# Effectiveness of dynamic gait exercises on glycemic control and mobility in older adults with diabetes

*Efectividad de los ejercicios de marcha dinámica sobre el control glucémico y la movilidad en adultos mayores con diabetes*

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## How to cite in APA

Diovin Derose Vianni, S, S., Surya Vishnuram, Syed Abudaheer K, Abdel Razzaq Al Hadidi, Riziq Allah Mustafa Gaowgzeh, & Ahmed Fekry Salman. (2025). Effectiveness of dynamic gait exercises on glycemic control and mobility in older adults with diabetes. *Retos*, *67*, 1116–1124. https://doi.org/10.47197/retos.v67.114283

## Abstract

Introduction: Dynamic gait exercises have been proposed as a strategy to enhance gait stability and metabolic control in older adults with diabetes. however, comparative effectiveness between dynamic gait and traditional exercise programs has not been fully investigated.
Objective: The objective of this study was to evaluate the effects of dynamic walking exercises on walking ability and glycemic control in older adults with diabetes and to compare these outcomes with those of traditional exercise programs.
Methodology: A randomized controlled trial was conducted with sixty participants randomly assigned to two groups of thirty each. dynamic gait index scores, glycated hemoglobin levels from medical records, and quality of life based on the sf-12 questionnaire were recorded before and after a twelve-week intervention.
Results: In the dynamic gait group, DGI scores improved from 16.24 ± 2.30 to 23.85 ± 1.87, hba1c levels decreased from 8.32 ± 0.32 to 5.78 ± 0.22, and sf-12 scores increased from 49.26 ± 6.10 to 67.86 ± 5.54. all changes were statistically significant ($p < 0.001$).
Discussion: These findings align with existing literature showing that task-specific gait training improves neuromuscular coordination and metabolic control in diabetic populations.
Conclusions: dynamic gait training should be integrated into rehabilitation programs to improve mobility and glycemic outcomes in older diabetic adults.

## Keywords

Diabetes mellitus; Dynamic gait exercises; Functional mobility; Glycemic control; Quality of life.

## Resumen

Introducción: Se han propuesto los ejercicios de marcha dinámica como estrategia para mejorar la estabilidad de la marcha y el control metabólico en adultos mayores con diabetes. Sin embargo, no se ha investigado completamente la efectividad comparativa entre ejercicios dinámicos y programas tradicionales.
Objetivo: Evaluar los efectos de los ejercicios de marcha dinámica sobre la capacidad de caminar y el control glucémico en adultos mayores con diabetes, y comparar estos resultados con los de programas tradicionales.
Metodología: Ensayo controlado aleatorizado con sesenta participantes asignados aleatoriamente a dos grupos de treinta. Se registraron puntuaciones del Índice de Marcha Dinámica, niveles de hemoglobina glucosilada de historias clínicas y calidad de vida según el cuestionario SF-12, antes y después de una intervención de doce semanas.
Resultados: En el grupo de marcha dinámica, el DGI mejoró de 16.24 ± 2.30 a 23.85 ± 1.87, la HbA1c bajó de 8.32 ± 0.32 a 5.78 ± 0.22 y el SF-12 subió de 49.26 ± 6.10 a 67.86 ± 5.54. Todos los cambios fueron significativos ($p < 0.001$).
Discusión: Estos resultados coinciden con estudios que muestran que el entrenamiento de marcha mejora la coordinación neuromuscular y el control metabólico.
Conclusión: El entrenamiento de marcha dinámica debe integrarse en programas de rehabilitación para mejorar movilidad y control glucémico en adultos mayores con diabetes.

## Palabras clave

Diabetes mellitus; ejercicios de marcha dinámica; movilidad funcional; control glucémico; calidad de vida.

