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Gait Analysis Using Wearable Sensors in Patients With Alzheimer's Dementia: A Preliminary Report

Saenal Lee,[1] **Sung-Ho Woo**,[2] **Ki Chang Nam**,[3] **Changon Moon**,[4] **Kwangmo Lee**,[4] **Kwang Ki Kim**,[1,2] **Hang-Rai Kim**,[1,2,5] **Jeewon Suh**[1]

[1]Department of Neurology, Dongguk University Ilsan Hospital, Goyang, Korea
[2]Institute of Interdisciplinary Brain Science, Dongguk University College of Medicine, Goyang, Korea
[3]Department of Medical Engineering, Dongguk University College of Medicine, Goyang, Korea
[4]Smart Medical Device Co., Ltd., Goyang, Korea
[5]ROA Neurology Clinic, Seongnam, Korea

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Correspondence to
Hang-Rai Kim
Department of Neurology, Dongguk University Ilsan Hospital, 27 Dongguk-ro, Ilsandong-gu, Goyang 10326; ROA Neurology Clinic, 168 Seongnam-daero, Bundang-gu, Seongnam 13618, Korea.
Email: alwaysolleh26@gmail.com

Jeewon Suh
Department of Neurology, Dongguk University Ilsan Hospital, 27 Dongguk-ro, Ilsandong-gu, Goyang 10326, Korea.
Email: viest43@gmail.com

ORCID iDs
Saenal Lee
https://orcid.org/0009-0006-4591-0966
Sung-Ho Woo
https://orcid.org/0009-0001-8552-2021
Ki Chang Nam
https://orcid.org/0000-0002-0484-7845
Changon Moon
https://orcid.org/0009-0008-6294-3270

ABSTRACT

Background and Purpose: Gait dysfunctions have been frequently observed in patients with Alzheimer's disease (AD). Previous studies have used various methods to assess the gait impairment in AD. Here, we developed a wearable gait sensor, a Smart-insole, which is embedded in shoe insoles. We evaluated whether gait parameters measured using the Smart-insole were associated with cognitive performance in patients with AD.
Methods: Participants aged 45–90 years, who were either cognitively unimpaired (CU) or had Alzheimer's disease dementia (ADD) were recruited from a hospital-based outpatient clinic, between January and December 2023. Participants performed three gait tasks (walk straight and turn test, timed up and go test, and ramp and stair test) while wearing the Smart-insole. The association of gait parameters with individual's cognitive status (CU vs. ADD) and cognitive test scores (Mini-Mental State Examination [MMSE] and various domain-specific cognitive tests from the Seoul Neuropsychological Screening Battery, 2nd Edition) was assessed.
Results: Patients with ADD demonstrated decreased gait pace, rhythm, and stability as evidenced by longer task, cycle, and stance times, a higher number of steps, greater variability in swing time, and lower cadence during the gait task. Furthermore, gait parameters showed nominal associations with individual's MMSE score and each cognitive domain score (fronto-executive, memory, and language function).
Conclusions: Smart-insole wearable sensors showed exploratory gait-related alterations in patients with ADD. These hypothesis-generating findings suggest that wearable insole-based gait assessment may provide complementary information for characterizing gait and cognitive dysfunction in ADD.

Keywords: Alzheimer Disease; Gait; Wearable Electronic Devices; Cognition

INTRODUCTION

Alzheimer's disease (AD) is the most common cause of dementia and is characterized by progressive cognitive impairment.[1] However, the concomitant balance and gait dysfunction has been recognized for many years.[2-4] Falls are the primary cause of both fatal and nonfatal injuries in individuals aged 65 and older[5] and especially those with AD.[6]

Kwangmo Lee
https://orcid.org/0009-0002-4198-5830
Kwang Ki Kim
https://orcid.org/0000-0001-5505-1540
Hang-Rai Kim
https://orcid.org/0000-0003-4197-4541
Jeewon Suh
https://orcid.org/0000-0003-3509-6447

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Conflict of Interest

Authors Changon Moon and Kwangmo Lee are affiliated with Smart Medical Device Co., Ltd., which developed the Smart-insole device used in this study. The remaining authors declare no potential conflicts of interest.

Author Contributions

Conceptualization: Lee SN, Nam KC, Moon C, Lee K, Kim KK, Kim HR, Suh J; Data curation: Lee SN, Kim HR, Suh J; Formal analysis: Lee SN, Woo SH, Kim HR, Suh J; Investigation: Lee SN, Kim KK, Kim HR, Suh J; Methodology: Lee SN, Nam KC, Moon C, Lee K, Kim KK, Kim HR, Suh J; Software: Woo SH, Nam KC, Moon C, Lee K, Kim HR, Suh J; Validation: Lee SN, Nam KC, Kim KK, Kim HR, Suh J; Writing - original draft: Lee SN, Kim KK, Kim HR, Suh J; Writing - review & editing: Lee SN, Woo SH, Nam KC, Moon C, Lee K, Kim KK, Kim HR, Suh J.

