DOI: 10.4274/jmsr.galenos.2025.2025-3-3

J Mult Scler Res 2025;5(1):13-17

RESEARCH ARTICLE

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

Tracking Walking Capacity in People with Multiple Sclerosis Without Disability: 3-year Follow-up of Objective and Subjective Gait Measures

Zuhal Abasiyanik[1], Cavid Baba[2], Pinar Yigit[2], Ulvi Samadzade[3], Turhan Kahraman[1]

[1]Izmir Katip Celebi University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Izmir, Turkiye
[2]Dokuz Eylul University Institute of Health Sciences, Department of Neurosciences, Izmir, Turkiye
[3]Izmir University of Economic Medical Point Izmir Hospital, Department of Neurology, Izmir, Turkiye

Abstract

Objective: This study aimed to examine changes in walking performance over a 3-year period in persons with multiple sclerosis (pwMS) with no or mild disability.

Materials and Methods: A total of 321 pwMS (mean age 32.3± 9.8 years, 75% female, median Expanded Disability Status Scale 1.0) were followed for 3 years. Walking performance was assessed using the Timed 25-Foot Walk Test (T25FW), Six-Spot Step Test (SSST), 2-Minute Walk Test (2MWT), Timed Up and Go (TUG) test, and the Multiple Sclerosis Walking Scale-12 (MSWS-12). Leisure-time exercise habits were assessed with the Godin Leisure-Time Exercise Questionnaire.

Results: Walking performance remained stable over the 3-year period. The median T25FW time showed no significant change (4.8 s to 4.7 s, p=0.3), nor did the SSST time (7.7 s to 7.2 s, p=0.517). Similarly, there were no significant changes in the 2MWT distance (171 m to 174 m, p=0.178) or TUG time (6.8 s to 6.9 s, p=0.831). Self-reported walking disability MSWS-12 and leisure-time physical activity levels also remained consistent (p=0.692 and p=0.394, respectively).

Conclusion: The findings indicate that pwMS with no or mild disability maintained stable walking performance over a 3-year span. This stability may be attributed to functional reserve and lifestyle factors that support mobility preservation despite disease progression. Future studies should incorporate more detailed gait analyses and further explore the role of lifestyle factors.

Keywords: Multiple sclerosis, walking, gait, capacity, performance

Introduction

Walking impairment is a major concern for persons with multiple sclerosis (pwMS) and can appear early in the disease course, even in those with minimal or no visible disability (1,2). Subtle declines in gait function may go unnoticed by patients but can have significant long-term effects on mobility, physical activity, and overall quality of life. Early detection of these gait changes is essential for implementing timely interventions and treatments aimed at maintaining mobility in MS (3,4).

In pwMS with low Expanded Disability Status Scale (EDSS) scores, minor impairments such as slower walking speed, shorter step length, and longer double support time can already be identified through instrumented or sensitive gait assessments, even in the absence of clear clinical symptoms. As EDSS score increase, more evident gait abnormalities often develop, including asymmetrical stepping, foot drop, balance issues, reduced gait regularity, greater variability, and altered gait kinematics and kinetics (5,6). Recognizing these

Address for Correspondence: Zuhal Abasıyanık PhD, Izmir Katip Celebi University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Izmir, Turkiye
E-mail: zuhalabasiyanik@gmail.com **ORCID-ID:** orcid.org/0000-0003-3086-8102
Received: 10.04.2025 **Accepted:** 24.04.2025 **Publication Date:** 09.05.2025

Cite this article as: Abasiyanik Z, Baba C, Yigit P, Samadzade U, Kahraman T. Tracking walking capacity in people with multiple sclerosis without disability: 3-year follow-up of objective and subjective gait measures. J Mult Scler Res. 2025;5(1):13-17

Copyright© 2025 The Author. Published by Galenos Publishing House on behalf of the Multiple Sclerosis Research Association.
This is an open access article under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License.

progressive gait changes in relation to EDSS stages is important for designing targeted rehabilitation strategies.