## Introduction

Diabetes Diabetes (DM) is a critical public health issue affecting more than 537 million people worldwide and is expected to increase its prevalence in the coming decades. (International Diabetes Federation, 2021). According to the World Health Organization (2016), Gait impairments are a common issue among geriatric diabetic patients, contributing to reduced mobility, postural instability, and an increased risk of falls (Martinelli et al., 2013). Diabetes-related neuromuscular deficits and proprioceptive dysfunction further exacerbate these challenges, impacting functional independence and quality of life (Faradilla Rahim et al., 2023). Conventional exercise programs, including walking and resistance training, offer general health benefits but often fail to address gait-specific impairments (Huang, 2015). Physiotherapy-based interventions play a crucial role in enhancing functional mobility and neuromuscular performance in elderly patients with diabetic neuropathy, further supporting the growing emphasis on individualized, movement-focused rehabilitation strategies for managing diabetes-related gait impairments (Ahmed et al., 2024). Expanding the scope of rehabilitation strategies, highlighted the futuristic role of isokinetic training in diabetic care, emphasizing its holistic potential in enhancing muscular performance, joint stability, and functional mobility in patients with diabetes (Khan et al., 2024). Furthermore, Recent research has demonstrated that dynamic gait exercises, which incorporate multidirectional movement, task-specific challenges, and cognitive-motor tasks, are practical in improving gait stability and mobility (Ko et al., 2013). Recent comparative studies, such as that by (Mythili et al., 2023), have shown that both functional strength training and neurodynamic exercises can significantly enhance balance and gait in patients with diabetic peripheral neuropathy, emphasizing the growing focus on tailored neuromuscular interventions in diabetes rehabilitation. Studies also suggest that proprioceptive and balance training can enhance postural control, resulting in improved neuromuscular coordination (Lakshmiprasanna et al., 2024). Additionally, vibrating insoles have been shown to enhance sensory feedback and improve dynamic balance, thereby optimizing movement efficiency (Asghar et al., 2024). In terms of metabolic benefits, structured gait training has been associated with improved glycemic control, indicating that exercise interventions can positively impact glucose metabolism. While dynamic gait exercises emphasize task-specific movement and postural adaptation, external cueing strategies, such as laser guidance, can also improve gait parameters in neurologically impaired populations, reinforcing the value of targeted gait interventions in restoring locomotor function (Lin et al., 2019). Complementing this shift toward specialized gait interventions, antigravity treadmill training significantly enhances balance and gait function in diabetic populations, reinforcing the effectiveness of task-oriented, neuromuscular strategies in addressing diabetes-related mobility deficits (Abdelaal & El-Shamy, 2022). Despite these advancements, comparative research on the impact of dynamic gait exercises on both gait stability and glycemic control remains limited (Jiwani et al., 2021). In support of balance-focused interventions, diabetic foot gymnastics significantly enhanced postural stability among elderly patients with diabetes, highlighting the relevance of lower-limb exercise protocols in addressing gait-related complications in this population (Sutarti et al., 2018). The objective of this study is to evaluate the efficacy of dynamic gait exercises in improving walking and metabolic outcomes and to compare them with traditional training programs.

## Method

In this randomized controlled trial (RCT), the efficacy of dynamic gait exercises in enhancing glycemic control, walking performance, and standard of living in elderly Individuals with diabetes was compared to that of traditional exercises. A quantitative explanatory research approach was used to generate a causal relationship between interventions and measurement results.

### *Participants*

Sixty elderly patients with diabetes were gathered, meeting the inclusion and exclusion criteria. Using computer-generated randomization (block randomization with a 1:1 ratio), Participants were assigned at random to either the control group or the dynamic gait exercise group. By ensuring that outcome assessors were blinded to group assignment, blinding was maintained. Participants were informed they were receiving gait training but were unaware of specific intervention differences. The statistician analyzing the data was also blinded. Due to the nature of exercise interventions, blinding of participants and therapists was not possible.

### *Power Analysis for Sample Size*

A power analysis was conducted to determine the required sample size for this study. Prior studies examining the effect of dynamic gait exercises on balance and glycemic control found an effect size (Cohen's d) of 0.8. An $\alpha$ level of 0.05, a power ($1-\beta$) of 0.80, and an anticipated dropout rate of 15% required at least 60 participants (30 in each group), according to G*Power 3.1, to detect a statistically significant difference.