Previous studies have employed various methods to assess the gait deficits in patients with AD. These include measurements of gait time or speed while walking on a walkway with a chronometer[2] or an embedded gait sensor,[7] walking with wireless sensors attached to the body,[4,8] and walking during video-based gait analyses.[9,10] The results indicated that patients with AD tend to have decreased gait velocity,[2,8] increased gait variability,[7] or both.[11]

Wearable gait sensors have an advantage over other methods of gait analysis as they can be easily utilized to measure gait performance in real-life environments. A previous study developed wearable shoe devices with sensors attached under the shoe heel and used them to measure gait changes in patients with cognitive impairment.[12]

The present study used the Smart-insole, a recently developed wearable gait sensor embedded in shoe insoles. Previous studies have explored smart insole systems and wearable gait sensors in individuals with cognitive impairment and dementia.[13,14] However, some of these studies primarily focused on feasibility assessment or machine learning—based classification approaches. In contrast, this study evaluated associations between clinically interpretable gait parameters measured using a Smart-insole and cognitive performance across multiple gait tasks in patients with clinically diagnosed Alzheimer's disease dementia (ADD).

METHODS

Participants

Data were collected from the outpatient clinic of the Dongguk University Ilsan Hospital, Goyang, Republic of Korea. Participants aged 45–90 years, who were either cognitively unimpaired (CU) or had ADD were recruited between January and December 2023. The CU group was defined as clinically normal adults without evidence of cognitive impairment based on clinical assessment by two neurologists, including absence of subjective memory concerns, normal neurological examination findings, and a Clinical Dementia Rating (CDR) global score of 0. They were recruited from among the siblings or other family relatives of patients seen in the outpatient clinic. Participants with ADD met the criteria for the clinical diagnosis of AD as outlined by the National Institute of Neurological and Communicative Disorders Association.[15] Participants with ADD completed the Mini-Mental State Examination (MMSE) and were rated using the CDR. A subset of participants (n=20) completed the Seoul Neuropsychological Screening Battery, 2nd Edition (SNSB-II), a detailed neuropsychological test assessing attention, language, visuospatial, memory, and fronto-executive functions.[16] Four domain-specific tests were used: fronto-executive function (Controlled Oral Word Association Test, Korean–Color Word Stroop Test, and Korean-Trail Making Test B), visuospatial function (Rey Complex Figure Copy), language (Korean-Boston Naming Test), and memory (Seoul Verbal Learning Test, delayed recall). The scores were converted to z-scores based on norms corresponding to the participant's age and education. The fronto-executive function was assessed using a composite score, which is the average of the score of three domain-specific tests. Participants were excluded if they had psychiatric disorders affecting cognition, a history of brain surgery or traumatic brain injury, recent stroke within 3 months, severe musculoskeletal disorders impairing independent ambulation, or other conditions judged by the investigators to interfere with study participation.

The participants also underwent laboratory tests, including complete blood count, blood chemistry assessment, vitamin B12 and folate evaluation, syphilis serological assessment, and thyroid function tests. Brain magnetic resonance imaging (MRI) confirmed the absence of structural lesions, including territorial cerebral infarction, brain tumors, hippocampal sclerosis, and vascular malformations.

Gait tasks

Gait parameters were collected from the Smart-insole device while participants were instructed to perform the following tasks.

Walk straight and turn test (WST)

In the WST test, the participants were instructed to walk along a straight route for 4 m, starting from an upright position (standing) (**Fig. 1A**). Participants were instructed to walk at a self-selected speed. The start and end points of the route were marked on the floor for recording. The test was repeated three times, and the averaged data were used in subsequent analyses.

Timed up and go test (TUG)

In the TUG test, participants were instructed to rise from a chair and immediately start walking along a straight path for 3 m. At the end of the 3 m route, they made a 180° turn and returned to the sitting position (**Fig. 1B**). The TUG test was conducted according to the protocol established in a previous study.[17] The test was repeated three times, and the averaged data were used in subsequent analyses.