In clinical settings without access to instrumental assessments, standardized tools are commonly used to measure walking ability in MS, including the Timed 25-Foot Walk Test (T25FW), 6-Minute Walk Test (6MWT), 2-Minute Walk Test (2MWT), MS Walking Scale (MSWS-12), Timed Up and Go (TUG) test, and Six-Spot Step Test (SSST) (7). Some studies have identified abnormal results in clinical walking tests even among pwMS with low levels of disability (4,8). While these assessments are commonly used in clinical practice and research, there are still few longitudinal studies that track changes over longer periods, especially in individuals with no or minimal disability (e.g., EDSS scores between 0 and 1.5). Understanding how walking performance evolves in this population is important for detecting early signs of disease progression and shaping therapeutic interventions (9).

This study aimed to investigate longitudinal changes in walking performance over a 3-year period in pwMS with no or minimal disability. By monitoring both functional walking tests and patient-reported outcomes, we sought to identify whether early gait changes could be detected and to assess the degree of walking decline. The findings may offer valuable insights into the early development of mobility impairment in MS and help guide targeted rehabilitation strategies to preserve walking function.

Materials and Methods

This study is part of an ongoing longitudinal project, approved by the Dokuz Eylul University Ethics Board (approval no.: 2021/17-05, date: 02.06.2021). All participants provided written informed consent after receiving a full explanation of the study.

Inclusion criteria were a confirmed diagnosis of MS (10), age between 18 and 60 years, and an EDSS score between 0 and 1.5. Participants were excluded if they had any condition affecting walking ability or any other neurological disorder.

Outcomes

Timed 25-Foot Walk Test (T25FW)

Participants were instructed to walk a marked 25-foot (7.62 m) course as quickly as possible while ensuring their safety. The test was performed twice, and the average of the two times was used as the final score. Longer times indicated slower walking speed (11). The T25FW has demonstrated good to excellent test-retest reliability, with intraclass correlation coefficients (ICC) ranging from 0.71 to 0.99 (12).

Six-Spot Step Test (SSST)

The SSST is a timed functional mobility test that evaluates speed, balance, coordination, and lower limb function. Participants were required to move as quickly as possible to specified targets and kick five cylindrical blocks out of marked circles on the floor. Each participant completed four trials (twice for each leg), and the average time across all trials was used as the final score (13,14). The SSST has demonstrated excellent test-retest reliability (ICC:0.99) (12,15).

Timed Up and Go Test (TUG)

The TUG assessed functional mobility by measuring the time taken for participants to rise from a seated position, walk 3 m, turn around, walk back, and sit down (16). The TUG test has shown excellent test-retest reliability (ICC:0.90) in pwMS with mild disability (17).

2-Minute Walk Test (2MWT)

The 2MWT assessed walking endurance. Participants were instructed to walk as far as possible within 2 min without taking a rest. The total distance covered was recorded (18). The 2MWT has demonstrated excellent test-retest reliability (ICC:0.95) in pwMS with mild disability (17).

MS Walking Scale-12 (MSWS-12)

The MSWS-12 consists of 12 items that assess perceived walking difficulties in daily life. Each item is scored from 1 (not at all) to 5 (extremely), with higher scores reflecting greater walking impairment. The total score was converted to a scale ranging from 0 to 100 (19). The MSWS-12 has shown excellent test-retest reliability, with ICC values between 0.89 and 0.98 (12).

Godin Leisure-time Exercise Questionnaire (GLTEQ)

Leisure-time physical activity was assessed using the Godin Leisure-Time Exercise Questionnaire (GLTEQ), which consists of three items evaluating the frequency of strenuous, moderate, and mild exercise. Higher scores reflect greater levels of physical activity (20). The GLTEQ is a valid and reliable self-reported measure of physical activity in pwMS, with an ICC of 0.74 (21).

Statistical Analysis

Normality was assessed by examining histograms and plots. Descriptive statistics are presented as mean and standard deviation or median and interquartile range (IQR), as appropriate. Since the walking assessments were not normally distributed, the Wilcoxon signed-rank test (a non-parametric test) was used to compare results between visits 1 and 2. Additionally, exploratory analysis was conducted to examine the relationship between changes in EDSS scores and changes in clinical walking outcomes using Spearman correlation analysis. Data were analyzed using IBM SPSS version 28.0 (Armonk, NY, IBM Corp). A p-value of 0.05 or less was considered statistically significant result.