*Inclusion criteria*

- Individuals aged 60 years or older.
- And have either (type 1 and type 2) diabetes are eligible.
- HbA1c (glycated hemoglobin) values ranging from 6.5 to 9.0%
- The capacity to walk without the use of assistive equipment

*Exclusion criteria*

- Severe cognitive decline, such as dementia
- Advanced diabetic complications such as retinopathy or severe neuropathy
- History of recent falls or fractures
- Contraindications to physical activity

Participants were randomly assigned to two groups:

- Group A (dynamic gait exercise group) (n = 30)
- Group B (conventional exercise group) (n = 30)

### *Procedure*

The study intervention lasted 12 weeks, and both groups participated in supervised exercise sessions three times a week. Each session lasted 45 minutes.

*Group A (dynamic gait exercises)*

Participants performed task-specific gait training, including:

- Walking on level surfaces
- Changing speeds
- Head turns
- Obstacle negotiation
- Turning and stair climbing, tailored to individual abilities and progression.

These exercises were designed to challenge balance, coordination, and cognitive-motor integration, improving neuromuscular control and mobility.

*Group B (conventional exercises)*

Participants engaged in traditional aerobic and resistance exercises, including:

- Static stretching exercises
- Light aerobic activities
- Lower limb strengthening exercises
- Balance training

Both groups underwent progressive intensity adjustments based on participant tolerance and the therapist's assessment.

### *Instrument*

#### *Primary outcome measures*

Glycated hemoglobin (HbA1c) levels were taken from medical records to assess glycemic control.
The Dynamic Gait Index (DGI) was used to evaluate gait performance and postural stability.

#### *Secondary outcome measure*

The quality of life was measured using the Short Form-12 (SF-12) Health Survey, which assesses both mental and physical health. All assessments were conducted pre- and post-intervention to determine changes resulting from the exercise programs.

### *Data analysis*

- SPSS version 22 was utilized for the statistical analysis.
- To evaluate within-group differences before and during the intervention, paired t-tests were used.
- The differences in post-test scores between the groups were analyzed using independent t-tests
- The cutoff criterion for the statistical threshold of significance was $p < 0.05$.

## Results

This study's findings demonstrate the effects of dynamic gait exercises compared to conventional exercises on glycemic control, gait performance, and quality of life in geriatric patients with diabetes. All participants completed the 12-week intervention without any adverse events.

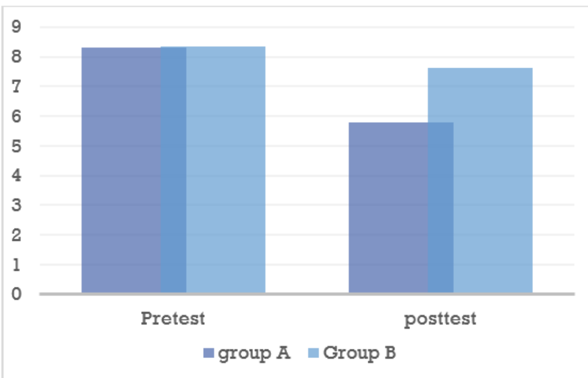
### *Glycemic control (HbA1c levels)*

According to the preliminary test results, the groups' HbA1c levels did not differ significantly ($p > 0.05$). The researchers were unable to prove a causal association between the two groups despite post-test data showing that the dynamic gait exercise group's HbA1c levels were significantly lower than those of the traditional exercise group ($p < 0.001$).

Table 1. Comparison of HbA1c levels between groups

| HbA1c (%) | Group A (dynamic gait exercises) | Group B (conventional exercises) | t-test | p-value |
|---|---|---|---|---|
| pre-test | 8.32 ± 0.32 | 8.33 ± 0.28 | 35.67 | 0.492 |
| post-test | 5.78 ± 0.22 | 7.89 ± 0.24 | 6.52 | < 0.001 |

Figure 1. HbA1c values before and after the test are compared



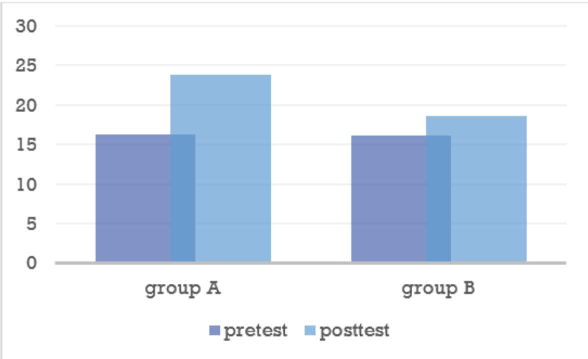
Gait performance (dynamic gait index - DGI)

When comparing the dynamic gait exercise group to the traditional exercise group, post-test DGI scores showed a statistically significant improvement ($p < 0.001$).

