise is recommended as it carries a low risk of inducing hypoglycemia.[12] These exercises additionally reduce lower other T2DM related complications such as neuropathy, nephropathy, and retinopathy, thus lowering morbidity/mortality.[13] Furthermore, regular exercise with appropriate diet and routine medical care help prevent macro and microvascular complications and promote diabetes management.[14] Thus, regular exercise may prevent or delay T2DM development.

Managing Blood Glucose with Walking: Walking, a simple aerobic exercise, enhances insulin efficiency, blood glucose regulation, lipid profile, cardiovascular health and helps in weight maintenance.[15] Interrupting prolonged sitting with brief bouts of light-intensity walking or simple resistance activities every 30 minutes significantly reduces postprandial glucose, insulin and C-peptide levels in adults with T2DM, offering a practical strategy for improving glycemic control in individuals with both diabetic and prediabetic conditions.[16]

Studies suggest that walking for 3-7 hours per week and even small increments in daily physical activity, such as an additional 500 steps per day can decline cardiovascular disease events and reduce mortality.[17,18] Short 2 to 5 minutes post-meal walks moderate blood sugar spikes, reducing sudden glucose fluctuations linked to cardiovascular risk.[19] Brisk walking is linked to a significantly lower risk of developing T2DM and has an immediate beneficial effect on cholesterol levels.[20] A 30-minute brisk walk can improve post-prandial blood glucose levels compared with sedentary behaviour.[21]

Walking is low-risk, more accessible and appropriate for all ages. It also relieves stress, improves mood, and promotes better sleep, all of which positively influence blood glucose levels.[22,23]

Increased physical activity duration and frequency rather than intensity of activity can help attenuate glucose concentrations. Long-term, consistent exercise has greater effects on glucose levels than short term exercise adherence.[24] A systematic review and meta-analysis by Jayedi A et al.[25] indicate that faster walking speeds are associated with a graded reduction in the risk of type 2 diabetes; therefore, in addition to increasing total walking time, encouraging faster walking speeds may further enhance the health benefits of walking.

A change in both systolic and diastolic blood pressure is seen after walking.[26] Walking improves insulin sensitivity with effects lasting up to 24 hours post-exercise, reduces insulin and medication requirements, thus lowers healthcare costs and improves disease management as well.[27-29] Studies across genders have shown that compared to men, women with T2DM engage in less moderate-to-vigorous physical activities across lifespan and may exhibit more cardiovascular risk factors.[23]

However, there is limited evidence on instant metabolic impacts of walking on improving glycemic control in people with T2DM across age and genders. Therefore, this study aims to assess the immediate effects of walking on anthropometric physiological and biochemical parameters among individuals with T2DM in Puri district, Odisha.

The study, aligned with SDG 3 (good health and well-being), seeks to understand the physiological and behavioural mechanisms that support diabetes self-management and improve overall metabolic health affected by T2DM.

METHODOLOGY

Study Design: The study adopted a community-based quasi-experimental single-group pre-post intervention design to evaluate the immediate physiological and metabolic effects of walking among 108 participants with T2DM (47 females and 61 males). Through health camp announcement, T2DM patients voluntarily enrolled themselves. Participants were selected using a purposive convenience sampling approach, focusing on individuals diagnosed with T2DM (Figure 1).

Individuals aged ≥18 years with T2DM and no acute illness or physical disability were included in the study. As per medical history and physician's certification, the T2DM was confirmed. Participants on insulin who had injected within the previous 2 hours, as well as those with uncontrolled hypertension (SBP > 180 mmHg), pregnancy, foot ulcers, or recent cardiovascular events, were excluded. Participants were distributed across age groups, including 46 individuals aged ≤45 years and 62 individuals aged >45 years, ensuring representation of both middle-aged and older populations.