Results

A total of 321 pwMS (mean age 32.3±9.8 years, 75% female) were followed over a 3-year period. The median EDSS score at baseline was 1.0. Clinical and demographic characteristics are presented in Table 1.

Across the 3-year follow-up, changes in walking performance were evaluated using various measures (Table 2). The median T25FW time remained stable, decreasing slightly from 4.8 s at baseline to 4.7 s at visit 2 (p=0.3). Similarly, performance on the SSST showed a minor improvement from 7.7 s (IQR: 6.8-8.7) to 7.2 s (IQR: 6.4-8.6), which was not statistically significant (p=0.517). The 2MWT demonstrated a small median increase in distance from 171 m (IQR: 157.3-187) to 174 m (IQR: 154.3-189.8) (p=0.178). TUG test results showed minimal change, with times increasing slightly from 6.8 s (IQR: 6.2-7.6) to 6.9 s (IQR: 6.3-7.9) (p=0.831). Self-reported walking disability, assessed through the MSWS-12, and leisure-time physical activity levels both remained stable over the 3 years (p=0.692 and p=0.394, respectively). Overall, no statistically significant changes were observed in walking performance over the 3-year period. Additionally, there were no significant correlations between changes in EDSS scores and changes in any of the clinical walking tests (p>0.05).

Discussion

This study examined longitudinal changes in walking performance over a 3-year period in pwMS with no or mild disability. The results showed no significant decline across objective walking performance measures, including the T25FW, SSST, 2MWT, and TUG, nor in perceived walking ability assessed by the MSWS-12.

The stable T25FW times over 3-years suggest that short-distance walking speed is preserved in pwMS at this disability level. This finding aligns with a previous study that reported no decline over 2-years in a group with a median EDSS of 2 and a median T25FW of 3.94, although worsening was noted in participants with greater disability and a higher risk of progression (22). Similarly, the absence of significant change in SSST performance indicates that dynamic stability and coordination are maintained, likely reflecting functional reserve that supports mobility even during more demanding tasks. The stable TUG results further reinforce the notion that functional mobility remains intact in this cohort. While walking performance often declines in individuals with greater disability, our findings suggest that pwMS with mild impairments can maintain walking function over time. This preservation may be explained by functional reserve, which enables compensation for disease effects at an early stage, or by factors such as medication adherence and lifestyle habits. Although we assessed leisure-time physical activity using the self-reported GLTEQ, we did not include objective measurements of physical activity or a detailed assessment of lifestyle behaviors. Future research should address these factors more thoroughly, as doing so may offer valuable insights into disease management.

The lack of significant change in self-reported walking ability indicates that participants did not perceive notable changes in their mobility over the 3-year period, consistent with the objective walking assessments. This finding suggests that pwMS with no or minimal disability may maintain a stable perception of their walking ability, possibly due to effective compensatory mechanisms or stable disease activity.

Monitoring and following subtle deficits during the early or low-disability stages of MS is critical for implementing early and targeted interventions. The validated tests used to assess Progression Independent of Relapse Activity primarily rely on clinical measures, which may not be sensitive enough to detect subtle changes (23,24). As suggested by the findings of this study, the lack of deterioration in clinical tests may be considered a positive result for disease management. However, it is essential to recognize the potential limitations of these tests in identifying subtle progression. While a key strength of our study is the 3-year follow-up of walking function in a large sample, it

Table 1. Demographic and clinical characteristics of participants

	Total (n=321)
Age (years), mean (SD)	32.3 (9.8)
Gender, n (%)	
Female	239 (74.5%)
Male	82 (25.5%)
EDSS, median (interquartile range)	1.0 (0-1.5)

