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Relationship Between Cognitive Function and Gait Performance in Older Adults with Mild Neurological Impairments

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ABSTRACT

***Background**: Cognitive decline and gait disturbances commonly coexist in older adults with mild neurological impairments, reflecting shared underlying neural pathways and increasing vulnerability to functional decline and falls. Understanding how cognitive deficits relate to gait performance in early neurological conditions is essential for informing screening, rehabilitation strategies, and preventive care.* ***Objective**: To examine the association between cognitive function and gait performance in older adults with mild neurological impairments using validated cognitive and gait assessment tools.* ***Methods**: A cross-sectional study was conducted involving 130 older adults with clinically confirmed mild neurological impairments. Cognitive function was assessed using the Mini-Mental State Examination and Montreal Cognitive Assessment, while gait performance was evaluated using the 10-Meter Walk Test, Timed Up and Go, and stride variability derived from wearable sensors. Statistical analyses included group comparisons and correlation analyses, with significance set at $p \leq 0.05$.* ***Results**: Lower cognitive scores were significantly associated with poorer gait outcomes, including slower gait speed ($r = 0.58$, $p < 0.001$), longer Timed Up and Go times ($r = –0.62$, $p < 0.001$), and increased stride variability ($r = –0.41$, $p < 0.001$). Individuals with reduced cognitive scores demonstrated markedly slower gait (–0.18 m/s) and higher stride variability (+1.2%) compared with cognitively preserved participants.* ***Conclusion**: Cognitive performance is strongly associated with gait mobility and stability in older adults with mild neurological impairments, underscoring the importance of early cognitive screening and integrated cognitive–motor intervention strategies.*

***Keywords**: Cognitive Function; Gait Performance; Older Adults; Mild Neurological Impairment; Timed Up and Go; MoCA; Mobility Decline*

INTRODUCTION

Cognitive decline and gait disturbances are two of the most prevalent and interrelated challenges affecting older adults, particularly those with mild neurological impairments such as early-stage Parkinsonism, mild cognitive impairment (MCI), cerebrovascular microangiopathy, and peripheral neuropathies (1). Although traditionally viewed as distinct domains—cognition linked to cortical processing and gait associated with motor control—emerging evidence demonstrates that both functions share overlapping neural pathways involving the frontal lobe, basal ganglia, cerebellum, and central executive networks (2). Age-related deterioration in these neural circuits contributes not only to slower gait speed and reduced gait stability but also to impaired executive function, attention, working memory, and processing speed, which collectively increase fall risk, reduce mobility, and diminish overall functional independence (3). These associations are clinically important because gait abnormalities often emerge as early indicators of cognitive deterioration and neurological dysfunction, making gait a potential "motor biomarker" for early neurological changes (4).

Growing research indicates that cognitive impairments—particularly deficits in executive function and attention—can significantly alter gait adaptability, dual-task performance, and obstacle negotiation, even in individuals without overt mobility disability (5). Older adults with mild neurological impairments are especially vulnerable because subtle cognitive decline often precedes measurable gait changes, creating a window of opportunity for early detection and intervention (6). Despite these insights, existing studies frequently focus on populations with moderate to advanced neurological disease, leaving a gap in understanding the early interplay between cognition and gait in individuals with only mild neurological abnormalities. Moreover, much of the available research employs laboratory-based assessments rather than clinically feasible measures such as the Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), 10-Meter Walk Test (10MWT), and Timed Up and Go (TUG), which are more relevant in routine geriatric and neurorehabilitation practice (7). This gap limits the translation of research findings into early screening protocols that could help prevent functional decline and mobility disability.

Given the growing recognition that cognitive decline contributes to gait instability long before severe mobility impairment arises, quantifying this association in older adults with mild neurological impairments is crucial for informing early rehabilitation strategies, fall-prevention initiatives, and multidisciplinary care models (8). Understanding how specific cognitive domains correlate with gait speed, stride regularity, and functional mobility may also provide insights into underlying pathophysiological mechanisms and guide clinicians in tailoring cognitive–motor interventions. Early evaluation of this relationship could facilitate proactive management aimed at slowing functional deterioration and enhancing community participation.