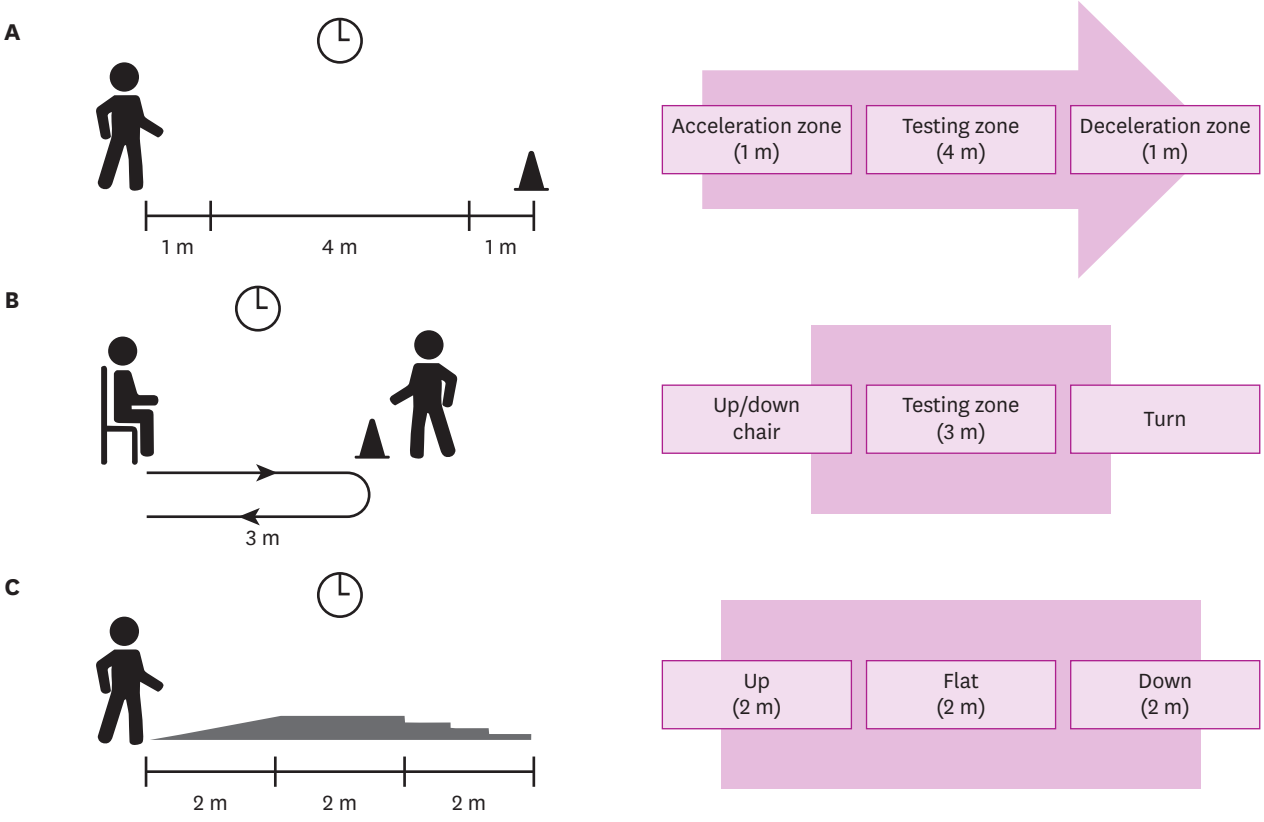

Fig. 1. Gait task protocols.
Description of (A) walking straight test, (B) timed up and go test, and (C) ramp and stair test.

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Ramp and stair test

In the ramp and stairs test, participants were instructed to ascend a ramp, that was 0.2 m in height, walk on a flat surface for 2 m, and descend a set of stairs (**Fig. 1C**). The test was repeated three times, and the averaged data were used in subsequent analyses.

Smart-insole

A wearable gait sensor, the Smart-insole were developed to stably acquire gait-related motion signals during walking. The sensor consisted of a microcontroller (AT32F403A, Artery Technology, Hsinchu, Taiwan), a 9-axis sensor (BMS160, BOSCH, Baden-Württemberg, Germany), Global Positioning System (GPS) tracker, Long-Term Evolution (LTE) modem (SIM7000E, SIMCom, Shanghai, China), and a rechargeable battery (**Fig. 2A**). The main board, which can be easily inserted into shoes, was installed at the bottom of the insole. The sensor provided acceleration, gyroscopic, and geomagnetic measurements in all spatial directions. Gait events were identified based on heel-strike and toe-off detection. To improve signal stability, filtering algorithms were applied during preprocessing, and sensor operation was optimized to minimize noise. These procedures enabled the calculation of gait parameters, including stance time, swing time, cycle time, cadence, and number of steps. Integrating an LTE modem and GPS tracker into a Smart-insole enhances the functionality of the device by enabling real-time data transmission and location tracking. In this study, we did not utilize GPS trackers because they were outside the scope of this study. During the development phase of the Smart-insole, a preliminary concurrent comparison was conducted in a small sample of CU adults (n=20), in which cycle time derived from the smart insole demonstrated moderate-to-strong correlations with measurements obtained from an established gait analysis system (GAITRite) (**Supplementary Fig. 1**).[18]

Data acquisition

The Smart-insole was placed in the shoe of the participant's dominant (right) foot, while a dummy insole was placed in the shoe of the opposite (left) foot. The Smart-insole