EDSS: Expanded disability status scale, SD: Standard deviation

Table 2. Changes in walking measures over 3 years

	Visit 1	Visit 2	Change	p-value
T25FW, seconds	4.8 (4.3-5.3)	4.7 (4.3-5.2)	-0.06 (-0.53-0.44)	0.3
SSST, seconds	7.7 (6.8-8.7)	7.2 (6.4-8.6)	-0.32 (-1.3-0.68)	0.517
2MWT, meters	171 (157.3-187)	174 (154.3-189.8)	0 (-11-15)	0.178
TUG, seconds	6.8 (6.2-7.6)	6.9 (6.3-7.9)	0.28 (-0.63-1.15)	0.831
MSWS-12 (%)	25.9 (22.2-35.2)	25.9 (22.2-37.4)	0 (-5.6-3.7)	0.692
GLTEQ	0 (0-15)	1 (0-17.25)	0 (-7-10)	0.394

Values are presented as median (interquartile range)

T25FW: Timed 25-Foot Walk Test, SSST: Six-Spot Step Test, 2MWT: 2-Minute Walk Test, TUG: Timed Up and Go Test, MSWS-12: 12-item MS Walking Scale, GLTEQ: Godin Leisure-Time Exercise Questionnaire

is important to note that our assessments were based solely on clinical tests measuring time and distance. More detailed gait parameters related to neural control, such as stability, variability, and smoothness, which may not be captured by these tests, could be important for long-term monitoring and identifying progression risk (25-28). Additionally, our assessments were limited to relatively short-duration tests and did not include extended walking tasks that could reveal fatigue. Previous research has shown that speed trajectories during the 6MWT can help detect progression over 2-years (22).

Study Limitations

The study sample consisted of individuals with no or mild disability, which may limit the generalizability of the findings to those with more severe disability. The absence of a healthy control group also restricts the ability to make comparisons. Furthermore, although our participants had low disability levels, we were unable to identify those at higher risk of progression. As such, separate analyses for individuals at higher risk should be conducted to better assess potential deterioration. Additionally, factors such as fatigue, cognitive function, lifestyle behaviors, and environmental influences were not considered, but these may impact long-term walking performance. This study also did not include detailed clinical information, such as immunomodulating treatment status or magnetic resonance imaging lesion load, which could limit our ability to explore potential predictors of walking performance. Future research should include these variables to offer a more comprehensive understanding of mobility changes in MS. Lastly, the clinical walking tests used in this study may lack the sensitivity to detect subtle gait changes in pwMS with minimal disability, potentially overlooking early functional decline. Ceiling effects may also limit their ability to capture meaningful longitudinal changes.

Conclusion

This study indicates that pwMS with no or mild MS-related disability maintain stable walking performance over a 3-year period, with no significant decline in objective measures or self-reported walking ability. These results suggest that the functional reserve may help preserve mobility at this early stage of the disease. However, the limited sensitivity of clinical measures to detect subtle changes underscores the need for more comprehensive assessments, including complex gait parameters and long-duration tests, to better identify progression and guide early interventions.

Ethics

Ethics Committee Approval: The non-invasive Research Ethics Board of Dokuz Eylul University approved the study protocol (approval no.: 2021/17-05, date: 02.06.2021).

Informed Consent: Each participant provided written informed consent.