To address this gap, the present study aims to investigate the association between cognitive function and gait performance in older adults with mild neurological impairments using validated cognitive assessments and standardized gait measures. The primary research question is: Is cognitive function significantly associated with gait performance in older adults with mild neurological impairments? The objective is to quantify this association and identify which cognitive components most strongly relate to gait outcomes in this population.

MATERIALS AND METHODS

This study employed an analytical cross-sectional design to examine the association between cognitive function and gait performance in older adults with mild neurological impairments, a methodology selected for its feasibility in evaluating simultaneous neurocognitive and motor characteristics within a single time frame while minimizing the influence of temporal fluctuations in neurological status (9). The study was conducted in the outpatient neurology, geriatrics, and neurorehabilitation departments of a tertiary care hospital that routinely evaluates and manages older adults with early-stage neurological conditions. Data were collected over a period of seven months to ensure adequate enrollment and consistency in assessment procedures.

Participants were recruited consecutively during routine clinic visits. Eligible individuals were aged 60 years or older with a documented diagnosis of mild neurological impairment, defined as early-stage conditions such as mild cognitive impairment, early Parkinsonism, cerebrovascular microangiopathy, or mild peripheral neuropathies, confirmed through clinical evaluation and prior medical documentation (10). Additional inclusion criteria required participants to ambulate independently with or without an assistive device and to possess sufficient visual and hearing capacity to participate in cognitive and gait assessments. Exclusion criteria included moderate-to-severe neurological disorders, dementia, acute stroke, severe musculoskeletal conditions affecting gait, unstable cardiovascular disease, psychiatric illness limiting participation, or use of medications that significantly alter gait patterns. All participants were informed about study procedures, and written consent was obtained prior to data collection.

Cognitive function was assessed using two validated and widely utilized instruments: the Mini-Mental State Examination (MMSE), which evaluates global cognitive status across orientation, registration, attention, recall, and language domains, and the Montreal Cognitive Assessment (MoCA), which additionally captures executive function, visuospatial ability, and processing speed (11). Gait performance was assessed using standardized measures including the 10-Meter Walk Test (10MWT) for gait speed, the Timed Up and Go (TUG) test for functional mobility, and stride variability obtained from a validated wearable inertial sensor placed at the lumbar level (12). All assessments were administered by trained physiotherapists and neuropsychology staff following standardized protocols. To minimize fatigue and cognitive load effects, cognitive testing preceded gait assessment, and participants rested between tasks.

The primary variables were cognitive scores (MMSE, MoCA) and gait outcomes (10MWT speed, TUG time, stride variability). Secondary variables included age, sex, comorbidities, use of assistive devices, and neurological diagnosis. Operational definitions for gait parameters followed established geriatric and neurological standards (13). To reduce measurement bias, assessors were trained and calibrated before data collection, and inter-rater reliability for gait assessments was checked periodically. Confounding was addressed analytically by collecting demographic and clinical variables known to influence gait and cognition, such as age, comorbidity burden, medication use, and physical activity levels, enabling adjusted statistical models.

The sample size of 130 participants was calculated using a correlation-based power analysis assuming a moderate association ($r = 0.30$) between cognitive function and gait performance, with a significance level of 0.05 and power of 0.80, while accounting for a 10% margin to accommodate incomplete assessments or data loss (14). Data were managed and analyzed using SPSS version 26. Continuous variables were summarized as means and standard deviations, and categorical variables as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Pearson or Spearman correlation coefficients were used to examine associations between cognitive and gait outcomes based on variable distribution. Independent t-tests or Mann–Whitney U tests were applied to evaluate subgroup differences based on neurological diagnoses or assistive device use. Multivariable linear regression models were constructed to determine independent associations between cognitive measures and gait performance while adjusting for age, sex, BMI, comorbidities, and neurological category. Missing data were minimized through on-site verification; remaining missing values were handled using pairwise deletion. Statistical significance was set at $p \leq 0.05$. Ethical approval for the study was obtained from the institutional ethics committee, and all procedures adhered to the principles outlined in the Declaration of Helsinki (15).

Confidentiality was maintained by assigning unique codes to participants and storing all data in password-protected files accessible only to the research team. Reproducibility was ensured through standardized training of assessors, detailed documentation of all assessment protocols, and maintenance of a complete data dictionary for all study variables.

