Research Report

Simple Mobility Tests Predict Use of Assistive Devices in Older Adults

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ABSTRACT

Background: Assistive devices (ADs) for ambulation are commonly provided to improve safety and independence in older adults. Despite the common use of these devices, there are no standard prescribing guidelines, and non–health care providers, including caregivers and family members, often make decisions about the need for ADs. Identifying factors or a single screening test associated with AD use would benefit clinicians and non–health care caregivers in making decisions to adopt an AD for patients, clients, and family members.
Purpose/Objectives: The purpose of this cross-sectional study was to identify the test that best predicts ADs for ambulation and non-AD use among community-dwelling individuals.
Methods: Eighty-five older adults (81.6 ± 8.2 years old) who underwent outpatient physical therapy participated in this study. They participated in a series of tests, including the Timed Up and Go, handgrip and quadriceps strength, the 30-second chair-rise test, the 5-m fast gait speed, the Functional Independence Measure, the locomotive syndrome tests (stand-up test, 2-step test [2ST], and the Locomo-5 Checklist), and numeric pain scales. Mann-Whitney *U* tests were used to identify differences between those who did and did not use an AD for ambulation. Logistic regression analyses were used to examine which test best predicted AD use.
Results: 80% of participants (n = 68) used an AD for ambulation. There were significant differences in all test variables between users and nonusers ($P = .033$ to $P < .001$), except for quadriceps strength, age, and pain (all $P > .05$). Only the 2ST was a significant predictor of AD use, with a cutoff distance of the toe-to-toe stride shorter than 93% of body height (sensitivity: 72%, and specificity: 82%, $P = .048$).
Discussion: Simple functional measures differed between those who did and did not use ADs for ambulation; however, only the 2ST predicted AD status. Individuals who cannot step 93% of their body height may be appropriate for an AD.
Conclusions: If comprehensive clinical evaluations are not available to make decisions about AD use, the 2ST can be used to make clinical recommendations for an AD for ambulation.
Key words: ambulance, assistive devices, community-dwelling, locomotive syndrome, older adults

(*J Geriatr Phys Ther* 2024;47(4):175-182.)

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This study was supported by MHLW Grant Number 19FA1017 (Project Director: Etsuo Chosa. Sub-recipient: Dr. Muranaga).

The authors declare no conflicts of interest.

Supplemental digital contents are available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.jgptonline.com)

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DOI: 10.1519/JPT.0000000000000413

CLINICAL IMPLICATIONS

- Assistive devices (ADs) for ambulation are often prescribed without a comprehensive physical therapy evaluation.
- The 2-step test is a simple screening test that adequately identifies the individuals who use ADs for ambulation and was found to predict ADs for ambulatory status with a clinical cutoff of 93% of the body height (sensitivity: 72%, and specificity: 82%).
- The 2-step test may be useful to identify individuals who are similar to older adults who use an AD for ambulation, especially for those testing who may have limited examination space or expertise.

INTRODUCTION

Physical disability is a global issue, affecting approximately 15% of the world's population.[1] People with physical disabilities commonly use assistive devices (ADs) for ambulation, which can improve basic mobility and quality of life.[2-7] Nearly 80% of people with disabilities use an AD for ambulation, and this proportion has doubled in the last decade.[8] Although the need for ADs is increasing, non–health care individuals, such as caregivers or family members, often make decisions about AD use based on patient preference and socioeconomic factors.[3] This can have negative consequences; those who use a device when it is not necessary may impede other motor tasks, and those who do not use one when it is necessary may be at a greater risk of falling or functional impairments.[2,9]

Physical therapists (PTs) often prescribe ADs for older adult patients as part of a plan of care. The decision to use an AD for ambulation is made after a comprehensive evaluation that often includes an assessment of intrinsic factors (muscle strength, balance ability, and cognitive levels), extrinsic factors (home and community environment), and psychological factors (resistance to AD usage). This evaluation requires clinical experience, training, and the space and resources of a typical clinic environment.[6] Yet, the first decision on using ADs for ambulation often occurs without a comprehensive evaluation by PTs. With a simple test that can be used with training, paraprofessionals and family members can make appropriate AD recommendations for ambulation when needed or provide health care providers with a more concise method for making decisions when there is limited time, resources, or access to in-person evaluations.

