An Investigation of the Predictors of Comfortable and Fast Gait Speed in Community-Dwelling Older Adults

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ABSTRACT

Background/Purpose: To identify the unique predictors of comfortable and fast gait speed in community-dwelling older adults using measures of physical performance (eg, lower extremity strength and balance), self-reported balance confidence, and global cognitive function.

Methods: Demographic information was collected from 60 healthy, community-dwelling older adults older than 60 years. Participants completed the following assessments: Mini-Mental State Examination; Activities-Specific Balance Confidence Scale; 30-second Chair Stand (30-SCS); Functional Reach (FR); and gait speed (comfortable and fast) using the GAITRite system. Hierarchical linear regression was used to examine the relationship of both fast and comfortable gait speeds with functional performance (CST and FR), cognition (Mini-Mental State Examination), Activities-Specific Balance Confidence Scale, and demographic information (age, gender, and body mass index).

Results and Discussion: Functional performance measures (30-SCS and FR) explained 55.4% and 64.7%, respectively, of the variance in comfortable and fast gait speed. Unique predictors for comfortable gait speed included 30-SCS, FR, and body mass index. Unique predictors of fast gait speed included 30-SCS, FR, gender, body mass index, and Activities-Specific Balance Confidence Scale score. These predictors explained 68.5% and 80.4% of the total variance in comfortable and fast gait speed, respectively. Global cognition was not a unique predictor of gait speed when performance measures were statistically controlled. However, the current study measured global cognitive status rather than the specific cognitive constructs, such as processing speed or executive function. Further research is needed to determine the role of cognition in the composition of gait speed.

Conclusions: Gait speed is an important indicator for many outcomes such as fall risk, mortality, and functional status. Understanding that key variables of strength and balance comprise a large portion of gait speed allows clinicians to better direct their care and optimize rehabilitation outcomes. This study specifically used functional measures of strength and balance that can be easily implemented in the clinical setting.

Key Words: functional outcomes, physical performance, rehabilitation

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INTRODUCTION

Approximately 8.5%, or 617.1 million, of the worldwide population was identified as 65 years of age or older in 2015. The United States' older adult population is at 21% to 27.9%, with projected significant increases over the next several decades.[1] With the population of older adults on the rise, clinicians and researchers must understand the variables important in predicting future health status to identify factors that may be amenable to intervention to maximize the functional independence of older adults. One of these factors may be gait speed. It is a reliable and valid[2] measure that has been called the "the sixth vital sign"[3] as it is one of the best predictors of changes in health status. Gait speed is an attractive assessment tool because it is a simple, quick, and inexpensive while easily comparable against established norms by a variety of practitioners across patient populations and clinical settings.[4]

Assessment of both comfortable and fast gait speed provides a vast amount of information related to numerous health-related outcomes, such as disability,[5] functional decline,[6] falls,[7] frailty,[8] cognitive decline,[7,9] hospitalization,[10,11] and all-cause mortality.[7,12] Specifically, a cutoff comfortable gait speed of 1.0 m/s in healthy older adults places them at high risk for health-related events including lower extremity limitations, hospitalization, and death.[11] Declines in fast gait speed have been shown to predict disability in the domains of mobility, activities of daily living, and instrumental activities of daily living as it is needed when faced with environmental challenges such as crossing the street or hurrying to the bathroom.[13,14]

It is crucial to understand the underlying mechanisms influencing gait speed as this information can assist in managing declines through intervention and plan of care development. Current literature reveals that influencing variables such as physical performance measures (eg, strength and balance),[15-21] demographic characteristics (eg, age and body composition),[22,23] and cognitive status[24-26] may contribute to an individual's gait speed. Lower extremity strength has consistently shown to be predictive of both comfortable and fast gait speed, whether it is just leg extensor strength[15-17] or a composite strength measure including multiple lower extremity muscles.[18] It is also known that balance capacity affects the stability of an individual during gait. Gait initiation requires a sequence of anticipatory postural adjustments to stabilize posture in preparation of forward stepping, and the gait cycle requires a constant state of maintaining equilibrium as the individual's center of mass moves away from the base of support.[19] Standing balance assessed through postural sway has shown predictive value for comfortable and fast gait speed.[15,16,20] In addition to using performance-based measures, self-reported falls efficacy measures, such as the Activities-specific Balance Confidence (ABC) Scale, have been shown to be predictive of comfortable gait speed in both healthy and clinical populations.[18,21] Thus, declines in gait speed can be influenced by psychological factors in addition to physical performance limitations.