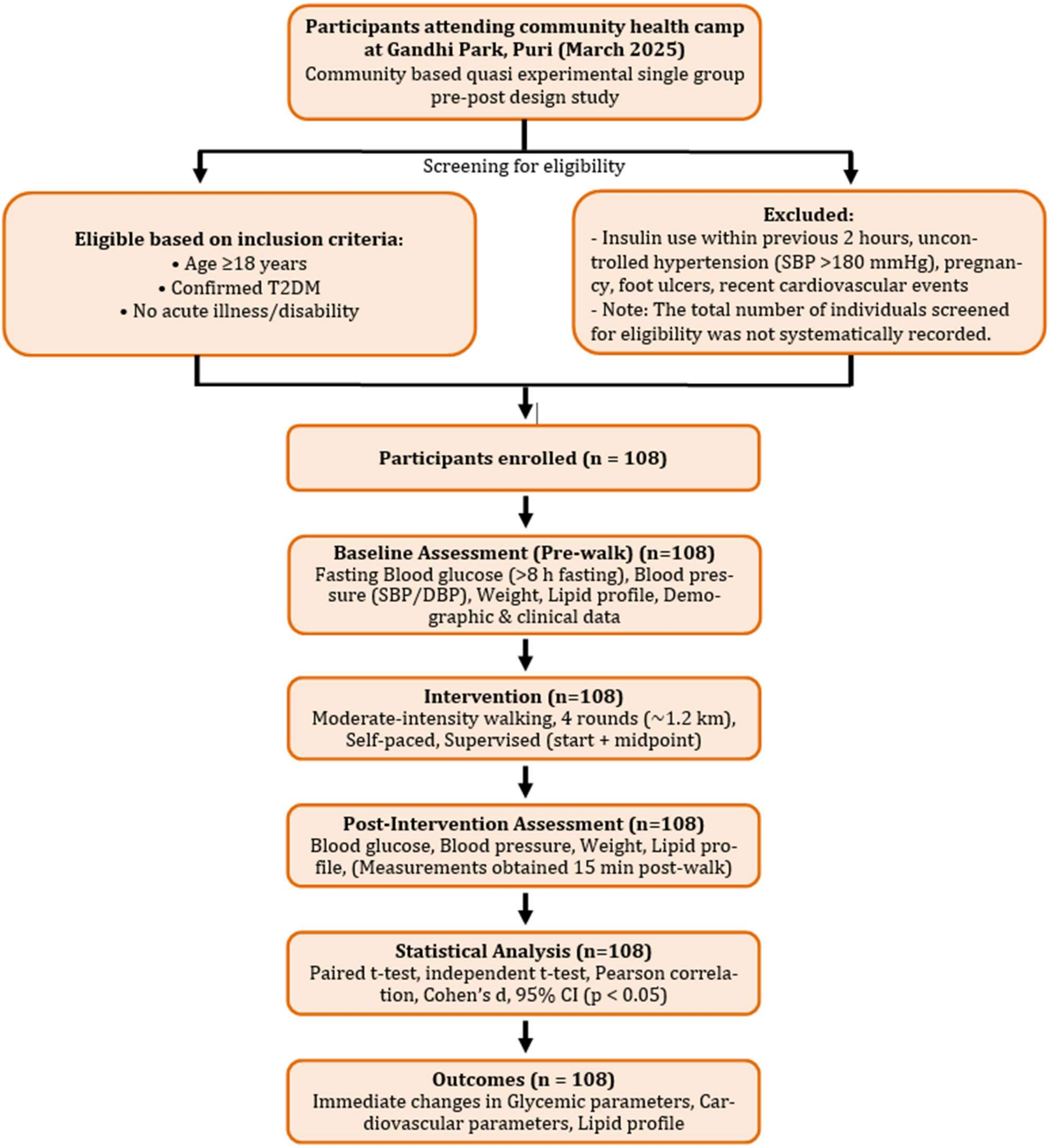

Figure 1: CONSORT-style Participant Flow Diagram

The study was conducted in March 2025 at Gandhi Park, Puri district, Odisha, India. A single-session intervention was employed to assess the immediate physiological and metabolic effects of walking, in alignment with the study objectives.

Participants in fasting condition (empty stomach, >8 hours of taking food) were considered for the study. They were instructed to walk a distance of 1.2 km by completing four rounds of the park premises under supervision (approximately 300 m per round). Study subjects were encouraged to choose their own pace of walking at a moderate intensity, which was comfortable and would raise heart rate without fatigue. Trained personnel supervised the sessions at the beginning and midpoint, though not throughout the entire duration, to ensure observance of the protocol, maintain consistency, and monitor safety.