While many tests can be used to screen for functional ability, locomotive syndrome (LS) tests have been recently developed to detect subtle age-related mobility decline in older adults. This diagnostic procedure is simple and easy to use even in community settings.[10-15] The LS diagnosis includes 3 stages of functional limitations: 1) no limitation, 2) minimal decline in physical function, and 3) substantial limitation in physical function that requires the intervention of a health care professional.[11] The LS tests include 2 performance-based outcome measures (stand-up test [SUT] and 2-step test [2ST]) and 1 self-report questionnaire to assess physical function (Locomo-5 Checklist [Loco-5]). Each test is evaluated with a numeric score. The lowest score among these 3 tests will determine the individual's LS stage. Severe LS stages are significantly associated with mobility decline, poor balance, muscle weakness, and perceived physical functional limitations,[10-15] and can also differentiate between independent community dwellers and assistant care beneficiaries.[16] Therefore, LS tests may also have value in identifying patients who require ADs for ambulation. In Japan, LS tests are often performed by nonclinical administrators in senior centers, shopping malls, and other social settings.

Identifying validated methods of providing appropriate care in the absence of in-person evaluations has become more important with the expansion of telehealth[17] and continued barriers many patients face receiving in-person health care.[18] Therefore, the objective of this study was to determine whether physical examination tests can differentiate and predict those who currently do and do not use ADs for ambulation in community-dwelling older adults. We hypothesized that performance-based LS tests would predict AD use.[3]

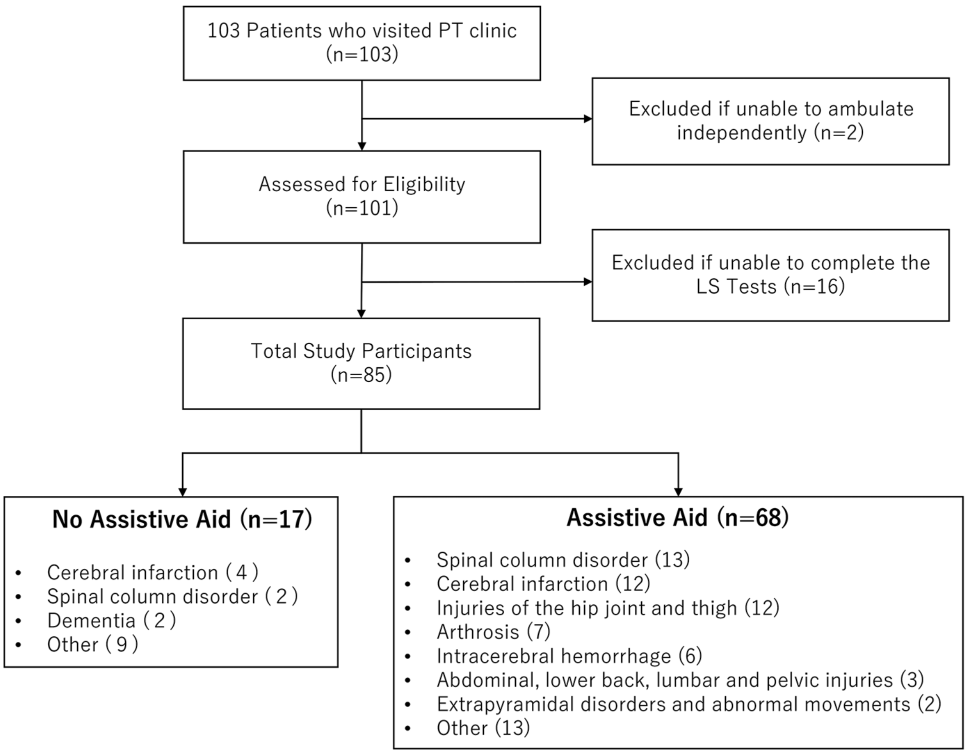


Figure 1. Flow diagram of the study design and finalization of the study size. LS, indicates locomotive syndrome; PT, physical therapist. This figure is available in color online (www.jgeript.org).