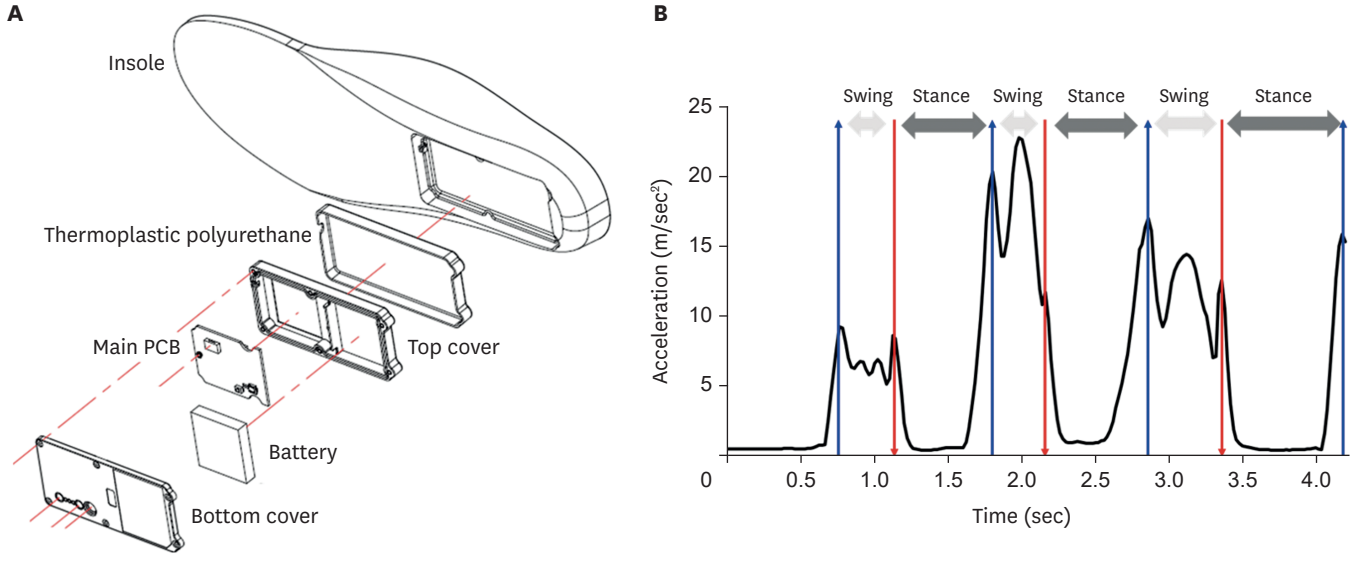

Fig. 2. Smart-insole device and gait parameter extraction.
(A) Compositions of Smart-insole. (B) Gait parameters measurement from Smart-insole. Acceleration peaks are detected at the toe (blue arrow) and heel strike (red arrow).
PCB: printed circuit board.

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transmitted data to the server via an LTE communication network at a sampling frequency of 50 Hz, and the client computer received and stored the data for real-time gait analysis.

Gait parameters calculation

In this study, acceleration and gyroscope sensor measurements from the 9-axis sensors were utilized to calculate the gait parameters. After preprocessing with low-pass filtering, the acceleration was calculated from the gyroscopic measurements of each axis. Subsequently, the net acceleration was calculated as the square root of the sum of the squares of the acceleration values for each axis. A peak detector was used to distinguish the swing and stance phases. Two peaks were observed at the toe-off (blue arrow in **Fig. 2B**) and heel strike (red arrow in **Fig. 2B**) during each gait cycle.

After defining the swing and stance phases of the foot, the following five gait parameters were calculated. (1) Task time (seconds) is described as the total time spent on a task. (2) Swing time (seconds), described as the time from when the right foot leaves the floor until it returns to the ground. (3) The stance time (seconds) is described as the duration during which the right foot remains in contact with the floor. (4) The cycle time (seconds) is described as the sum of the swing and stance times. (5) Cadence describes the number of steps per unit of time.

For each gait task, the average and standard deviation (SD) values of the swing, stance, and cycle time were measured. We calculated SD values to measure the variability of each parameter. Thus, for each gait task, nine gait parameters (task time, number of steps, cadence, average, and SD of each swing, stance, and cycle time) were measured, resulting in a total of 27 gait parameters (3×9) being analyzed in this study.

The study protocol was approved by the Institutional Review Board of Dongguk University Ilsan Hospital (approval No.2023-07-02), and informed consent was obtained from each participant in accordance with the guidelines outlined in the Declaration of Helsinki.

Statistical analysis

The baseline demographic characteristics of the patients with ADD and CU individuals were compared using an independent *t*-test for continuous variables and the χ^2 test for categorical variables.

To evaluate whether gait parameters, measured by the Smart-insole differ between patients with ADD and CU individuals, we conducted the following logistic regression analysis expressed as: ADD = β_0 + β_1 age + β_2 sex + β_3 education year + β_4 body mass index (BMI) + β_5 leg length + β_6 gait parameter. Furthermore, to test the clinical utility of the gait parameters, we developed multivariate logistic models to distinguish patients with ADD from with CU individuals. We performed receiver operating characteristic curve analysis and measured the area under the receiver operating characteristic curve (AUC). To evaluate the association between gait parameters and cognitive performance, we conducted the following linear regression analysis expressed as cognitive score = β_0 + β_1 age + β_2 sex + β_3 education year + β_4 BMI + β_5 leg length + β_6 gait parameter. Given the exploratory nature of this preliminary study and the large number of gait parameters analyzed, the statistical analyses were intended to explore potential associations between gait parameters and cognitive measures. As the MMSE and SNSB were performed only on a subset of participants, this analysis was also restricted to these specific groups. Uncorrected *p*-values are presented in the main analyses,

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and the results should be interpreted cautiously. As sensitivity analyses, multiple-comparison adjustment was performed using the Benjamini–Hochberg false discovery rate (FDR). FDR corrections were performed independently for the 9 parameters within each specific gait task and outcome model.

MATLAB (MathWorks R2020a, Natick, MA, USA) and SPSS 21 (IBM Corp., Armonk, NY, USA) were used for statistical analyses and visualization of the results.

RESULTS

Table 1 displays the demographic characteristics of the study participants. Patients with ADD were older than CU individuals. Additionally, most patients with ADD had a CDR of 0.5 or 1 (mild dementia).