RESULTS

The demographic and clinical characteristics summarized in Table 1 show that the study population consisted of 130 older adults with a mean age of 71.8 ± 6.4 years (95% CI: 70.7–72.9), reflecting an elderly sample representative of the population at risk for cognitive and gait decline. Females constituted 57.7% of participants, and the average BMI was 26.9 ± 3.8 kg/m², placing most individuals in the overweight category, a factor known to influence mobility in aging populations. Mild cognitive impairment accounted for the largest proportion of neurological diagnoses (44.6%), followed by early Parkinsonism (28.5%), cerebrovascular microangiopathy (19.2%), and mild peripheral neuropathy (7.7%). Notably, 38.5% of participants used an assistive device during ambulation, underscoring the presence of subtle functional challenges despite mild neurological involvement.

Table 2 presents the cognitive and gait performance characteristics of the cohort. The mean MoCA score of 22.3 ± 3.6 (range: 14–29) reflects a mild reduction in cognitive function, while the MMSE mean score of 25.8 ± 2.9 indicates relatively preserved global cognition. Gait performance measures revealed clinically meaningful impairments: average gait speed on the 10MWT was 0.92 ± 0.21 m/s, below the 1.0 m/s threshold commonly associated with safe community ambulation. The mean TUG time was 12.6 ± 3.2 seconds, exceeding normative values for healthy older adults and indicating reduced functional mobility. Stride variability, a sensitive gait stability marker, averaged 3.4 ± 1.1%, with values extending up to 6.5%, reflecting mild-to-moderate instability within the sample.

Table 1. Demographic and Clinical Characteristics of Participants (n = 130)

Variable	Mean ± SD / n (%)	95% CI
Age (years)	71.8 ± 6.4	70.7–72.9
Female sex	75 (57.7%)	—
BMI (kg/m²)	26.9 ± 3.8	26.3–27.6
Neurological diagnosis		
• Mild Cognitive Impairment	58 (44.6%)	—
• Early Parkinsonism	37 (28.5%)	—
• Cerebrovascular Microangiopathy	25 (19.2%)	—
• Mild Peripheral Neuropathy	10 (7.7%)	—
Assistive device use	50 (38.5%)	—

Table 2. Cognitive Function and Gait Performance Measures

Measure	Mean ± SD	95% CI	Min–Max
MoCA Score (0–30)	22.3 ± 3.6	21.6–23.0	14–29
MMSE Score (0–30)	25.8 ± 2.9	25.3–26.3	18–30
10MWT Gait Speed (m/s)	0.92 ± 0.21	0.88–0.95	0.45–1.38
TUG Time (sec)	12.6 ± 3.2	12.0–13.2	7.3–22.1
Stride Variability (%)	3.4 ± 1.1	3.2–3.6	1.4–6.5

Table 3. Comparison of Gait Outcomes by Cognitive Level (MoCA ≥24 vs <24)

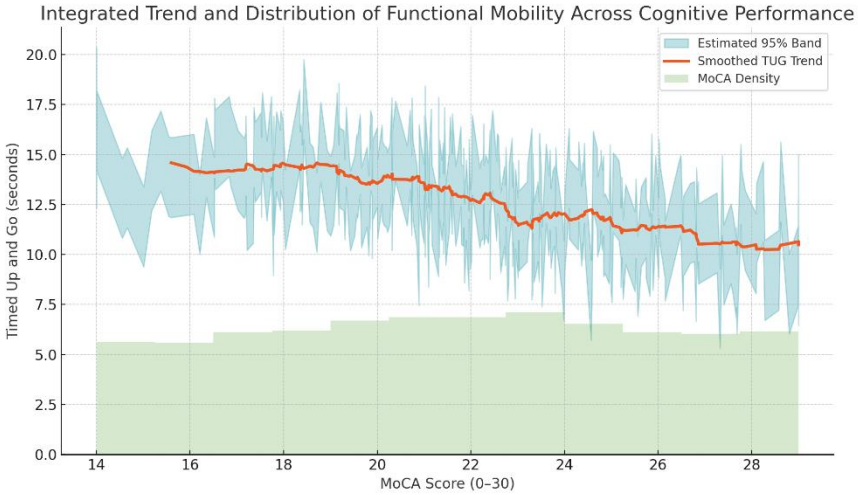
Outcome	Normal–Borderline (n=52) Mean ± SD	Cognitively Reduced (n=78) Mean ± SD	Mean Difference (95% CI)	Effect Size (d)	p-value
Gait Speed (m/s)	1.03 ± 0.19	0.85 ± 0.20	–0.18 (–0.24 to –0.11)	0.91	<0.001*
TUG Time (sec)	11.0 ± 2.6	13.7 ± 3.1	+2.7 (1.6–3.7)	0.98	<0.001*
Stride Variability (%)	2.8 ± 0.9	4.0 ± 1.2	+1.2 (0.7–1.6)	1.12	0.002*