METHODS

Participants

This cross-sectional study was conducted with independent community-dwelling older adults in Japan who participated in a structured rehabilitation program. Eighty-five individuals participated in this study (women: n = 54, age: 81.6 ± 8.2 years; Figure 1). Inclusion criteria included independent community dwellers 65 years and older currently undergoing outpatient geriatric rehabilitation sessions supported by governmental community care benefits in Japan.[19,20] This community-based care provides social and physical activities for older adult communities to prevent age-related disability. They may receive preventive care through physical or social activities or require therapeutic interventions in an outpatient setting due to medical conditions (eg, osteoarthritis).[21] Exclusion criteria for this study included the inability to ambulate independently at home (without the physical assistance of another individual) or those with cognitive impairments defined as a Mini-Mental State Examination score below 21.[22]

After confirming their understanding of the study's purpose and testing procedures, all participants provided written informed consent approved by the Institutional Review Board at the hospital (#17-037-171129). Research PTs collected data during the tri-monthly physical therapy evaluations between November 2017 and February 2018. Research PTs performed chart reviews to examine whether participants used any AD for ambulation and classified participants into 2 groups (ie, non-AD for ambulation and AD for ambulation). Additional participant information, including age, sex, anthropometric data (ie, body height and weight), level of care required, pain, balance, muscle strength, physical function, and LS testing were extracted from medical records.

Pain Assessments

Pain in the lower extremities during exercise was assessed using the Numerical Rating Scale, an 11-point pain score rating, with 0 being no pain and 10 being the worst pain imaginable.[23] This test has excellent reliability (r = 0.95-0.96).[24]

Balance Assessments

The Timed Up and Go (TUG) test was used to evaluate balance and mobility.[25] This test has high test-retest reliability (intraclass correlation coefficient [ICC]: r = 0.97-0.99) and is commonly used to screen individuals who are at risk of falling in the clinical setting.[25,26] Participants were asked to stand up from a 40-cm chair with armrests, walk a 3-m pathway at a self-selected speed, turn around, and return to the chair. The TUG test was performed twice, and the 2 trials were averaged for analysis.

Muscle Strength Assessments

Handgrip strength, quadriceps strength, and the 30-second chair-rise test (30sCRT) were assessed for overall muscle strength for the upper and lower limbs.

Handgrip strength

Participants were asked to hold a Digital Smedley Hand Dynamometers (T.K.K.5401, Takei Scientific Instruments Co, Japan). The tested arm was positioned parallel to the trunk in a seated position. The grip width was adjusted based on the patient's hand size, with the second proximal interphalangeal joint flexed at 90°. Two maximum contractions were captured for both hands, and the maximum value of the 4 trials was used for the analysis. Measurement of handgrip strength has been validated and is often used to assess the overall muscle strength in older individuals.[27] This test has high test-retest reliability (ICC: r >0.8).[27]

Quadriceps strength measured as the Weight Bearing Index

Quadriceps strength during maximum voluntary isometric contraction was assessed using a hand-held dynamometer (μTas F-1, Anima Inc, Tokyo, Japan). Participants were asked to sit on a chair with the hip and knee flexed to 90° (see Supplemental Digital Content 1, available at: http://links.lww.com/JGPT/A182). Participants were encouraged to extend with the maximal force for 5 seconds. One trial for each limb was captured. Quadriceps torque was calculated by the captured force (N) multiplied by the distance between the medial knee joint space and the point of the force application. We calculated the Weight Bearing Index (WBI) by normalizing the average torque of the quadriceps in each limb by the individual's body weight. The WBI has been validated and has been used in clinical decision-making.[28] This procedure has excellent reliability (ICC: r = 0.99).[29]

30-second chair-rise test

The 30sCRT was used to evaluate muscle strength[30] and overall power[31] in the lower extremities. Participants were asked to sit on a 40-cm highchair with their arms crossed in front of their chest. They were then instructed to repeatedly rise out of the chair as fast as possible for 30 seconds. This test was performed once. This test has excellent reliability (r = 0.84-0.92).[30]

Physical Functional Assessments

Gait speed and independent functional measures were assessed to determine physical function.