Furthermore, age has been found to independently predict gait speed, even in healthy older adults, demonstrating slower gait speed with increasing age.[22] Callisaya et al[15] argue that although age is an unalterable trait, many physical variables such as strength and balance also change with age and are amenable to intervention. It is important to better understand this relationship as clinicians and researchers must determine the level of modifiability in gait speed as age is a nonmodifiable risk factor whereas age-related changes constructs such as balance and strength can be addressed. Body composition has also been considered when examining the cause of mobility limitations in older adults. Beavers et al [23] revealed increases in thigh intramuscular fat-predicted annual gait speed declines in both men and women during a 4-year period. Although sarcopenia prevalence has been shown to increase with age, body composition is an alterable trait that can be modified to prevent mobility limitations.

Aside from physical abilities and demographic characteristics, literature suggests that cognitive function is associated with gait speed.[9,24-26] Executive function and processing speed specifically were associated with poorer gait outcomes including comfortable gait speed.[9,26] Global cognitive status also has been found to be associated with declines in gait speed, with researchers revealing a 1 standard deviation decrease in global cognition, and executive function was equal to aging 1.5 to 2 years in terms of comfortable gait speed.[24] While this relationship is strong, it is poorly understood requiring more research.

These previous studies have provided important information regarding the predictors of gait speed; however, few studies include simultaneous measures of physical performance and cognition. Having these measured together allows a better understanding of the interplay between cognitive and physical function as there might be shared variance between assessments with respect to prediction of gait speed. In addition, many of the studies investigating the cognitive predictors of gait speed have examined only comfortable gait speed. It is important to determine whether comfortable gait speed and fast gait speed comprise similar predictors or require alternative interventions. Environmental and task constraints often dictate the selection of gait speed, and the ability to walk at faster speeds may involve greater demands of physical or cognitive performance. Therefore, to build on the successes and address the limitations of previous studies, the current study aimed to identify unique predictors of both comfortable and fast gait speed in community-dwelling older adults using multiple physical measures along with various measures of cognitive function.

METHODS

Participants

This observational study included 60 community-dwelling older adults (75.18 years of age [SD: 8.55], 68.3% were female) who were initially screened through a telephone interview to determine eligibility based on the following inclusion criteria: 60 years of age or older and able to walk at least 20 ft with or without an assistive device. To limit confounding variables, the individuals were excluded if they had a diagnosis of Parkinson's disease, brain tumor, and traumatic brain injury; a score of less than 19/30 on the Mini-Mental State Examination (MMSE)[27]; conditions of the inner ear, brain stem, or cerebellum that would cause dizziness or falls; use of psychoactive medications or medications that cause sedation, confusion, or hypotension; or visual impairments that affect the ability to complete activities of daily living. The study was approved by the Institutional Review Board at the University of Central Florida (SBE-16-12062). The participants gave verbal informed consent prior to participation.

Measures

The MMSE was used to determine eligibility as well as to assess global cognitive function.[27,28] It tests different cognitive domains or functions including orientation to place, word registration, attention and calculation, word recall, language, and visual construction. Test-retest reliability of the MMSE is high at 0.89 for intratester reliability and 0.83 for intertester reliability.[28] A score of less than 24 out of 30 generally indicates the presence of cognitive impairment.[27]

Gait speed was assessed with the 12-ft GAITRite(CIR Systems, Inc, Franklin, New Jersey)[29] using a distance of 3 ft to allow acceleration and deceleration. The participants were asked to walk at a "comfortable pace" on the

GAITRite system and then were asked to walk "as fast as you safely can". The average of the 3 trials was calculated for both comfortable and fast gait speeds.