Prior to the walking intervention, conditions were not rigorously standardized, participants were instructed to adhere to their customary routines. A safety protocol was in place during the walking session (e.g., stopped if signs of hypoglycemia, etc.). However, no withdrawals occurred during the walking session. Also, walking speed was not monitored by any objective device. Post-prandial measures were taken 15 minutes after walking.

Anthropometric Physiological, and Biochemical Measurements:

Body weight: Body weight (kg) was measured using a calibrated Omron HBF-214 Body Composition Monitor. Shoes were removed, and measurements were collected at the same time of the day. The machine was used within 1 month of calibration at a local healthcare professional's chamber.

Blood pressure: Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were measured using an automated sphygmomanometer with the left arm in a seated position. Three measurements were recorded for each outcome to enhance precision. Participants rested for 30 min before the pre-measurement and rested for 15 min after walking prior to collecting post-intervention value.

Blood glucose: Blood glucose was assessed using a glucometer (Accusure) using standard capillary sampling techniques. Subjects were fasting at the time of blood collection.

Lipid profile: Venous blood samples (6 mL) were collected under fasting conditions. Total cholesterol (TCHL), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL) were analyzed at Dr. Lal Path Labs using the enzymatic colorimetric method.

The consistency and reliability of all measurements were ensured by utilizing identical instrumentation and by adhering to standardized protocols for both pre- and post-session assessments, which were conducted by trained healthcare personnel.

Data Sources: Data collection encompassed health camps and routine health check-ups, which included blood glucose testing. Qualified medical doctors and laboratory technicians facilitated the collection of blood samples. Designated healthcare personnel documented participants' weight and blood pressure readings. A structured interview schedule was used to gather data on participant demographics, including age and gender, the type and duration of diabetes, adherence to prescribed medications, and the frequency of medical check-ups. This also included information on participants' lifestyle factors, medical history (specifically concerning blood pressure, weight, and blood glucose levels), and their self-reported quality of life. The use of multiple data sources and methodological triangulation was employed to enhance the reliability and overall accuracy of the findings.

Statistical Analysis: Statistical analyses were performed using SPSS version 20.0, encompassing both descriptive and inferential techniques. A 95% significance level ($p < 0.05$) was adopted as the threshold for statistical significance. Descriptive statistics for continuous variables were expressed as Mean ± Standard Deviation (SD). A paired sample t-test was applied to assess pre-post comparison of physiological and biochemical parameters, while the independent sample t-test was used for age-wise comparison (≤45 vs >45 years). Levene's test for equality of variances was conducted. The Shapiro-Wilk test of normality was conducted and supported the assumptions underlying the t-tests. Effect size was estimated using Cohen's *d*. Additionally, 95% Confidence Intervals (CI) were calculated to assess the precision and reliability of the mean changes.

Cohen's d was calculated as:

d = Mean Difference/ Standard Deviation $_{pooled}$ …(i)

Effect sizes were interpreted as small, medium, large, or very large. A p-value < 0.05 was considered statistically significant.

Subgroup Analysis: Gender-wise analysis assessed the differences in blood glucose reduction between male and female participants. Age-wise analysis examined the consistency of glycemic response across age groups (≤45 years and >45 years).

Ethical Considerations

The study was approved by the University Level Ethical Committee of KIIT Deemed to be University, Bhubaneswar in line with ICMR Guidelines (Approval No.: KIIT/ULEC/015/ 2025). Participants were informed about the purpose and processes of the study, confidentiality, and their right to withdraw at any stage, and the written informed consent was obtained from all participants. All collected data were kept anonymous with restricted access.

RESULTS

The study involved 108 adult participants, among diverse age groups and both sexes, to evaluate the immediate effects of walking on physiological and metabolic indices.

Table 1 shows females had significantly higher BMI (p = 0.020), all participants were on OAD (Oral Antidiabetic Drugs) medication, with significant gender differences (p = 0.007), and 57% had hypertension (p = 0.005), while the duration of T2DM was comparable. Annual health check-ups were common, while regular exercise data were limited.