5-m fast gait speed

The 5-m fast gait speed (GS) was measured. Participants were asked to walk as fast as possible through an 11-m hallway. The first and last 3 m were excluded to eliminate the effects of acceleration and deceleration. The time to pass through the middle 5-m section was used to calculate GS. Two trials were captured, and the faster trial was used for the analysis. The GS is a clinically valid test with excellent reliability (ICC = 0.90-0.96, r = 0.89-1.00).[32-34]

Functional Independence Measure

The Functional Independence Measure (FIM) was used to assess participants' disability levels and ability to perform activities of daily living. The test contains 18 items composed of 13 motor tasks and 5 cognitive tasks. Each item is scored on a 7-point scale of disability, with 1 being total assistance and 7 being complete independence. Participants with a total score of 126 are considered functionally independent.[35,36]

Locomotive Syndrome Tests

The LS tests contain 2 performance-based tests (SUT and 2ST) and 1 questionnaire (Loco-5). Generally, these 3 tests are performed sequentially to assess physical function. The individual test indicating the lowest level of function is used to determine the person's LS stage (Table 1).

The stand-up test

The SUT is an LS performance-based test to assess mobility levels for controlling vertical movements. Participants were told to stand up from a 40-cm-height chair with both legs first and then with a single leg. If the participant completed the single-leg tasks, the test progressed to a second single-leg task using chairs lower in height. Participants passed the tests if they could stand up from the chair and hold their standing position for 3 seconds without losing balance. If participants did not pass the single-leg task, the test progressed to a task using both legs and lower chairs. The numeric scores were based on the chair's height and whether the participant used 1 or 2 legs during the last task (Figure 2). If the participant was able to stand on 1 leg from a height of 40 cm, the score would be 5. This test has high reliability (Cronbach κ = 0.73, P < .001) and clinical validity with a significant correlation with age (r = −0.51; P < .001).[11]

The 2-step test

In the 2ST, participants take 2 steps forward as far as possible while maintaining balance and safety. After completing the 2 steps, the participant must retain the balance for 3 seconds with the feet together. The average of 2 trials was used to determine the numeric score, and the distance was normalized to the participant's body height (Figure 3). This test has excellent test-retest reliability (r = 0.84). Significant though low correlations exist between 2ST scores and both age-dependent mobility decline (r = −0.38 for 178 males and r = −0.32 for females, P < .001) and SUT scores (r = 0.31, P < .001).[11]

The Locomo-5 Checklist

The Loco-5 is a simple self-reported questionnaire based on the original 25-question Geriatric Locomotive Function Scale (25-GLFS) that assesses functional deficits. This test has excellent reliability (r = 0.96) and concurrent validity (0.85).[37] This survey was created through a factor analysis approach to identify the primary factors associated with functional limitations in older Japanese adults as measured on the 25-GLFS. These primary factors were selected to create the simplified version of the scale, known as the Loco-5.[38] Although the Loco-5 is designed as a self-reported questionnaire, the designated PT read the questions aloud if participants preferred to answer verbally. The Loco-5 consists of 5 questions: 1) difficulty in ascending and descending stairs, 2) difficulty in walking at a brisk pace, 3) distance that can be walked without resting, 4) difficulty in shopping and carrying home about 2 kg, and 5) difficulty in slightly burdensome household activities such as using a vacuum cleaner. Each is answered on a 5-point scale (0: no difficulty; −4: extreme difficulty), scoring 20 points.