The 30-second Chair Stand (30-SCS) Test assessed lower extremity strength by counting the number of full stands without use of arms from a seated position in 30 s.[30] Eriksrud and Bohannon[31] reported the correlations of the knee extension muscle force measurements with sit-to-stand success ranging from 0.65 to 0.7 without the use of hands and from 0.55 to 0.6 for those using their hands to stand. The ability to complete more repetitions is indicative of greater lower extremity strength. To assess balance, the Functional Reach (FR) test was performed. The FR test correlated ($r = 0.71$) well with center of pressure excursion and had high retest reliability ($r = 0.81$).[32] A cutoff score of 10 in is used to identify fall risk in older adults.[33] The participants were instructed to stand close to the wall and position the arm at 90° of shoulder flexion with a closed fist.[32] The participants were then instructed to "Reach as far as you can forward without taking a step. The location of the third metacarpal was recorded from zero on a yardstick to the end point after reaching forward.[32,34]

[Editor's note: More recent evidence concludes that the FR does not predict falls, c.f. Rosa, MV, Perracini, MR, Ricci, NA. Usefulness, assessment and normative data of the Functional Reach Test in older adults: A systematic review and meta-analysis. *Arch Gerontol Geriatr*. 2019;81(2): 149-170, and Lusardi, MM, Fritz, S, Middleton, A, et al., Determining risk of falls in community dwelling older adults: a systematic review and meta-analysis using posttest probability. *J Geriatr Phys Ther*. 2017;40(1):1-36.]

The Falls Efficacy Scale—International (FES-I) and the ABC Scale were used to gather participants' perception regarding fear of falling and balance confidence, respectively. Higher scores on the FES-I (range from 7 to 28) indicate a greater fear of falling.[35] A score greater than 10 is generally associated with increased risk of falls.[36] The ABC Scale has excellent validity (Cronbach $\alpha = 0.95$) and reliability ($r = 0.92$) in older adults.[37-39] Higher ABC Scale (range from 0% to 100%) scores indicate greater confidence of not falling when performing activities.[40] A score of less than 67% has been found to be associated with future falls.[40]

Procedure

The study was composed of a onetime data collection point scheduled individually for each participant. Upon receiving informed consent, each participant completed the MMSE to ensure eligibility, followed by a brief medical history questionnaire. The participants then completed the FES-I and ABC scale, followed by physical performance–based measures including the 30-SCS, FR, and gait speed (comfortable and fast).

Statistical Analysis

Data were entered in the SPSS Statistical Software (Version 22.0, IBM Statistics) for analysis. Descriptive statistics were analyzed for sample representation and comparison to known normative data. Bivariate correlation analyses were used to determine the level of association between the demographic, performance, cognitive, and self-report variables. The results from this analysis determined the independent variables used in the hierarchical linear regression models. Four nested hierarchical linear regression models were constructed to examine the independent association of both fast and comfortable gait speeds with functional performance (30-SCS and FR), cognition (MMSE), ABC Scale, and demographic information (age, gender, and body mass index [BMI]). The ABC Scale was chosen for analysis over FES-I due to its slightly higher correlation with gait speed. Both were not included to avoid multicollinearity as these measures were highly intercorrelated ($r = -0.87$). This statistical approach was chosen in attempts to best understand the interplay between these constructs and how the shared variance was distributed. Alpha was set at .05.

RESULTS

The participant characteristics are presented in Table 1. The average age of the participants was 75.18 years (SD: 8.55) and 68.3% were female. The participants in the study had an average comfortable gait speed of 1.16 m/s (SD: 0.30) and an average fast gait speed of 1.59 m/s (SD: 0.46). Normal comfortable gait speed has been reported to be between 1.13 and 1.52 m/s for men and 1.06 and 1.48 m/s for females (70-79 years of age) and normal fast gait speed as between 1.71 and 2.44 m/s for men and 1.46 and 2.03 m/s for females (70-79 years of age)[41]; therefore, our sample performed in the normal range.