Physiological and Biochemical Effects of Walking: Table 2 shows that all physiological and biochemical parameters improved significantly following the walking session (p < 0.001). Mean body weight decreased by 0.20 ± 0.01 kg, while SBP and DBP reduced by 5.78 ± 1.49 mmHg and 3.40 ± 0.08 mmHg, respectively.

Blood glucose levels declined by around 6.45%, indicating an immediate glycemic response. Lipid parameters also improved, with reductions observed in total cholesterol (5.42%), triglycerides (7.37%), LDL (3.69%), and VLDL (7.37%), while HDL increased by 4.47% (Table 2).

Despite statistical significance, most effect sizes were small to negligible, suggesting modest immediate effects of a single walking session, with comparatively greater impact observed in VLDL. Overall, the results indicate consistent short-term improvements in cardiometabolic parameters among individuals with T2DM.

Gender-Wise Reduction in Blood Glucose Levels: Table 3 shows that both males and females experienced improvements across all parameters following the walking session. Reductions in blood glucose were observed in both males (11.35 mg/dL) and females (13.63 mg/dL), indicating a consistent glycemic response. Similar decreasing trends were noted for SBP, DBP, weight, total cholesterol, triglycerides, and LDL, along with an increase in HDL in both groups (Table 3).

No statistically significant gender differences were observed in the pre- and post-intervention values (p > 0.05), suggesting that the effects of walking were comparable across males and females. Though, females showed a slightly greater reduction in blood glucose, the difference was not statistically significant, indicating similar metabolic responsiveness between genders.

Age-wise Reduction in Blood Sugar: Participants below 45 years and those above 45 years show similar results in blood sugar level reduction (Table 4). This indicates that walking did not demonstrate significantly different glycemic effects across age groups.

Reductions were also observed in SBP, DBP, body weight, total cholesterol, and triglycerides, along with an increase in HDL in both groups. However, no statistically significant differences were found between the two age groups (p > 0.05), indicating that the effects of walking were consistent across age categories. These findings suggest that walking is equally effective in improving cardiometabolic parameters among both younger and older individuals with T2DM.

Table 1: Socio-Demographic and Clinical Characteristics of Study Participants (n = 108)

Characteristic	Total (n=108)	Male (n= 61)	Female (n= 47)	p-value* (Male vs Female)
Age (years), Mean ± SD	47.39±10.33	47.4±10.3	48.5±9.9	0.570
Age ≤ 45 years, n (46.3%)	47.4±10.32	47.4±10.3	48.45±9.9	0.590
Age >45 years, n (53.7%)	48.23±10.29	48.11±10.37	49.80+9.21	0.370
BMI (kg/m^2), Mean ± SD	25.95±4.97	25.2±4.65	27.7±5.66	0.020
Duration of T2DM (years)	8.02±3.49	8.08±3.54	8.26±3.51	0.790
On OAD medication, n (100%)	108	68	40	0.007
Hypertension history, n (57%)	62 (57%)	42 (69%)	20 (43%)	0.005
Frequency of medical check-up	Annual	Annual	Annual	
Regular exercise habit, n (%)	Overall 5days/week	-	-	

* Independent Sample t-test

Table 2: Mean Pre-Post Changes in Physiological and Biochemical Parameters

Parameter	Pre-Walk (Mean ± SD)	Post-Walk (Mean ± SD)	Mean Change ± SD	p-value* (Pre & Post)	Cohen's d
Weight (kg)	71.69±10.9	71.49±10.89	0.2 ± 0.01	0.001	0.02 (Negligible)
SBP (mmHg)	134.3±18.12	128.52±16.63	5.78 ± 1.49	0.011	0.33 (Small)
DBP (mmHg)	86.05±10.62	82.68±10.54	3.4 ± 0.08	0.041	0.32 (Small)
Blood Glucose (mg/dL)	180.2±45.03	168.58±41.83	11.62 ± 3.2	0.022	0.27(Small)
Total Cholesterol (mg/dL)	194.31±43.54	183.78±42.84	10.53 ± 0.79	0.005	0.24 (Small)
Triglycerides (mg/dL)	187.37±61.67	173.56±56.25	13.81 ± 5.42	0.021	0.23 (Small)
HDL (mg/dL)	44.93±7.7	46.94±7.99	2.01 ± 0.29	0.001	0.26 (Small)
LDL (mg/dL)	125.84±35.6	121.19±34.17	4.65 ± 1.43	0.006	0.13 (Negligible)
VLDL (mg/dL)	37.47±12.33	34.71±11.24	2.76 ± 1.09	0.015	0.23 (Small)

Note: * Paired Sample t-test; Cohen's d: < 0.2 = negligible, 0.2-0.5 = small, 0.5-0.8 = medium, > 0.8 = large, > 1.3 = very large.