Data Analysis

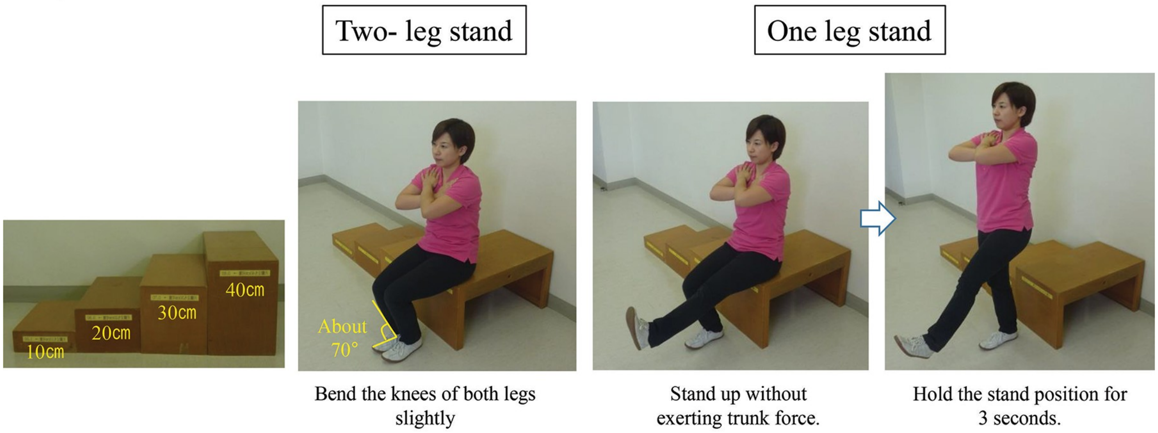
Due to heterogeneous data distribution, Mann-Whitney U tests and χ^2 tests for independence were used to describe clinical differences between groups (those who do and do not use an AD for ambulation). A logistic regression analysis with forced entry was applied to examine the best prediction of AD usage for each clinical assessment. The significant predicting tests independently created the receiver operating characteristic (ROC) curve to examine

Table 1. Diagnostic Scheme for Locomotive Syndrome

			SUT	2ST	Loco-5	Plan of Care
LS stage definition	Stage 0	No functional limitations	≥5	>130% of BH		N/A
	Stage 1	Starting to decline in mobility	3-4	110%–130%		Self-exercise, community-based wellness activities, and dietary education
	Stage 2	Progressing toward decline in mobility	≤2	<110%		Therapeutic interventions by health care professionals

Abbreviations: BH, Body Height; Loco-5, Locomo-5 Checklist; LS, locomotive syndrome; N/A, not applicable; SUT, stand-up test; 2ST, 2-step test.

A)



B)

Height	Two-leg stand					One-leg stand			
	Fail at 40cm	40cm	30cm	20cm	10cm	40cm	30cm	20cm	10cm
Score	0	1	2	3	4	5	6	7	8

Figure 2. Procedure and scoring system of the stand-up test. (A) Testing stools are 4 different heights as 40, 30, 20, and 10 cm. The test progresses either the double-limb or single-limb test based on the result for the default test. (B) The last successful trial before the failing trial determines the test results based on this scoring system.

clinical validity, including clinical threshold, sensitivity, and specificity. The α levels were set as .05. All data analyses were processed using SPSS statistical software (SPSS version 24, IBM Inc).

RESULTS

Sixty-eight participants (80%) used an AD for ambulation and women were more likely than men to use an AD (70.6%, P = .007). There was no significant difference between AD and non-AD groups in level of disability, frequency of receiving governmental supportive care, or other demographic characteristics, such as age and anthropometry (P > .050; Table 2).

Individuals who used an AD for ambulation demonstrated significantly slower TUG than non-AD users (⊿: 4.0 seconds, P < .001) (Table 3). Assistive device for ambulation users had significantly lower handgrip strength (⊿: 23%, P = .030), but did not have weaker quadriceps strength (⊿: 5%, P > .050). Both GS and the FIM were

