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[De la Cámara, MÁ, Higuera-Fresnillo S, Sadarangani KP, Esteban-Cornejo I, Martínez-Gómez D, Veiga OL. Clinical and ambulatory gait speed in older adults: associations with several physical, mental, and cognitive health outcomes. *Phys Ther*. 2020;100:718–727.]

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Published Ahead of Print:
January 3, 2020

Accepted: August 23, 2019
Submitted: March 25, 2019

Clinical and Ambulatory Gait Speed in Older Adults: Associations With Several Physical, Mental, and Cognitive Health Outcomes

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Background. Although clinical gait speed may indicate health and well-being in older adults, there is a lack of studies comparing clinical tests with ambulatory gait speed with regard to several health outcomes.

Objective. The objective of this study was to examine the associations of clinical gait speed, measured by the 2.44-m walk test and the ambulatory gait speed with several physical, mental, and cognitive health outcomes in older adults.

Design. A cross-sectional design was used.

Methods. The study population comprised 432 high-functioning, community-dwelling older adults (287 women) aged between 65 and 92 years. Clinical and ambulatory gait speeds were measured using the 2.44-m walk test and a portable gait analysis device, respectively. Multiple linear regressions were used to examine the association of clinical and ambulatory gait speeds with several health outcomes (body mass index, waist circumference, systolic and diastolic blood pressure, chronic conditions, self-rated health, exhaustion, upper- and lower-body strength, physical and mental health status, cognitive status, and self-rated cognitive status).

Results. The results showed that the average gait speed for clinical and ambulatory measures cannot be directly compared. Clinical gait speed was associated with 7 health outcomes, and the ambulatory gait speed was associated with 6 health outcomes. The significant associations between measures of gait speed and the health outcomes converged in 5 of the 13 health outcomes studied; however, the strength of associations was singly different between measures.

Limitations. The short monitoring time, the inability to distinguish between the ambulatory gait speed inside the home and outdoor gait speed, and the under-representative sample are limitations of the study.

Conclusion. The results indicated differences in the number and strength of associations between clinical and ambulatory gait speed. Both measures have construct validity because they have been associated with physical and health outcomes; however, they may have different predictive validity. Further research should be conducted to compare their predictive validity in longitudinal designs.



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The ability to walk is an important element in most basic and instrumental activities of daily life in older adults. In health-related research, there has been increasing interest in measuring walking speed because it has been suggested as a practical clinical measure and screening tool in this population.¹ Walking speed, also named gait speed, may indicate health and well-being because slowed gait speed in older adults is a strong predictor of adverse outcomes, including risk of falls,² disability,^{3,4} cardiovascular diseases, and mortality.⁵ Therefore, gait speed is considered as a practical and informative “vital sign” in older adults.⁶

The assessment of gait speed is suitable for clinical settings (clinical gait speed) as it is a quick, reliable, inexpensive, and practical indicator. Clinical gait speed is generally measured by asking older adults to walk at their usual speed over a short walking distance (eg, 2.44, 4.6, or 10 m). The time they require to complete a given distance is considered their usual gait speed. However, a single and sparsely spaced measure of gait speed may not be representative of their free-living conditions (ambulatory gait speed).^{7,8} This shows the fundamental problem of applying results from a clinical situation to a real-life situation.⁹ Also, we should stress the importance of assessing ambulatory gait speed, measured by a portable gait analysis device, to extrapolate results from a clinical to a real-world situation.

Despite clinical gait speed being a reliable and valid indicator of physical, mental, and cognitive health outcomes,^{5,10,11} there is a lack of studies comparing clinical versus ambulatory gait speed regarding health outcomes. Consequently, it is not known whether gait speed measured in clinical settings is associated in the same way with gait speed measured in a free-living condition (ie, ambulatory gait speed) or which of these measures may be more closely related to various health outcomes.