Mean scores for the FES-I and the ABC Scale were 24.58 (SD: 8.24) and 82.20 (SD: 17.41), respectively, indicating that the sample overall did not have a fear of falling

Table 1. Participant Demographic Characteristics (N = 60)

Variable	Mean (SD)	Range
Age, y	75.18 (8.55)	61-92
Height, m	1.68 (0.11)	1.5-1.9
Weight, kg	75.14 (16.64)	45.8-113.4
BMI	26.89 (6.06)	17.8-42.3
MMSE	27.77 (1.84)	22-30
FES-I	24.58 (8.24)	16-44
ABC Scale score	82.20 (17.41)	24.4-100
30-s Chair Stand score	11.52 (4.03)	0-20
Functional Reach score, cm	30.59 (8.38)	13.2-52.9
Comfortable Gait Speed, cm/s	116.25 (30.16)	31.2-173.7
Fast Gait Speed, cm/s	159.26 (45.61)	28.7-249.9

Abbreviations: ABC, Activities-specific Balance Confidence; BMI, body mass index; MMSE, Mini-Mental State Examination score; FES-I, Falls Efficacy Scale-International score.

and were confident that they would not fall while performing activities.[38,40,42-44] The FR score average was 30.59 cm (SD: 8.39), indicating normal performance based on normative data for FR range between 26.67 and 33.53 cm for individuals between 70 and 87 years of age.[32] The average score for the 30-SCS was 11.52 repetitions (SD: 4.03), indicating slight lower extremity weakness with normative values between 12.7 and 14.2.[30,45,46]

Bivariate correlation coefficients are reported in Table 2. Comfortable gait speed was significantly associated with all performance, self-report, and cognitive measures, as well as age and BMI. Fast gait speed had the same significant associations with the addition of gender. In the hierarchical linear regression (Tables 3 and 4), functional performance measures (30-SCS and FR) explained 55.4% and 64.7% of the variance (adjusted r^2) in both comfortable and fast gait speed, respectively. The addition of MMSE scores did not significantly contribute to the prediction of comfortable gait speed but did for fast gait speed (F change = 5.201; P = .26). Model 3 added the self-report measure ABC Scale that contributed significantly to both comfortable (F change = 4.003; P = .05) and fast (F change = 6.391;

Table 2. Pearson Correlation Matrix

Variable	Comfortable Gait Speed, cm/s	Fast Gait Speed, cm/s
Sex	−0.22	−0.41[a]
Age, y	−0.48[b]	−0.59[b]
Height, m	0.25	0.43
Weight, kg	−0.21	−0.04
BMI	−0.39[b]	−0.32[c]
MMSE	0.46[b]	0.50[b]
FES-I	−0.62[b]	−0.67[b]
ABC Scale score	0.63[b]	0.69[b]
30-s Chair Stand score	0.67[b]	0.70[b]
Functional Reach score, cm	0.57[b]	0.64[b]

Abbreviations: ABC, Activities-specific Balance Confidence; BMI, body mass index; MMSE, Mini-Mental State Examination score; FES-I, Falls Efficacy Scale-International score.
[a]P = .001.
[b]P < .001.
[c]P < .05.

Table 3. Hierarchical Linear Regression Summary for Comfortable Gait Speed (Centimeters per Second)

Independent Variable	Comfortable Gait Speed				
	R^2	R^2 Change	Unstandardized B (Standard Error)	Standardized β	P
Model 1	0.569	0.569[a]			
30-SCS			3.96 (0.70)	0.53	<.001
FR			1.36 (0.34)	0.38	<.001
Model 2	0.593	0.024			
30-SCS			3.64 (0.71)	0.49	<.001
FR			1.19 (0.34)	0.33	.001
MMSE			2.81 (1.55)	0.17	.075
Model 3	0.620	0.028[b]			
30-SCS			3.08 (0.75)	0.41	<.001
FR			0.93 (0.36)	0.26	.01
MMSE			2.02 (1.56)	0.12	.20
ABC Scale score			0.39 (0.19)	0.22	.05
Model 4	0.685	0.065[c]			
30-SCS			3.20 (0.77)	0.43	<.001
FR			0.80 (0.35)	0.22	.02
MMSE			1.28 (1.51)	0.08	.40
ABC Scale score			0.36 (0.19)	0.21	.06
Sex			−5.42 (5.63)	−0.8	.34
Age			0.12 (0.38)	0.3	.75
BMI			−1.35 (0.42)	−0.27	<.01

Abbreviations: ABC, Activities-specific Balance Confidence; BMI, body mass index; FR, Functional Reach; MMSE, Mini-Mental State Examination; 30-SCS, 30-s Chair Stand.
[a]P = .001.
[b]P < .05.
[c]P < .001.