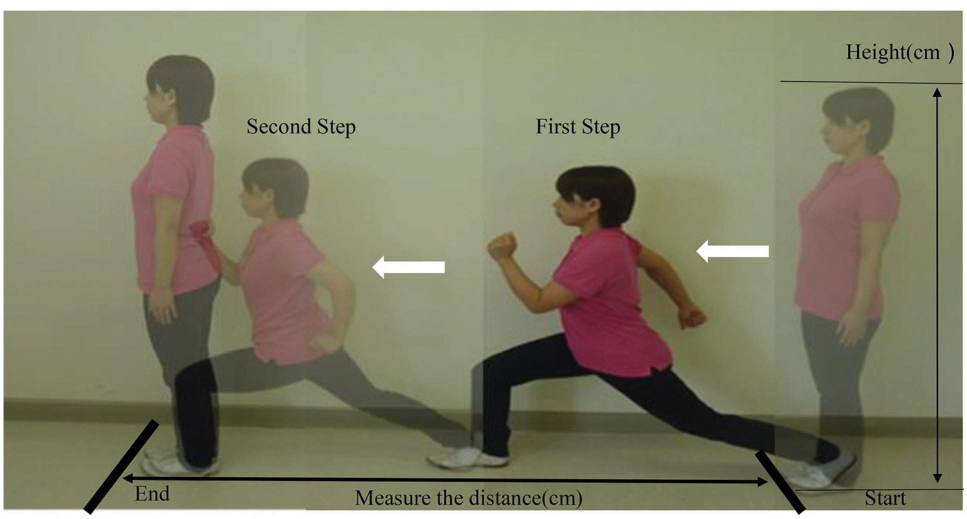


Figure 3. Procedure for the 2-step test. The toe-to-toe stride length is divided by the participant's body height (cm). This figure is available in color online (www.jgeript.org).

Table 2. Comparison Between 2 Groups of the Basic Attribute[a]

Sociodemographic Data	All Participants (n = 85)	No Assistive Aid (n = 17)	Assistive Aid (n = 68)	*P* Values
Men, n (%)	31 (36.5)	11 (64.7)	20 (29.4)	.007[b]
Women, n (%)	54 (63.5)	6 (35.3)	48 (70.6)	
Age, median [interquartile range], y	84.0 [75.5-87.0]	78.0 [74.5-85.5]	84.0 [77.0-87.0]	.478[c]
Height, median [interquartile range], cm	153.0 [146.0-161.5]	157.0 [150.0-167.8]	152.0 [146.0-160.0]	.090[c]
Weight, median [interquartile range], kg	52.8 [44.6-61.3]	58.1 [44.5-65.4]	51.4 [44.7-60.5]	.325[c]
Disability level, n (%)				.419[b]
Support level	28 (32.9)	7 (41.2)	21 (30.9)	
Care level	57 (67.1)	10 (58.8)	47 (69.1)	

Abbreviations: ADLs, activities of daily living; IADLs, instrumental activities of daily living.
[a]Support level indicates a condition that does not require personal assistance to perform basic ADLs, but may require assistance with IADLs. Care Level means a condition that requires personal assistance to perform basic ADLs.
[b]χ^2 test.
[c]Mann-Whitney *U* test.

significantly different between groups as those who used an AD for ambulation had slower gait (⊿: 0.39 m/s, *P* < .001) and more severe disability in physical function (⊿: 3, *P* = .033). All LS tests showed significant differences between groups. The score for the SUT was significantly lower in those who used an AD for ambulation (⊿: 1, *P* < .001). Assistive device for ambulation users had a lower (worse) score in the 2ST (⊿: 0.37, *P* < .001) and a higher (worse) score in the Loco-5 (⊿: 5.0, *P* < .001).

Only the 2ST significantly predicted ADs for ambulation use in the logistic regression (odds ratio [OR]: 0.004; 95% CI: 0.00-0.96, *P* = .048). Since the change in 1 unit of body height is not physiologically likely for this test, we also calculated the odds ratio based on a change of 1 standard deviation (2.8% of body height). For each increase in total step distance of 2.8% of body height, there was a 14% reduction in risk of using an AD (OR: 0.86; 95% CI: 0.73-0.99) (Table 4). The ROC analysis for the 2ST revealed that the area under the curve was 0.86 (95% CI: 0.76-0.95) with a cutoff value of 0.93 (sensitivity: 72%, and specificity: 82%, Figure 4).