This is relevant since mobility requires a well-integrated functioning of motor, sensory, and cognitive systems, and mobility declines substantially during aging. Understanding the association of both clinical and ambulatory gait speed with health outcomes would help to guide clinical care and develop intervention strategies that may increase independence, which, in turn, may positively influence overall health. Therefore, the aim of this study was to examine the associations of clinical gait speed, measured by the 2.44-m walk test, and ambulatory gait speed, measured by a portable gait analysis device, with several physical, mental, and cognitive health outcomes in older adults. The 2.44-m walk test was selected because it is widely used and easy to conduct in small and busy clinical settings and in epidemiological studies.^{12,13}

Methods

Participants

The sample comprised 607 high-functioning, community-dwelling older adults (383 women) aged between 65 and 92 years who participated in the IMPACT65+ study. This study was designed to examine the associations of objectively measured physical activity with frailty, quality of life, and other health indicators in older adults.¹⁴ Data were collected from April 2015 to June 2017. Before participants took part in the IMPACT65+ study, they were informed of the nature of the study, and written informed consent was obtained from all participants. The study protocol was approved by the Research Ethics Committee of the Autonomous University of Madrid, Spain.

Clinical Gait Speed

Usual gait speed was measured using the 2.44-m walk test following standardized procedures.^{15,16} This test was performed before the placement of the Intelligent Device for Energy Expenditure and Activity (IDEEA, MiniSun LLC, Fresno, CA, USA) device. Participants were informed about the protocols, and instructions were as follows: “I want you to walk until you cross that line, at your normal speed, as if you were walking down the street.” Participants were allowed to use any kinds of aids (crutches, walkers, etc.). Each participant completed 1 trial with the trained researchers walking alongside the participants. When participants did not follow the instructions, the trained researchers stopped the trial to remind the participant of the instructions and prompted the participant to try again. The test was performed once, and the completion time was recorded in seconds using a hand-held stop watch.^{15,16} Total course time was transformed to meters per second as follows: $\frac{\text{test distance}}{\text{test time}}$.

Ambulatory Gait Speed

Participants were fitted with the IDEEA device.¹⁴ This device is a portable gait analysis system that can record over 40 types of daily activities and postures, including walking. It has shown a high accuracy in assessing walking speed, yielding a prediction error of 0.0036 ± 0.3708 miles per hour (mph) and a correlation between predicted speed and actual speed of 0.987.^{17,18} It consists of 5 small sensors (each approximately $16 \times 14 \times 4$ mm in size and weighing 2 g) attached to the skin by hypoallergenic medical tape and a small data collection device (microcomputer) that can be worn on the belt ($7.8 \times 5.5 \times 1.9$ cm and 150 g). The sensors were attached as follows: (1) 1 sensor to the sternum, just below the sternal angle, vertical to the x-axis; (2) 2 sensors to the thighs, in the anterior sides of the upper legs, halfway between the hip and knee; and (3) 2 sensors to the feet, on the inferior side of the feet, under the arch.¹⁸ The battery life of this device gives up to 60 hours

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of autonomy, and the participants wore it during 2 consecutive days (ie, 48 hours) while continuing with their daily activity routine. Despite this short monitoring time, this device has proven to be highly reliable for measuring several movement and nonmovement behaviors in this population with only 2 days of measurements.¹⁹ This device is not water resistant, so all participants were instructed not to perform water-based activities during that period. In addition, the device was initialized using each participant's weight, height, age, and sex, and an individual calibration, following the software instructions, was made. A trained researcher fitted and removed the device. Data were collected at 32 Hz, and those participants who did not provide at least 10 hours of valid waking time per day were excluded of the analyses. The validity of an automated algorithm to identify the sleep period time in 24-hour data from the IDEEA device in older adults is shown elsewhere.²⁰ Because the output of walking speed in this device is in miles per hour, we calculated ambulatory gait speed in meters per second with the following conversion: 1 mph = 0.44704 m/s.