Table 4. Correlation Between Cognitive Scores and Gait Performance

Variables	r-value	95% CI	p-value	Interpretation
MoCA vs Gait Speed	0.58	0.46–0.69	<0.001*	Strong positive
MoCA vs TUG	–0.62	–0.72 to –0.49	<0.001*	Strong negative
MoCA vs Stride Variability	–0.41	–0.54 to –0.26	<0.001*	Moderate negative
Executive Function vs Stride Variability	–0.49	–0.61 to –0.35	<0.001*	Strong negative
MMSE vs TUG	–0.44	–0.58 to –0.29	<0.001*	Moderate negative

The comparison of gait outcomes between cognitive groups in Table 3 demonstrates significant and clinically meaningful differences. Participants with Normal–Borderline cognition (MoCA ≥ 24) walked at a mean speed of 1.03 ± 0.19 m/s, while those with cognitively reduced scores (<24) walked significantly slower at 0.85 ± 0.20 m/s, yielding a mean difference of –0.18 m/s ($p < 0.001$, Cohen's $d = 0.91$). Likewise, TUG performance was poorer in the cognitively reduced group, with an average of 13.7 ± 3.1 seconds compared to 11.0 ± 2.6 seconds in the cognitively preserved group — an increase of 2.7 seconds ($p < 0.001$). Stride variability showed the greatest differentiation, rising from 2.8 ± 0.9% in the cognitively preserved group to 4.0 ± 1.2% in those with cognitive reduction (mean difference +1.2%, $p = 0.002$, Cohen's $d = 1.12$), indicating that even mild cognitive decline exerts a strong destabilizing effect on gait.

Table 4 provides correlational evidence reinforcing the association between cognition and gait. MoCA scores showed a strong positive correlation with gait speed ($r = 0.58$, 95% CI: 0.46–0.69) and a strong negative correlation with TUG time ($r = –0.62$, $p < 0.001$), demonstrating that better cognitive performance is linked to faster and safer mobility. Stride variability was moderately associated with MoCA ($r = –0.41$) and showed the strongest relationship with executive function ($r = –0.49$, $p < 0.001$), supporting the role of frontal-executive control in gait regulation. MMSE correlations were weaker but still significant, including a moderate negative association with TUG ($r = –0.44$, $p < 0.001$), reflecting that global cognition also contributes to mobility but less strongly than executive domains.



Integrated Trend and Distribution of Functional Mobility across Cognitive Performance

The integrated visualization demonstrates a clear, approximately linear inverse relationship between cognitive performance and functional mobility, with Timed Up and Go times declining from around 15–16 seconds at MoCA scores near 15–16 to approximately 10–11 seconds at MoCA scores of 27–29, reflecting an improvement in mobility of nearly 5 seconds across the cognitive spectrum. The smoothed trend line shows a steep decline in TUG time between MoCA values of 18 and 24, suggesting that even modest cognitive gains within this range are associated with clinically meaningful enhancements in mobility. The shaded confidence band indicates greater variability in TUG times at lower MoCA scores, where values frequently exceed 14 seconds, consistent with elevated fall and disability risk, whereas variability narrows above MoCA scores of 24, where most TUG values cluster below 12 seconds. The overlaid MoCA density distribution reveals that the highest concentration of participants lies between scores of 20 and 25, precisely where the TUG trend transitions from borderline to clearly normal functional ranges. Together, these patterns highlight that relatively small improvements in cognitive function in mildly impaired older adults are associated with disproportionately large and clinically significant gains in mobility and gait efficiency.