Table 2. DGI score comparison between groups

| DGI score | Group A (dynamic gait exercises) | Group B (conventional exercises) | t-test | p-value |
|---|---|---|---|---|
| Pre-test | 16.24 ± 2.30 | 16.15 ± 2.27 | -0.64 | 0.527 |
| Post-test | 23.85 ± 1.87 | 18.62 ± 2.10 | 5.34 | < 0.001 |

Figure 2. Comparison of DGI results pre and post-test



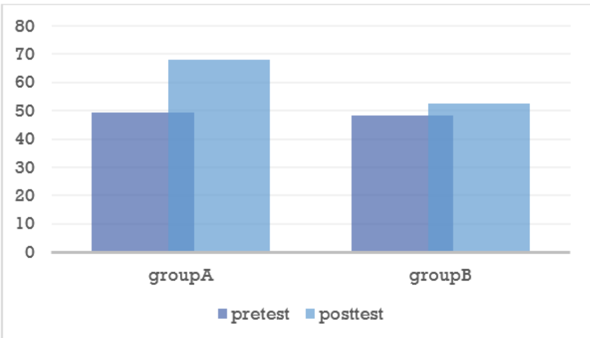

Quality of life (SF-12 scores)

The dynamic gait exercise group significantly outperformed the traditional exercise group in terms of quality of life, as assessed by the SF-12 questionnaire ($p < 0.001$).

Table 3. Comparison of SF-12 scores between groups

| SF-12 score | Group A (dynamic gait exercises) | Group B (conventional exercises) | t-test | p-value |
|---|---|---|---|---|
| Pre-test | 49.26 ± 6.10 | 48.16 ± 7.07 | -12.35 | 0.316 |
| Post-test | 67.86 ± 5.54 | 52.70 ± 6.57 | -2.57 | < 0.001 |

Figure 3. Comparison of SF 12 results pre-and post-test




## *Summary of findings*

- HbA1c levels significantly decreased in group A, indicating improved glycemic control.
- DGI scores improved significantly in group A, reflecting enhanced gait stability.
- SF-12 scores showed superior improvement in group A, indicating better quality of life outcomes.

These findings confirm that dynamic gait exercises are more effective than conventional exercises in enhancing glycemic management, mobility, and overall well-being in geriatric diabetic patients.