Table 4. Hierarchical Linear Regression Summary for Fast Gait Speed (Centimeters per Second)

Independent Variable	Fast Gait Speed				
	R^2	R^2 Change	Unstandardized B (Standard Error)	Standardized β	*P*
Model 1	0.659	0.659[a]			
30-SCS			6.11 (0.94)	0.54	<.001
FR			2.39 (0.45)	0.44	<.001
Model 2	0.688	0.029[b]			
30-SCS			5.57 (0.94)	0.49	<.001
FR			2.12 (0.45)	0.39	<.001
MMSE			4.66 (2.05)	0.19	.03
Model 3	0.721	0.032[b]			
30-SCS			4.65 (0.97)	0.41	<.001
FR			1.69 (0.45)	0.31	<.01
MMSE			3.37 (2.02)	0.14	.10
ABC Scale score			0.63 (0.25)	0.24	.01
Model 4	0.804	0.084[a]			
30-SCS			4.41 (0.92)	0.39	<.001
FR			1.36 (0.41)	0.25	<.01
MMSE			1.40 (1.79)	0.06	.44
ABC Scale score			0.48 (0.22)	0.18	.04
Sex			−25.43 (6.72)	−0.26	<.001
Age			−0.28 (0.45)	−0.05	.54
BMI			−1.90 (0.51)	−0.25	<.001

Abbreviations: ABC, Activities-specific Balance Confidence; BMI, body mass index; FR, Functional Reach; MMSE, Mini-Mental State Examination; 30-SCS, 30-s Chair Stand.
[a] $P = .001$.
[b] $P < .001$.

$P = .14$) gait speed. The full model (model 4), including functional performance, cognition, ABC Scale, and demographic information, explained 64.3% and 77.8% of the variance (adjusted r^2) in comfortable and fast gait speed, respectively. The addition of BMI, gender, and age contributed significantly to both comfortable (F change = 3.571; $P = .20$) and fast gait speed (F change = 7.408; $P < .001$).

Unique predictors remaining in the full model for comfortable gait speed included 30 SCS ($B = 3.20$, $\beta = 0.43$, $P < .001$), BMI ($B = -1.351$, $\beta = -.27$, $P < .01$), and FR ($B = 0.80$, $\beta = 0.22$, $P = .02$). This indicates that individuals who demonstrated greater lower extremity strength, had a lower BMI, and demonstrated greater balance were able to walk faster at a comfortable pace. Unique predictors remaining in the full model of fast gait speed included 30 SCS ($B = 4.41$, $\beta = 0.39$, $P < .001$), gender ($B = -25.43$, $\beta = -0.26$, $P < .001$), BMI ($B = -1.90$, $\beta = -0.25$, $P < .001$), ABC Scale ($B = 0.48$, $\beta = -0.18$, $P < .04$), and FR ($B = 1.36$, $\beta = 0.25$, $P < .01$). This indicates that individuals who were male, had greater lower extremity strength, had a lower BMI, had more balance confidence, and had better balance walked faster in the fast gait speed condition.

DISCUSSION

This cross-sectional, observational study contributes to the current body of literature as the primary objectives were to identify unique predictors of comfortable and fast gait speed in community-dwelling older adults using both physical and cognitive assessments. Results indicate that lower extremity strength, balance, and BMI were unique predictors of comfortable gait speed while lower extremity strength, balance, gender, ABC Scale score, and BMI were identified as unique predictors of fast gait speed. As summarized in the hierarchical linear regression model 4, these predictors explained 64.3% of the total variance in comfortable gait speed and 77.8% of the total variance in fast gait speed.