Table 3: Gender-wise Comparison of Pre-Post Changes in Parameters

Parameter	Male Pre (Mean ± SD)	Male Post (Mean ± SD)	Female Pre (Mean ± SD)	Female Post (Mean ± SD)	p-value (Male vs Female)
Blood Glucose (mg/dL)	180.21±45	168.86±46.9	183.69±45.55	170.06±47.1	0.695
SBP (mmHg)	134.29±18.11	128.68±16.63	134.22±17.82	128.53±16.63	0.981
DBP (mmHg)	86±10.62	82.56±10.87	86.15±10.93	82.84±10.21	0.944
Weight (kg)	71.24±10.94	70.98±10.91	72.41±10.97	72.15±10.95	0.581
Total Cholesterol (mg/dL)	197.74±43.54	185.11±56.24	189.86±43.86	179.19±42.5	0.352
Triglycerides (mg/dL)	190.24±62	174.91±73.68	183.64±63.31	171.82±56.26	0.591
HDL (mg/dL)	44.89±7.66	47.97±7.3	44.22±7.52	47.53±8.07	0.653
LDL (mg/dL)	122.81±35.57	121.56±34.41	122.81±35.91	120.14±34.16	0.832
VLDL (mg/dl)	35.49±12.33	31±10.63	34.75±12.66	30.6±10.63	0.480

* Independent Sample t-test

Table 4: Age-wise Comparison of Pre-Post Changes in Parameters

Parameter	≤ 45 yrs Pre (Mean ± SD)	≤ 45 yrs Post (Mean ± SD)	>45 yrs Pre (Mean ± SD)	>45 yrs Post (Mean ± SD)	p-value* (two age groups)
Blood Glucose (mg/dL)	183±45.2	167±47.4	182.8±45.9	166.4±48.16	0.981
SBP (mmHg)	134.3±18.17	128.3±16	134.88±17.9	128.7±15.9	0.875
DBP (mmHg)	86.05±10.6	82.6±8.3	86.29±10.6	82.9±8.2	0.911
Weight (kg)	69.9±11	68.8±11	70.03±10.6	68.9±10.6	0.952
Total Cholesterol (mg/dL)	201.2±42.4	176.7±36.1	199.5±43.2	175.4±36.2	0.845
Triglycerides (mg/dL)	181.4±61.4	161.7±53.8	179.9±60.99	160.2±53	0.902
HDL (mg/dL)	39.71±7.7	43±7.3	39.5±7.5	42.7±7.3	0.894
LDL (mg/dL)	125.3±35.3	101.3±30.2	124.04±35.8	100.6±30.6	0.920
VLDL (mg/dL)	36.3±12.3	32.3±10.8	36±12.2	32.03±10.6	0.920

* Independent Sample t-test

Table 5: Correlation Matrix for Changes in Physiological and Metabolic Parameters Following Walking Intervention (95%CI)

Variable Pair	r (Pearson)	p value	CI	Interpretation
Pre vs Post Blood Glucose	0.989**	<0.001	95%	Significant positive correlation indicating consistency of Blood glucose measurements pre- and post-intervention
Pre vs Post SBP	0.966**	<0.001	95%	Significant positive correlation indicating consistency of SBP measurements pre- and post-intervention
Pre vs Post DBP	0.752**	<0.001	95%	Significant positive correlation indicating stable DBP response patterns
Blood Glucose Change vs Weight Change	0.074	0.445	95%	No significant association between glycemic reduction and weight change
Blood Glucose change vs SBP change	0.070	0.470	95%	No significant relationship between glycemic and SBP changes
Blood Glucose change vs DBP change	0.196	0.142	95%	No significant relationship between glycemic and DBP changes

Notes: Bi-variate correlation analysis was performed using Pearson's correlation coefficient. Correlations involving change scores represent associations between pre-post intervention differences. **Correlation is significant at the 0.01 level (2-tailed).