## Discussion

This study confirms that dynamic gait exercises significantly improve gait stability, glycemic control, and quality of life among elderly diabetic patients. The Dynamic Gait Index (DGI) scores in the dynamic gait group showed a statistically significant increase from 16.24 ± 2.30 to 23.85 ± 1.87 ($p \leq 0.001$), supporting the role of task-specific gait training in neuromuscular coordination. In addition to improved gait performance, participants demonstrated a notable reduction in HbA1c levels, from 8.32 ± 0.32 to 5.78 ± 0.22 ($p \leq 0.001$), indicating that structured gait training has a positive influence on glucose metabolism. This finding aligns with previous studies demonstrating that functional mobility exercises enhance insulin sensitivity and glycemic control (Saleh et al., 2024). Compared to existing studies, the improvements in gait observed in this study align with prior research highlighting the benefits of sensorimotor training in diabetic peripheral neuropathy (Ahmad et al., 2021). Our findings also support those of Jiwani et al., (2021), who found that geriatric walking programs significantly improved HbA1c and mobility scores. Additionally, our results are consistent with those of (Orlando et al., 2024), which demonstrate that vibrating insoles enhance proprioception and postural control; however, structured gait training may provide more sustained neuromuscular benefits. Futhermore (Ferriolli et al., 2014) emphasized the benefits of aerobic exercise for glycemic control, our findings demonstrate that gait-based interventions can achieve comparable metabolic benefits while also enhancing postural stability. The SF-12 scores showed significant improvements in both physical and mental health components after dynamic gait training ($p \leq 0.001$). SF-12 scores improved from 49.26 ± 6.10 to 67.86 ± 5.54 ($p < 0.001$), indicating gains in both physical and mental health indicating increased confidence in movement, reduced fear of falling, and improved psychological well-being. These findings are consistent with (Ann Reena, 2024), who reported that lower extremity training enhances both physical function and psychological resilience in patients with diabetes. Despite these positive outcomes, some limitations exist. The short duration of the study (12 weeks) may not fully capture long-term adaptations in gait and metabolic outcomes, as prior research suggests that longitudinal studies are necessary to assess the sustainability of improvements (Ahmad et al., 2017). Furthermore, individual differences in neuropathy severity may influence gait responses, underscoring the need for personalized gait training interventions (Hizomi Arani et al., 2023). These results are consistent with previous research emphasizing the role of exercise therapy in improving metabolic and cardiovascular health outcomes in at-risk populations (Susanto et al., 2024). highlights how structured exercise interventions, including dynamic movement training, contribute to reducing the risk of obesity, diabetes, and cardiovascular complications in older adults. This aligns with our findings that dynamic gait exercises not only improve mobility but also enhance glucose metabolism and insulin sensitivity. These findings are further supported by (Najafi, 2013), who highlighted the potential of gamified exercise interventions in preventing falls among individuals with diabetic peripheral neuropathy by enhancing motivation, adherence, and neuromuscular engagement elements that closely align with the cognitive-motor integration emphasized in dynamic gait training. Furthermore, the positive impact of dynamic training on glycemic control is reinforced by (Virto et al., 2023), who demonstrated that a 12-week exercise intervention significantly reduced HbA1c levels in patients with metabolic disorders. While their study focused on cancer patients, the physiological mechanisms underlying the improvements in glucose metabolism and systemic inflammation are relevant to individuals with diabetes. This supports the hypothesis that regular dynamic gait training can serve as a viable intervention for long-term glycemic control in older adults with diabetes. Future studies should investigate how gait can be sustained over time and how glycemic improvements can be achieved, integrating larger sample sizes, fall prevention assessments, and additional neuromuscular evaluations to optimize rehabilitation strategies for diabetic patients (Allet et al., 2010).

## Conclusions

This study demonstrated that dynamic gait exercises are significantly more effective than conventional exercises in improving glycemic control, gait performance, and standard of living in elderly diabetic patients. Participants who engaged in dynamic gait exercises exhibited more significant reductions in HbA1c levels, improved Dynamic Gait Index (DGI) scores, and higher SF-12 quality of life scores compared to those in the conventional exercise group. The findings of this study contributed to the growing evidence supporting task-specific gait training as a superior intervention for improving neuromuscular coordination, balance, and metabolic function in older adults with diabetes. By incorporating multidirectional movements, obstacle negotiation, and cognitive-motor integration, dynamic gait exercises provided more excellent functional benefits than traditional aerobic training. The results of this study suggested that rehabilitation programs for geriatric diabetic patients should prioritize dynamic gait exercises to enhance both physical health and quality of life. Healthcare practitioners, including physical therapists and diabetes specialists, could integrate these exercises into standard diabetes management protocols to reduce fall risk and optimize mobility. Although this study provided valuable insights, certain limitations should be considered. The maximum study duration was eight weeks, and the sample size was somewhat small. Future studies should investigate the lasting impacts of dynamic gait training, including its impact on fall prevention, muscle strength, and cardiovascular health. Additionally, studies involving more extensive and more diverse populations could help generalize the findings to a broader diabetic population. In conclusion, incorporating dynamic gait exercises into diabetes rehabilitation programs can enhance glycemic control, improve functional mobility, and promote overall well-being in older adults. The full potential of task-specific gait training in improving the health outcomes of elderly individuals with diabetes should be further investigated in future research.

## Acknowledgements

The authors thank Saveetha University for its generous support throughout this entire research study.

## Financing

Self-funded

## Conflicts of Interest

All authors clearly stated that they have no conflicts of interest.

## Data availability

Usually, the data sets are created during and/or analyzed throughout the entire study and are available from the corresponding author upon reasonable request.

## Ethics approval

02/035/2024/ISRB/PGSR/SCPT.

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