These results support previous literature revealing that physical measures including leg muscle strength and balance are important predictors of gait speed[15,16,18,47] and explain the majority of variance in both comfortable and fast gait speed in the current study. Previous studies have commonly used handheld dynamometry to measure leg muscle strength and force platforms to measure postural sway, whereas the present study used functional measures that resemble familiar activities performed in daily life, such as the 30 SCS and the FR. This is a significant addition to the literature as it is helpful for clinicians to understand that common tests used in daily practice serve as appropriate and feasible assessment measures to determine the root cause of a deficit in gait speed.

Results of this study also contribute to the current knowledge by identifying factors that might explain changes in comfortable and fast gait speed over and above age. Age did not remain a unique predictor of gait speed in either full model.[15,21,48] The numerous reports of association between age and gait speed may be explained by a variety of age-related changes, rather than chronological age alone. When considering the vast range of interindividual differences between older adults, age-related changes in multiple body systems and structures, such as the musculoskeletal and cardiorespiratory systems, can produce functional limitations and these changes are not equal from one older adult to another. Rather than labeling old age as reason for gait speed decline, the clinicians should evaluate the specific age-related changes that are contributing to a decline in gait speed. Results also showed that BMI was a predictor of comfortable gait speed and may be explained as a proxy for body composition. As previously mentioned, changes in body composition have been shown to have predictive value for gait speed,[23] and true evaluation of fat composition with a body scan is likely to provide more valuable information related to changes in gait speed.

Assessment of balance confidence was included to capture the psychosocial aspect of gait speed as older adults with a fear of falling may adjust their gait speed in attempts to improve gait stability. Previous studies have shown that fear of falling is associated with slower gait speed, shorter stride length, and longer double support time.[49,50] Despite a sample mean within the normal range on the ABC scale in the current study, balance confidence predicted fast gait speed, indicating that older adults may not be confident walking at faster speeds because of fear of falling. Further research should explore the relationship of balance confidence as a predictor of gait speed; however, the relationship between gait speed and fear of falling promotes the biopsychosocial approach in evaluation of gait speed decline.

While the current study included cognitive function amidst physical performance measures, the assessment was a measure of global cognition. This is supported in current literature; however, emerging literature also has revealed significant associations between comfortable gait speed and processing speed,[51] executive function,[52] and memory.[52] Therefore, further research should include measures of these specific cognitive processes in addition to physical performance and psychosocial measures to allow the most comprehensive understanding of the older adult.

In addition, research that would stratify the analysis by gender could identify important differences between men and women. This understanding could guide clinicians in individualizing evaluations and plans of care based on the specific demographic need of each patient. A final area of future research should focus on elucidating the directional relationship between cognition and gait speed. It is well established that there exists a relationship between physical and cognitive performance[53,54]; however, while some authors have reported that a decline in gait speed is independently predictive of cognitive decline,[9] others have reported the opposite through cross-sectional designs.[24,26,54,55] If specific cognitive domains are indeed predictive of gait speed, development of targeted interventions could prevent or slow a decline in gait speed. Conversely, if gait speed deficits are predictive of cognitive decline, promotion to maintain physical function may serve as incentive for older adults to prevent cognitive slowing. Therefore, more prospective research at multiple time points (eg, 6 months, 1 year, 5 years) is needed to better understand the direction of this relationship.

Study Limitations

A few limitations should be considered when interpreting these results. The sample was homogeneous with most being of high socioeconomic status; therefore, limiting generalizability to a more diverse population of older adults. In addition, the sample mean was within norms for all outcome measures except for the 30 SCS, in which participants were slightly below the norm; therefore, it is unclear whether these results would be consistent in a more frail older adult population. More research is needed in diverse and potentially clinical populations to better inform clinicians on best practice.

CONCLUSION

Gait speed is a valuable screening tool for functional ability of older adults.

Comfortable gait speed was predicted by higher 30-SCS and FR score along with lower BMI while fast gait speed was predicted by higher 30-SCS, FR, ABC Scale, male sex, and lower BMI. These predictors of lower extremity strength, balance, balance self-efficacy, and BMI are modifiable variables that can be targeted in the clinic if found to be abnormal during evaluation.

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