Table 6: Subgroup Analysis by Medication Status and Disease Duration

Sub-group	n	Pre Blood Glucose (Mean ± SD)	Post Blood Glucose (Mean ± SD)	p-value* (Pre & Post)
On oral hypoglycaemic agents	108	180.21±45	168.58±41.83	0.000
On insulin therapy	0	-	-	-
On diet control only	0	-	-	-
<5 years T2DM duration	48	184±48.3	165±43.1	0.004
≥5 years T2DM duration	60	173±41.6	148±42.7	0.002

* Paired Sample t-test

All participants in the study were receiving oral hypoglycaemic agents; individuals on insulin-only regimens or those managed solely by diet were not represented in this cohort. Statistically significant reductions in blood glucose levels were observed across both categories of disease duration. Participants with a Type 2 Diabetes Mellitus (T2DM) duration of less than 5 years exhibited a more pronounced reduction, whereas those with a duration of 5 years or more also demonstrated significant improvement, though of a comparatively smaller magnitude.

These findings suggest that a walking intervention may be effective across various stages of diabetes progression. This efficacy could potentially be mediated by mechanisms such as improved insulin sensitivity, enhanced skeletal muscle glucose uptake, and increased energy expenditure.

Correlation Analysis

Strong positive correlations were observed between pre- and post-intervention blood glucose (r = 0.989, p = 0.000), SBP (r = 0.966, p = 0.000), and DBP (r = 0.752, p = 0.001), indicating consistency in individual physiological responses. However, change-score analysis demonstrated no statistically significant association between blood glucose reduction and changes in body weight (r = 0.074, p = 0.445) or blood glucose reduction with SBP (r = 0.070, p = 0.470) and DBP (r = 0.196, p = 0.142), suggesting that acute glycemic and cardiovascular responses to walking may operate through partially independent physiological mechanisms (Table 5).

As presented in Table 6, within this cohort of individuals with T2DM treated with oral anti-diabetic (OAD) agents, post-intervention blood glucose alterations exhibited no statistically significant association with variations in body weight. Furthermore, although reductions in SBP and DBP were observed, these changes did not strongly correlate with shifts in glycemic parameters. The observed relationships between blood glucose levels and SBP/DBP were statistically non-significant. This lack of statistical significance may be attributable to the relatively homogeneous diabetic profile of the study participants and the moderate prevalence of hypertension (57%) within the cohort.

All participants were on oral hypoglycaemic agents, with no representation from insulin-only or diet-controlled groups. Significant reductions in blood glucose were observed across both disease-duration categories. Participants with ≥5 years of T2DM showed greater reductions, while those with <5 years duration also demonstrated significant improvement.

These findings suggest that walking is effective across different stages of diabetes progression, potentially mediated through improved insulin sensitivity, enhanced skeletal muscle glucose uptake, and increased energy expenditure.

Discussion

T2DM is a complex metabolic condition allied with both cardiovascular and lipid disorders. The decline in insulin sensitivity with simultaneous improvements in lipid profile and blood pressure displays multifaceted benefits of walking on individuals with T2DM.[12,22,30] This study demonstrated that a single session of moderate-intensity walking was associated with significant short-term improvements in glycemic, cardiovascular, and lipid parameters among adults with type 2 diabetes mellitus. Reductions were observed in blood glucose, blood pressure, total cholesterol, triglycerides, LDL, and VLDL levels, accompanied by an increase in HDL cholesterol. The beneficial effects were generally consistent across age and gender groups, suggesting broad applicability of walking as an accessible lifestyle intervention. Although the observed effect sizes were modest, the findings support the potential role of regular walking as a practical strategy for improving cardiometabolic health and supporting diabetes self-management.

The study highlights that even a single session of moderate-intensity walking produces statistically significant improvements across glycemic, cardiovascular and lipid parameters, reinforcing the role of physical activity as an immediate therapeutic strategy.