Association between gait parameters and cognitive status

Differences in gait parameter profiles between CU individuals and patients with ADD across all three gait tasks are presented in **Supplementary Table 1**. Among the various gait parameters, six during the ramp and stairs test showed nominal associations with ADD diagnosis in the covariate-adjusted logistic regression analyses (**Table 2**, **Fig. 3A**). **Table 2** presents the results of covariate-adjusted logistic regression analyses performed in the total cohort (CU, n=50; ADD, n=50). The results demonstrated that patients with

Table 1. Participants demographics

Variables	CU (n=50)	ADD (n=50)	*p*-value*
Age (yr)	72.60±3.30	76.33±5.24	<0.001
Sex, female	36 (72.00)	31 (62.00)	0.395
Education (yr)	11.25±4.06	9.38±5.11	0.054
Leg length	80.20±6.02	80.92±6.05	0.552
Body mass index	24.09±2.60	22.98±2.83	0.045
MMSE	NA	22.62±3.97	
CDR			<0.001
0	50	0	
0.5	0	28	
1	0	21	
2	0	1	

Values are presented as number (%) or mean ± standard deviation.
CU: cognitively unimpaired, ADD: Alzheimer's disease dementia, MMSE: Mini-Mental State Examination; NA: not applicable, CDR: Clinical Dementia Rating Scale.
*Statistical values were calculated using independent *t*-tests for continuous variables and χ^2 tests for categorical variables.

Table 2. Association between gait parameters and ADD diagnosis

Variables	Odds ratio (95% CI)	*p*-value*
Ramp and stair test		
Cadence	0.881 (0.804–0.980)	0.018
Task time	1.112 (1.016–1.218)	0.021
Cycle time (mean)	3.354 (1.157–9.722)	0.025
Stance time (mean)	4.686 (1.078–20.372)	0.039
Swing time, SD (sec)	4.662 (1.023–21.237)	0.046
No. of steps	1.238 (1.000–1.532)	0.049

Table 2 presents the results of covariate-adjusted logistic regression analyses performed in the total cohort (cognitively unimpaired, n=50; ADD, n=50).
ADD: Alzheimer's disease dementia, CI: confidence interval, SD: standard deviation.
*Statistical values were calculated using logistic regression analysis expressed as ADD = β0 + β1 age + β2 sex + β3 education year + β4 body mass index + β5 leg length + β6 gait parameter.

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ADD tended to exhibit longer task, cycle, and stance times, a higher number of steps, greater variability in swing time, and lower cadence than those observed in CU individuals.

Using six significant gait parameters that showed association with ADD in the covariate-adjusted logistic regression analyses of the total cohort, we attempted to distinguish patients with ADD from CU individuals in an age-matched subset. Given the significant age distribution differences between the groups, we first balanced age distributions through 1:1 nearest-neighbor matching without replacement, using age as the matching variable and applying an absolute caliper of ±1.5 years. The restricted dataset comprised 25 patients with ADD and 25 CU individuals, with no significant differences between the groups in age (p=0.698), years