DISCUSSION

Most of the measures in this study differed between those who do and do not use an AD for ambulation. Interestingly, age and pain levels were not different among AD and non-AD users, although these factors are commonly considered determining factors in prescribing an AD for ambulation in older adults. Among the tests evaluated in this study, only the 2ST predicted AD status. Using the ROC analysis, a cut off score of 0.93 (equal to 93% of the participant's body height) was the best predictor of AD use (72% of sensitivity and 82% specificity). Previous work has found that a total step distance of less than 96% of body height in the 2ST was predictive of individuals who met the Japanese definition of frailty (ambulation less than 1.0 m/s).[39,40] A 2ST score below

Table 3. Comparison Between 2 Groups of the Physical Functions[a]

Physical Functions	All Participants (n = 85)	No Assistive Aid (n = 17)	Assistive Aid (n = 68)	*P* Values
Pain during movement[b]	2 [0-4]	0 [0-5]	2 [0-4]	.458
TUG, s	12.8 [10.1-16.7]	9.5 [8.2-10.6]	13.5 [11.2-18.9]	<.001
HGS, kg	17.5 [14.3-22.1]	21.0 [18.6-26.2]	16.3 [13.6-21.9]	.030
WBI, kg/kg	0.37 [0.27-0.43]	0.42 [0.31-0.50]	0.37 [0.25-0.43]	.083
30sCRT, times	10.0 [8.5-12.0]	12.0 [9.5-13.0]	10.0 [8.0-12.0]	.046
Gait speed, m/s	0.96 [0.80-1.25]	1.26 [1.07-1.66]	0.87 [0.77-1.14]	<.001
FIM total score	118 [112-122]	119 [117-123]	116 [110.0-121]	.033
SUT	2 [1-3]	3 [3-4]	2 [1-2]	<.001
2ST	0.85 [0.60-1.02]	1.16 [0.94-1.24]	0.79 [0.51-0.96]	<.001
Loco-5	9 [6-12.5]	6 [2-8]	11 [7-13]	<.001

Abbreviations: FIM, Functional Independence Measure; HGS, handgrip strength; Loco-5, Locomo-5 Checklist; SUT, stand-up test; 30sCRT, 2ST, 2-step test; 30-second chair-rise test; TUG, Timed Up and Go; WBI, Weight Bearing Index (quadriceps strength per body weight).
[a]All results are presented as median [interquartile range].
[b]Self-reported pain in the lower extremities during movement anchored with 0 (no pain at all) and 10 (unbearable pain)

Table 4. Result of Logistic Regression Analysis That Assumed Walk Aid Use or Nonuse a Dependent Variable

Factor	Odds Ratio	95%CI	*P* Values
Sex	4.88	0.46-51.76	.189
TUG	1.16	0.74-1.80	.521
HGS	0.99	0.85-1.16	.888
30sCRT	1.47	0.85-2.55	.173
Gait speed	0.41	0.02-9.42	.408
FIM	0.97	0.84-1.13	.734
SUT	0.40	0.15-1.09	.072
2ST	0.86	0.73-0.99	.048
Loko-5	1.18	0.95-1.47	.128

Abbreviations: CI, confidence interval; FIM, Functional Independence Measure; HGS, handgrip strength; Loco-5, Locomo-5 Checklist; SUT, stand-up test; 30sCRT, 30-second chair-rise test; 2ST, 2-step test; TUG, Timed Up and Go.

100% of body height has also been associated with falling and falling anxiety, which may also support why the 2ST was predictive of AD use for ambulation. The mean value of the 2ST for participants in this study was 0.81 ± 0.28 of body height, and the OR of the 2ST predicting the use of an AD was 0.86 based on the change in 1 standard deviation of 2.8% of body height. For a population with an average size height of 178 cm, 1 standard deviation in the 2ST (2.8% of height) equates to 4.98 cm. For every 4.98-cm increase in 2ST distance, there is a 14% reduction in the likelihood of using an AD.