Footnotes

Authorship Contributions

Surgical and Medical Practices: C.B., Concept: Z.A., C.B., P.Y., U.S., T.K., Design: Z.A., T.K., Data Collection or Processing: Z.A., C.B., P.Y., Analysis or Interpretation: Z.A., C.B., P.Y., U.S., T.K., Literature Search: Z.A., Writing: Z.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Krieger SC, Antoine A, Sumowski JF. EDSS 0 is not normal: Multiple sclerosis disease burden below the clinical threshold. Multiple Sclerosis Journal. 2022;28:2299-303.
2. Heesen C, Böhm J, Reich C, Kasper J, Goebel M, Gold SM. Patient perception of bodily functions in multiple sclerosis: gait and visual function are the most valuable. Mult Scler. 2008;14:988-991.
3. Riemenschneider M, Hvid LG, Ringgaard S, Nygaard MKE, Eskildsen SF, Gaemelke T, Magyari M, Jensen HB, Nielsen HH, Kant M, Falah M, Petersen T, Stenager E, Dalgas U. Investigating the potential disease-modifying and neuroprotective efficacy of exercise therapy early in the disease course of multiple sclerosis: The Early Multiple Sclerosis Exercise Study (EMSES). Mult Scler. 2022;28:1620-1629.
4. Cattaneo D, Gervasoni E, Anastasi D, Di Giovanni R, Brichetto G, Carpinella I, Cavalla P, Confalonieri P, Groppo E, Prosperini L, Tacchino A, Rovaris M, Solaro C. Prevalence and patterns of subclinical motor and cognitive impairments in non-disabled individuals with early multiple sclerosis: A multicenter cross-sectional study. Ann Phys Rehabil Med. 2022;65:101491.
5. Karatsidis A, Angelini L, Scaramozza M, Bartholome E, Clinch SP, Shen C, Lindemann M, Mazzà C, Scotland A, van Beek J, Belachew S, Craveiro L. Characterizing gait in people with multiple sclerosis using digital data from smartphone sensors: A proposed framework. Mult Scler. 2025;31:512-528.
6. Chee JN, Ye B, Gregor S, Berbrayer D, Mihailidis A, Patterson KK. Influence of multiple sclerosis on spatiotemporal gait parameters: a systematic review and meta-regression. Arch Phys Med Rehabil. 2021;102:1801-1815.
7. Soler B, Ramari C, Valet M, Dalgas U, Feys P. Clinical assessment, management, and rehabilitation of walking impairment in MS: an expert review. Expert Rev Neurother. 2020;20:875-886.
8. Thrue C, Hvid LG, Diechmann M, Gaemelke T, Stenager E, Dalgas U, Riemenschneider M. Early phase multiple sclerosis patients present substantial deficits in physical-, cognitive-, and patient-reported outcomes compared to matched healthy controls. Neurorehabil Neural Repair. 2025:15459683251318246.
9. Gervasoni E, Anastasi D, Di Giovanni R, Solaro C, Rovaris M, Brichetto G, Confalonieri P, Tacchino A, Carpinella I, Cattaneo D. Uncovering subtle gait deterioration in people with early-stage multiple sclerosis using inertial sensors: a 2-year multicenter longitudinal study. Sensors (Basel). 2023;23:9249.
10. Thompson AJ, Banwell BL, Barkhof F, Carroll WM, Coetzee T, Comi G, Correale J, Fazekas F, Filippi M, Freedman MS, Fujihara K, Galetta SL, Hartung HP, Kappos L, Lublin FD, Marrie RA, Miller AE, Miller DH, Montalban X, Mowry EM, Sorensen PS, Tintoré M, Traboulsee AL, Trojano M, Uitdehaag BMJ, Vukusic S, Waubant E, Weinshenker BG, Reingold SC, Cohen JA. Diagnosis of multiple sclerosis: 2017 revisions of the McDonald criteria. Lancet Neurol. 2018;17:162-173.
11. Fischer JS, Rudick RA, Cutter GR, Reingold SC. The Multiple Sclerosis Functional Composite Measure (MSFC): an integrated approach to MS clinical outcome assessment. The Multiple Sclerosis Functional Composite Measure (MSFC): an integrated approach to MS clinical outcome

assessment. National MS Society Clinical Outcomes Assessment Task Force. Task Force. Mult Scler. 1999;5:244-250.