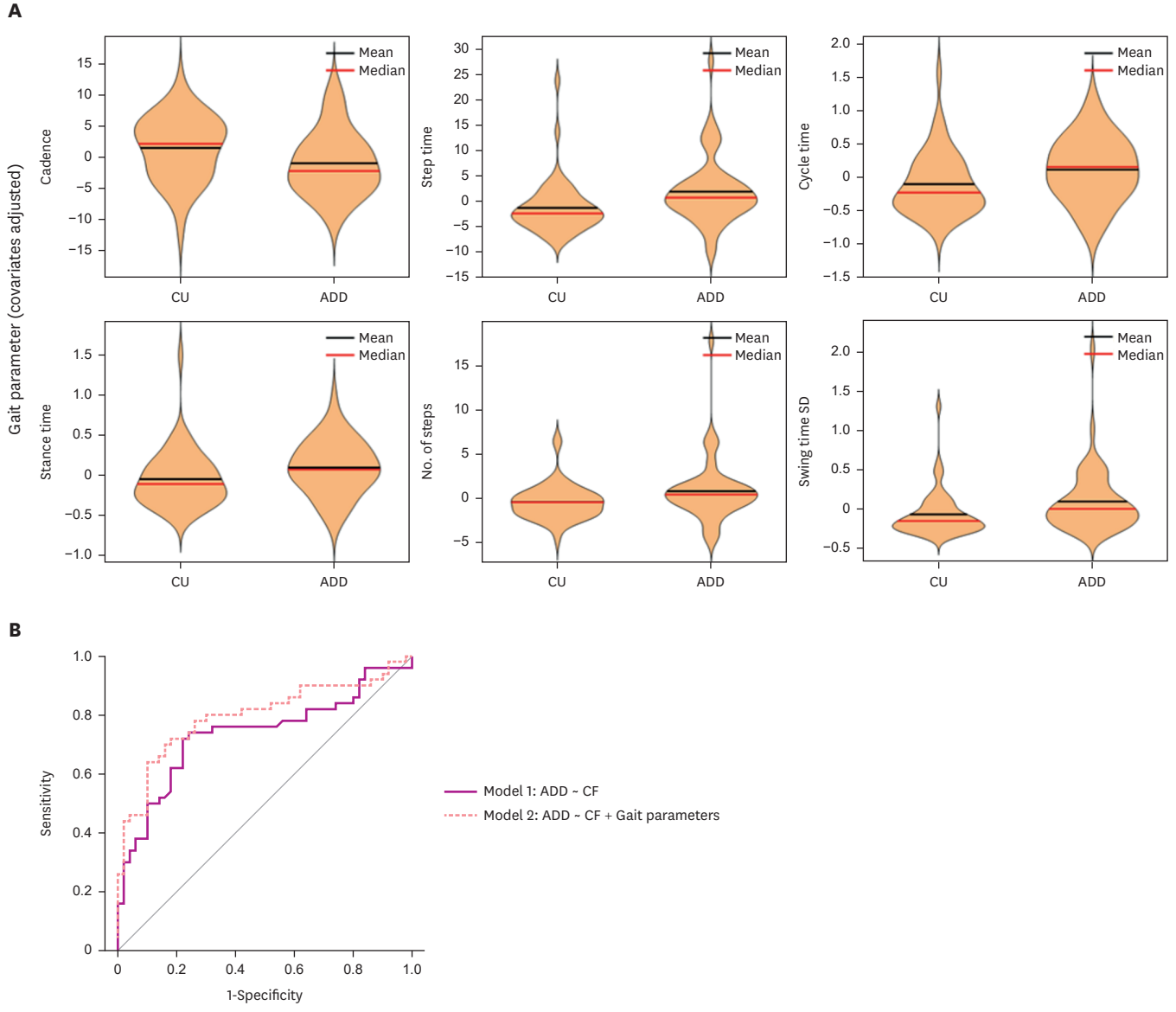

Fig. 3. Gait differences between cognitively unimpaired individuals and patients with Alzheimer's disease dementia.
(A) Violin plot displaying gait parameters during ramp and stair test between CU individuals and patients with ADD. (B) ROC curve for ADD classification. ROC curves were generated in the age-matched subset (CU, n=25; ADD, n=25) using the model developed from logistic regression analyses. Model: ADD diagnosis ~ clinical factors (sex, age, education and leg length) and gait parameters.
CU: cognitively unimpaired, ADD: Alzheimer's disease dementia, ROC curve: receiver operating characteristic curve, CF, Clinical factors, SD: standard deviation.

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of education (p=0.498), or BMI (p=0.689). In this dataset, the logistic model, incorporating the 6 gait parameters, achieved an AUC of 0.722 (95% confidence interval [CI], 0.579–0.864) (**Fig. 3B**). In contrast, gait parameters derived from the WST test and the TUG test did not show significant associations with ADD diagnosis after covariate-adjustment.

Association between gait parameters and cognitive scores

Analyses of cognitive scores were restricted to ADD participants with available MMSE (n=50) or SNSB data (n=20). Among the various gait parameters, two parameters of the WST, task time and number of steps, showed nominal associations with the MMSE score. The results demonstrated that among patients with ADD, a high number of steps and prolonged task time during the WST were associated with reduced MMSE scores (**Fig. 4A**).

We further evaluated the association between the gait parameters and each cognitive domain score for a subset of participants. First, we compared patients with ADD who underwent SNSB with those who did not. We observed that those who underwent the SNSB had a high level of education (**Supplementary Table 2**). Among the various cognitive scores, the fronto-executive function and memory scores were associated with the highest number of gait parameters while the visuospatial function scores were not associated with any of the gait parameters (**Fig. 4B**, **Table 3**).

Although the majority of nominal associations did not remain significant after FDR correction, two gait parameters(task time and number of steps) in the WST retained their significance with fronto-executive function after correction within each gait task. These findings suggest potential task-specific gait–cognition associations, though they should be interpreted cautiously and require validation in larger cohorts. The FDR-adjusted p-values are provided in **Supplementary Table 3**.

Table 3. Association between gait parameters and cognitive function

Variables	T-value (p-value)*			
	MMSE (n=50)	Fronto-executive function (n=20)	Memory function (n=20)	Language function (n=20)
WST				
Task time	−2.327 (0.024)	−3.923 (0.001)		−2.925 (0.011)
No. of steps	−2.739 (0.008)	−3.425 (0.004)		−2.744 (0.016)
Cycle time, mean			−2.337 (0.036)	
Cycle time, SD				
Stance time, mean		−2.255 (0.041)		
Stance time, SD				
Cadence			2.303 (0.038)	
Swing time, SD			-	−2.185 (0.047)
TUG				
Task time		−2.235 (0.043)		
Cycle time, SD				
Cadence			2.638 (0.020)	
Cycle time, mean			−2.226 (0.044)	

Analyses were restricted to participants with Alzheimer's disease dementia who had available cognitive data. MMSE analyses included 50 participants, whereas analyses of cognitive domains included 20 participants.
MMSE: Mini-Mental State Examination, WST: walk straight and turn test, SD: standard deviation, TUG: timed up and go test.
*Statistical values were calculated using linear regression analysis expressed as: cognitive score = $\beta_0 + \beta_1$ age + β_2 sex + β_3 education year + β_4 BMI + β_5 leg length + β_6 gait parameter.