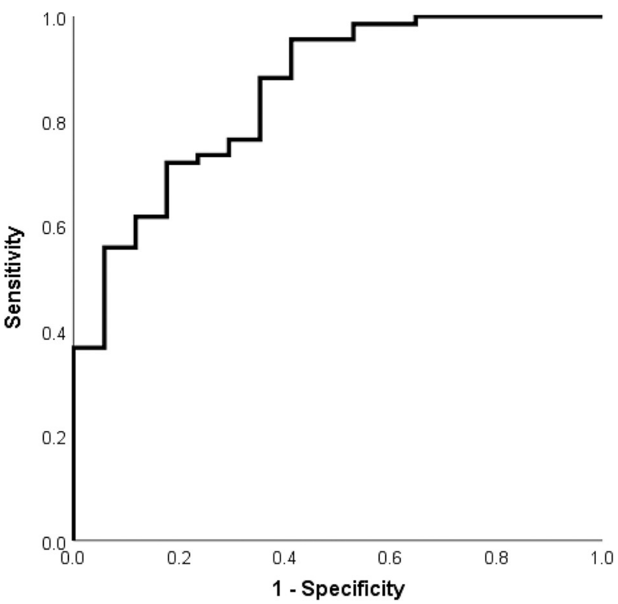


Figure 4. Receiver operating characteristic curve of the 2-step test to distinguish the presence or absence of assistive device use for ambulation. The AUC was 0.86 (95% CI: 0.76-0.95) with a cutoff value of 0.93 (sensitivity: 72%, and specificity: 82%). AUC indicates area under the curve.

The 2ST is often used to assess overall ambulatory ability, as it is significantly correlated with self-selected and maximal walking speed and 6-minute walking distance.[39,41] However, walking speed and the 6-minute walk test require substantial space. The 2ST can be performed in a small space, such as a clinical examination room, which may favor the feasibility of this test in ADs for ambulation screening and prescription. The 2ST can also be normalized by body height, which reduces the ceiling and floor effects of this test and may account for biological differences in sex and age.[11]

There are a few limitations to this study. First, the regional sampling might limit generalization to other locations and countries because of the different care systems for assistive beneficiaries. Second, in our sample, it was assumed that individuals who use ADs do so to improve gait stability and independence, and those who do not use ADs do not need them. However, since patient preference often determines the use of ADs, we cannot eliminate the possibility that some who use ADs did not need them, and some who did would be able to manage without them. Third, our patients were independent community dwellers who currently participate in physical therapy for various pathologies. This may limit the generalizability to community-dwelling adults not receiving physical therapy. However, the population in this study did not have severe physical limitations and may reflect a population for which AD prescription for ambulation is most difficult. Also, given the likelihood that those receiving physical therapy intervention are also the most likely to require an assessment of ADs for ambulation, this may be the most important population to assess. It is also important to consider that many other factors may contribute to ADs for ambulation needs. Fear of falling, access to care, comorbidities, and other physical factors may impact the decision to use an AD. Future studies should include additional patient characteristics in the predictive analyses. This study was a relatively small retrospective study with unequal group sizes, albeit these group sizes reflect the prevalence of ADs for ambulation use among individuals using outpatient physical therapy services. A larger-scale observational study to determine the specific AD for ambulation in various patients is needed.

This screening test should not be used to replace a comprehensive evaluation to identify the most appropriate AD, intervention, or plan of care. Given that this test cannot discriminate between the most beneficial type of AD (walker, cane, quad cane, etc), it should not be used to replace clinical decision-making. However, these tests are commonly performed by nonclinicians and may provide a supplemental way to evaluate a person's need when they do not have access to in-person care. It is also recommended that individuals found to have the need for an AD based on these test results follow up with a health care practitioner to identify the most appropriate device or course of care.

CONCLUSIONS

Assistive devices for ambulation are commonly administrated medical devices that improve balance and ability and reduce pain during physical performance. This study found that the 2ST predicted ADs for ambulation status, with a clinical cutoff of 93% of the body height. This simple screening could be implemented in community and wellness programs or in a telehealth setting to aid in decision-making when a comprehensive evaluation is not possible.

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