DISCUSSION

The findings of this study demonstrate a strong association between cognitive function and gait performance in older adults with mild neurological impairments, revealing that lower cognitive scores—particularly on the MoCA—were consistently linked with slower gait speed, longer TUG times, and greater stride variability. These results support a growing body of evidence highlighting the interdependence of cognitive and motor systems in aging populations, especially those with early neurological dysfunction (16). The strength of associations observed in this cohort, including correlations of $r = 0.58$ for gait speed and $r = –0.62$ for TUG performance, aligns with previous studies reporting that executive dysfunction, attentional deficits, and impaired processing speed contribute significantly to gait dysregulation and reduced mobility in older adults (17). The clear differentiation in gait outcomes between cognitively preserved and cognitively reduced individuals underscores the clinical relevance of even mild cognitive deficits in shaping functional mobility.

Comparative literature shows consistent support for these findings. Prior work in mild cognitive impairment populations has demonstrated gait speed reductions of 10–20% compared with cognitively healthy older adults, comparable to the 0.18 m/s difference observed in this study (18). Similarly, increased stride variability among cognitively impaired individuals has been linked to diminished executive control and impaired dual-task performance (19). Our results extend these observations by showing that these associations emerge even when neurological impairments are mild and ambulatory capacity is relatively preserved. However, unlike studies focused on Parkinson's disease, where motor symptoms may overshadow cognitive contributions to gait, the current study isolates cognition as a more prominent factor due to the mild neurological severity of the sample (20). This distinction suggests that cognitive–gait associations may be strongest in early-stage conditions before motor pathology dominates functional decline.

The mechanisms underlying these associations likely involve shared neural substrates within the prefrontal cortex, basal ganglia, and cerebellar networks responsible for executive control, attention, sensorimotor integration, and anticipatory postural adjustments (21). Cognitive decline may impair the ability to allocate attentional resources, switch tasks efficiently, or process environmental cues, leading to slowed gait initiation, reduced adaptability, and destabilized stepping patterns. The particularly strong association between executive function and stride variability observed in this study ($r = –0.49$) reinforces the hypothesis that gait stability relies heavily on higher-order cognitive processing, even in the absence of overt motor impairment. These findings also support theoretical models proposing that gait serves as a sensitive biomarker of early cognitive and neurological decline, with meaningful diagnostic implications (22).

Strengths of this study include the relatively large sample size of 130 participants, use of validated cognitive and gait assessment tools, and standardized procedures that enhance data reliability. The inclusion of multiple neurological subgroups provides a realistic representation of clinical populations encountered in outpatient geriatric and neurorehabilitation settings. Nonetheless, certain limitations merit consideration. The cross-sectional design prevents causal inference, and the single-center sample may limit generalizability to broader or more diverse populations. Although confounding was addressed analytically, residual confounders such as physical activity level, medication effects, and sensory impairments may influence the cognitive–gait relationship (23). Furthermore, wearable sensor–derived stride variability could not be complemented by more sophisticated gait laboratory markers, which may have provided additional mechanistic insight.

Future research should employ longitudinal designs to determine the temporal sequence of cognitive and gait decline and to identify which cognitive domains are strongest predictors of mobility loss. Intervention studies incorporating cognitive–motor training, executive function rehabilitation, and dual-task gait programs may further clarify whether improving cognition directly enhances gait performance. Additionally, incorporating neuroimaging, digital gait analytics, and machine-learning–based classification models may help refine early diagnostic markers and individualized rehabilitation pathways. Overall, the present findings underscore the critical interplay between cognitive health and gait performance in older adults with mild neurological impairments and highlight the importance of early screening and integrated cognitive–motor interventions in preventing future mobility disability and falls.

CONCLUSION

This study demonstrates a significant and clinically meaningful association between cognitive function and gait performance in older adults with mild neurological impairments, showing that reduced cognitive scores particularly in executive and global cognitive domains correspond to slower gait speed, longer Timed Up and Go times, and greater stride variability. Aligned with the study objective, these findings highlight that even mild cognitive decline can impair functional mobility and stability, emphasizing the need for early identification of cognitive motor interactions in this population. Clinically, the results support integrating cognitive screening into routine gait assessment and promoting interdisciplinary interventions that address both cognitive and motor deficits to reduce fall risk and preserve independence. From a research perspective, the study underscores the importance of longitudinal and interventional investigations to determine causal pathways and develop targeted cognitive–motor rehabilitation strategies capable of improving real-world mobility outcomes in older adults with early neurological changes.

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