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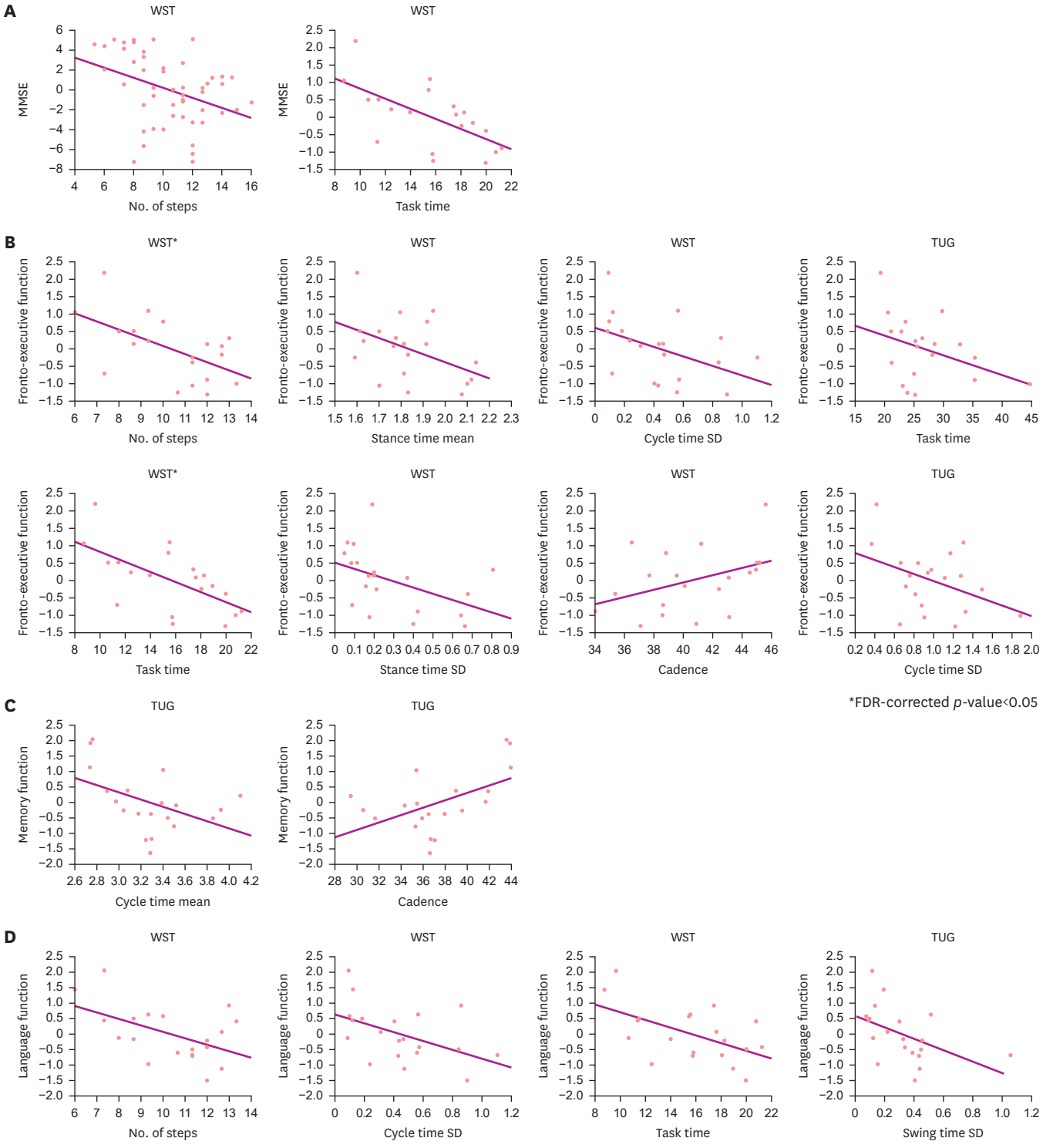

Fig. 4. Associations of gait parameters with cognitive performance.
Scatter plot of gait parameter and (A) MMSE, (B) fronto-executive function, (C) memory function, and (D) language function score.
MMSE: Mini-Mental State Examination, WST: walk straight and turn, SD: standard deviation, TUG: timed up-and-go, FDR: false discovery rate.

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DISCUSSION

In this study, we measured individual's gait parameters using the wearable sensor, the Smart-insole, and examined their association with cognitive performance. Our findings suggest that several Smart-insole derived gait parameters differ between patients with ADD and CU individuals. Importantly, these associations were observed in logistic regression analyses adjusted for age, sex, education years, BMI, and leg length.

Compared with CU individuals, patients with ADD demonstrated longer task, cycle, and stance times during the ramp and stair tests These findings suggest that the increased task time was attributed to increased cycle time, and increased cycle time was in turn caused by increased stance time. Furthermore, patients with ADD demonstrated a higher number of steps and lower cadence during the ramp and stair tests. As the path length of each task was constant, the increase in the number of steps indicated that patients with ADD had shorter step lengths compared to those in CU individuals. In addition, patients with ADD took longer between each step, as evidenced by the decreased cadence during the test.