12. Skjerbæk AG, Hvid LG, Boesen F, Taul-Madsen L, Stenager E, Dalgas U. Psychometric measurement properties and reference values of the six-spot step test, the six-minute walk test, the 25-foot walk test, and the 12-item multiple sclerosis walking scale in people with multiple sclerosis. Mult Scler Relat Disord. 2025;94:106242.
13. Sandroff BM, Motl RW, Sosnoff JJ, Pula JH. Further validation of the Six-Spot Step Test as a measure of ambulation in multiple sclerosis. Gait Posture. 2015;41:222-227.
14. Fritz NE, Jiang A, Keller J, Zackowski KM. Utility of the six-spot step test as a measure of walking performance in ambulatory individuals with multiple sclerosis. Arch Phys Med Rehabil. 2016;97:507-512.
15. Callesen J, Richter C, Kristensen C, Sunesen I, Næsby M, Dalgas U, Skjerbæk AG. Test-retest agreement and reliability of the Six Spot Step Test in persons with multiple sclerosis. Mult Scler. 2019;25:286-294.
16. Sebastião E, Sandroff BM, Learmonth YC, Motl RW. Validity of the Timed Up and Go Test as a measure of functional mobility in persons with multiple sclerosis. Arch Phys Med Rehabil. 2016;97:1072-1077.
17. Valet M, Lejeune T, Devis M, van Pesch V, El Sankari S, Stoquart G. Timed Up-and-Go and 2-Minute Walk Test in patients with multiple sclerosis with mild disability: reliability, responsiveness and link with perceived fatigue. Eur J Phys Rehabil Med. 2019;55:450-455.
18. Scalzitti DA, Harwood KJ, Maring JR, Leach SJ, Ruckert EA, Costello E. Validation of the 2-Minute Walk Test with the 6-Minute Walk Test and other functional measures in persons with multiple sclerosis. Int J MS Care. 2018;20:158-163.
19. Dib H, Tamam Y, Terzi M, Hobart J. Testing patient-reported outcome measurement equivalence in multinational clinical trials: An exemplar using the 12-item Multiple Sclerosis Walking Scale. Mult Scler J Exp Transl Clin. 2017;3:2055217317728740.
20. Gosney JL, Scott JA, Snook EM, Motl RW. Physical activity and multiple sclerosis: validity of self-report and objective measures. Fam Community Health. 2007;30:144-150.
21. Sikes EM, Richardson EV, Cederberg KJ, Sasaki JE, Sandroff BM, Motl RW. Use of the Godin leisure-time exercise questionnaire in multiple sclerosis research: a comprehensive narrative review. Disabil Rehabil. 2019;41:1243-1267.
22. Goldman MD, Chen S, Motl R, Pearsall R, Oh U, Brenton JN. Progression risk stratification with six-minute walk gait speed trajectory in multiple sclerosis. Front Neurol. 2023;14:1259413.
23. Kappos L, Wolinsky JS, Giovannoni G, Arnold DL, Wang Q, Bernasconi C, Model F, Koendgen H, Manfrini M, Belachew S, Hauser SL. Contribution of relapse-independent progression vs relapse-associated worsening to overall confirmed disability accumulation in typical relapsing multiple sclerosis in a pooled analysis of 2 randomized clinical trials. JAMA Neurol. 2020;77:1132-1140.
24. Giovannoni G, Hawkes CH, Lechner-Scott J, Levy M, Yeh EA. Smouldering-associated worsening or SAW: the next therapeutic challenge in managing multiple sclerosis. Mult Scler Relat Disord. 2024;92:106194.
25. Müller R, Hamacher D, Hansen S, Oschmann P, Keune PM. Wearable inertial sensors are highly sensitive in the detection of gait disturbances and fatigue at early stages of multiple sclerosis. BMC Neurol. 2021;21:337.
26. Carpinella I, Gervasoni E, Anastasi D, Di Giovanni R, Tacchino A, Brichetto G, Confalonieri P, Rovaris M, Solaro C, Ferrarin M, Cattaneo D. Instrumentally assessed gait quality is more relevant than gait endurance and velocity to explain patient-reported walking ability in early-stage multiple sclerosis. Eur J Neurol. 2021;28:2259-2268.
27. Cofré Lizama LE, Strik M, Van der Walt A, Kilpatrick TJ, Kolbe SC, Galea MP. Gait stability reflects motor tracts damage at early stages of multiple sclerosis. Mult Scler. 2022;28:1773-1782.
28. Pau M, Mandaresu S, Pilloni G, Porta M, Coghe G, Marrosu MG, Cocco E. Smoothness of gait detects early alterations of walking in persons with multiple sclerosis without disability. Gait Posture. 2017;58:307-309.