Participants demonstrated 6.45% reductions in blood glucose levels, aligning with previous evidence indicating that simple short-duration physical activity can significantly enhance the glycemic response.[16,30] However, the effect sizes were small, indicating that while the changes are statistically significant, the magnitude of immediate physiological impact remains modest and should be interpreted within the context of acute intervention.

The notable decrease in SBP (4.30%) and DBP (3.95%) indicates improved cardiovascular responsiveness. The strong positive correlations between pre- and post-SBP and DBP values indicate consistent individual responses to the intervention. However, the absence of significant correlations between changes in blood glucose and blood pressure suggests that glycemic and cardiovascular responses may operate through partially independent physiological pathways during acute exercise.[26]

Immediate improvements in lipid profile represent another key contribution of the study. Reductions in total cholesterol (5.42%), triglycerides (7.37%), LDL (3.69%) and VLDL (7.37%), along with an increase in HDL (4.47%), though modest in magnitude, may be attributed to enhanced metabolic turnover during physical activity.[20] The minimal reduction in weight (0.28%) may be attributed to increased caloric expenditure and water loss due to sweating, and short-term metabolic changes during walking. The findings are further supported by the lack of significant correlation between weight change and blood glucose reduction. This suggests that metabolic adaptations occur independently of measurable anthropometric changes in the short term.

Importantly, subgroup analyses revealed no significant differences across age and gender groups, indicating that the benefits of walking are consistent and generalizable across diverse demographic categories. Although females exhibited slightly greater glucose reduction, the difference was not statistically significant, suggesting comparable metabolic responsiveness.[23]

However, the lack of a control group restricts definitive attribution of the observed changes exclusively to the walking intervention, thereby limiting the strength of causal inferences.

Overall, the findings underscore that walking serves as a low-intensity, accessible and immediately effective intervention, particularly relevant for populations with limited capacity for structured exercise.[6,26]

Scope and Limitations

The study has certain limitations that need to be acknowledged. The study assessed immediate, short-term effects of a single walking session, and dietary intake, psycho-social and other factors were not taken into consideration. Compliance with regular physical activity extraneous to the study was not systematically tracked, with the exception of assessments conducted on the camp day. The study did not include a control group, which limits the ability to attribute the observed changes solely to the walking intervention and restricts causal inference. The immediate body weight reduction may be interpreted cautiously, as it may reflect fluid loss and short-term metabolic changes. Furthermore, measurements were taken before and after walking sessions only, limiting understanding of the temporal consistency of the findings. Precise walking duration was not recorded as the subjects were encouraged to choose their own pace intensity of walking, which may have introduced variability in exercise intensity across individuals. Additionally, the single-session approach captures only immediate effects, and the small effect sizes emphasize longitudinal observations to achieve clinically meaningful long-term outcomes.

Future research should include varying intensities of walking speed, various socio-economic and cultural backgrounds, in varied geographical locations. The combined effects of dietary interventions, resistance training, or behavioural counselling may further enhance the outcomes of the study.

Conclusion

This study indicates that a single instance of moderate-intensity walking elicits immediate and statistically significant improvements in glycemic, cardiovascular, and lipid parameters among individuals diagnosed with Type 2 Diabetes Mellitus. While the observed alterations are modest in scale, the consistent nature of the response across diverse age and gender demographics underscores walking as a widely applicable intervention with minimal barriers to adoption. The results further suggest that these acute metabolic benefits manifest independently of substantial changes in body weight, implying that even brief periods of physical activity can contribute meaningfully to the self-management of diabetes. Considering its minimal cost, broad accessibility, and practical feasibility within various community environments, walking represents a viable component for integration into both routine clinical care and broader public health initiatives.

In conclusion, walking represents a practical, scalable, and evidence-based strategy for improving cardiometabolic health in T2DM, with strong potential for integration into lifestyle-based disease management frameworks.

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Availability of Data: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of use of AI generative tool: Generative AI tools were used solely for language editing and improving readability. All content was reviewed and verified by the authors, who take full responsibility for the manuscript. No AI tool was used for data collection, analysis, interpretation, or generation of scientific conclusions.

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