We also observed association between gait parameters and cognitive performance. Specifically, poorer global cognition (MMSE score) was associated with longer task time and a greater number of steps during the WST. Furthermore, increased stance and task times, as well as the number of steps in the WST; and increased task time in the TUG were associated with lower fronto-executive function. In addition, increased cycle time and decreased cadence observed in the WST and TUG test were associated with decreased memory function, while the increased task time, increased SD of the swing time and number of steps on the WST were associated with decreased language function.

Previous studies have demonstrated that gait parameters, such as stance time and cadence, reflect gait rhythm and task time, meanwhile, the number of steps reflects the gait pace.[19] Based on previous findings, our results suggest that decreased gait pace and rhythm may be associated with ADD diagnosis and decreased cognitive performance in patients with ADD. Our results are consistent with those of previous studies that have demonstrated a reduced pace[20] and rhythm[21,22] in patients with AD compared to those in controls. Across the different gait tasks, gait parameters reflecting reduced gait pace and rhythm, including prolonged task and cycle times and reduced cadence, showed generally consistent associations with ADD diagnosis and cognitive impairment.

In addition to gait pace and rhythm, we observed an increased SD of the swing time in patients with ADD. Furthermore, in patients with ADD, increased SD of the cycle time in the WST test was associated with a decline in language function. Moreover, SD values reflect gait variability, which is a component of gait stability.[19] Our results on gait variability performance in AD aligned with those of previous studies,[7,23] which demonstrated higher gait variability in patients with AD than that in controls.

By leveraging gait parameters, we demonstrated that the model showed modest exploratory discriminatory performance between patients with ADD and CU individuals with an AUC of 0.722 (95% CI, 0.579–0.864). These findings suggest that gait parameters derived from the Smart-insole assessment may be associated with cognitive dysfunction in ADD, supporting the potential feasibility of wearable gait assessment in this population. However, further validation in larger independent cohorts is required.

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Interestingly, among the various cognitive scores, the fronto-executive function and memory scores were associated with the highest number of gait parameters. Previous research has suggested that reduced executive function and memory performance are associated with slow gait velocity.[2] Furthermore, decreased pace and increased gait variability are associated with frontal lobe atrophy, areas that mediate attention, and fronto-executive function.[24,25] Thus, our findings are consistent with those of previous studies.

Importantly, this study assessed three gait tasks (WST, TUG, and ramp-and-stair tests) designed to emulate daily ambulation. No single task consistently outperformed the others in detecting associations, although some associations were observed across all tasks. This pattern suggests that, in performance-based testing environments, gait changes may be difficult to detect with high sensitivity, as no specific task confers a clear detection advantage. Therefore, gait changes may be more sensitively detected in free-living environments. Indeed, a previous study continuously measured gait in a free-living community setting and sensitively observed gait changes in patients with ADD.[26] Wearable sensors have advantages over other methods for measuring gait changes in free-living environments.

In this context, although formal device validation was not the primary aim of this study, the present findings suggest that gait parameters measured using the smart insole may capture gait characteristics that are clinically interpretable in relation to cognitive impairment. The gait parameters analyzed in this study are commonly used measures reflecting gait pace, rhythm, and variability. In our analyses, these parameters differed between CU individuals and patients with ADD and were associated with cognitive performance. In addition, the direction of gait changes and their associations with cognitive impairment were similar to those reported in previous studies of AD. Taken together, these findings support the potential feasibility of using Smart-insole–derived gait parameters in future studies, while further validation is required before clinical application.

This study has several limitations. First, this was an exploratory preliminary study involving multiple gait parameters and cognitive outcomes. Although several nominal associations were observed in the primary analyses and the direction of gait changes observed in our study was similar to that reported in previous studies, the majority of the associations did not remain statistically significant after FDR correction for multiple comparisons. Therefore, the findings should be interpreted cautiously as hypothesis-generating and require validation in larger prospective cohorts. Second, the diagnosis of AD in our study was based on MRI findings, clinical symptoms, and cognitive tests. The majority of patients did not undergo positron emission tomography (PET) imaging or cerebrospinal fluid assays to confirm a definite diagnosis (two patients underwent amyloid PET and displayed positive amyloid-beta deposition). Third, standardized cognitive screening scores, such as the MMSE, were not available for all CU participants. Future studies should include standardized cognitive assessments across all participant groups to strengthen cognitive classification and clarify gait–cognition associations. Fourth, although the Smart-insole was compared with the GAITRite system in a small sample of healthy adults, this comparison does not establish full validation of spatiotemporal gait accuracy in patients with ADD. Further validation studies in cognitively impaired and diseased populations are needed. Fifth, upper-limb movements were not assessed by gait analysis.

In conclusion, gait parameters measured using the Smart-insole were associated with cognitive impairment in patients with ADD. These exploratory findings suggest that Smart-

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insole-based gait assessment may provide complementary information related to gait and cognitive dysfunction in ADD. Further validation in larger independent cohorts is required.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1

Comparison of gait parameters between CU individuals and patients with ADD across all gait tasks

Supplementary Table 2

Comparison of demographics based on the presence or absence of SNSB data

Supplementary Table 3

FDR-adjusted *p*-values for nominally significant findings in the primary analyses

Supplementary Fig. 1

Comparison of cycle time measured by the Smart-insole and GAITRite. Scatter plots show the relationship between cycle time derived from the Smart-insole and that measured using GAITRite in cognitively unimpaired adults (n=20).

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