Health Outcomes

We assessed several health outcomes including anthropometric parameters, blood pressure, chronic conditions, general health and exhaustion perception, strength, functional status, health-related quality of life, and cognitive status. For anthropometric parameters, body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in meters, and waist circumference was measured twice with a nonelastic tape and the average recorded in centimeters. Systolic and diastolic blood pressure were measured using an automatic oscillometric blood pressure (Omron M6 Comfort, Omron Healthcare Co., Ltd., Kyoto, Japan), and the average of 2 separate measurements was used for the analysis. Participants reported information on chronic conditions diagnosed by a physician such as coronary heart disease, stroke, asthma, rheumatism, cancer, hip fracture, Parkinson disease, and dementia/Alzheimer disease. Self-rated health was ascertained using the standardized health perception question: "In general, would you say your health is?"²¹ Responses ranged from 1 (ie, fair) to 5 (ie, excellent). Exhaustion was assessed by the sum of 2 questions from the Center for Epidemiologic Studies Depression Scale: "Please indicate how often you have felt this way during the last week, (1) I felt that everything I did was an effort and (2) I did not feel like doing anything."²² Responses ranged from 2 (<1 day) to 8 (5-7 days). Upper-body strength was measured using a handgrip dynamometer (TKK 5101 Grip D, Takey, Tokyo, Japan). This test was performed twice, and the maximum score of the dominant hand was obtained and averaged as an absolute measurement of upper-limb strength (kg). Lower-body strength was assessed by the 30-second chair stand test.²³ The test was performed once, and the number

of repetitions was recorded. Health-related quality of life (ie, physical and mental health-related components) was assessed by the SF-12, which is the short form of the SF-36 health survey and consists of 12 items scored in 2 components: the physical health-related component includes general health, physical functioning, role-physical and body pain, and the mental health-related component includes vitality, social functioning, role-emotional, and mental health. The median physical health-related component and mental health-related component have been shown to be 43 and 48, respectively, (with SD around 10) in a large sample of Spanish older adults (≥ 65 years).²⁴ For cognitive status, we used 2 indicators: the rapid cognitive screen (RCS)²⁵ for assessing cognitive impairment and the subjective cognitive decline (SCD)²⁶ for assessing self-rated cognitive impairment. The RCS test includes 3-items: recall of 5 words, clock drawing, and insight a story; the RCS score ranged from 0 (worst) to 10 (best). The SCD includes the following question: "Do you feel your memory is getting worse?" Responses ranged from 1 ("no") to 4 ("yes, that worries me seriously").

Statistical Analysis

The characteristics of participants are presented as means (SD) or n (%). Clinical and ambulatory gait speed were shown as means and frequencies in meters per second. Spearman correlation coefficient (ρ) was used to examine the relationship between clinical and ambulatory gait speeds, and the ρ was categorized according to the Cohen criteria as follows: >0.5 , large; 0.5 to 0.3 , moderate; <0.3 to 0.1 , small; and <0.1 , insubstantial.²⁷

Multiple linear regressions were used to examine the association of clinical and ambulatory gait speeds with the various health outcomes (BMI, waist circumference, systolic and diastolic blood pressure, chronic conditions, self-rated health, exhaustion, upper and lower-body strength, physical and mental health status, and cognitive status and self-rated cognitive status). Linear regressions were adjusted by sex, age, educational level, BMI (excluding when BMI is the outcome), tobacco smoking, alcohol consumption, and the intensity of daily activities. Each health outcome was transformed to standardized residuals (z score) and entered in individual regression model. To calculate P for lineal trend (P_{trend}), gait speed was introduced as a continuous variable. The associations between tertiles of clinical and ambulatory gait speeds and each health outcome were examined by multiple linear regressions adjusted by the same confounders; in this analysis, values of P_{trend} were estimated by modeling the categories of tertile-transformed variables as continuous variables. The results of linear regression were expressed as unstandardized beta coefficients (B) were conducted using STATA version 12.0 (StataCorp, College Station, TX, USA), and statistical significance was set at $P < .05$.

Role of the Funding Source

The funding organizations had no role in the study design; the collection, analysis, or interpretation of the data; or the decision to submit the manuscript for publication.

Results

There was a high rate of device breakage and data loss; consequently, of 607 participants, only 432 (66.4% women) had valid data. Therefore, only the results of the 432 participants with valid data are presented. More than one-half had primary studies or lower (58.2%), were older than 70 years (56.7%), and reported not having any chronic conditions (55.2%) (Tab. 1).

The average clinical gait speed measures were 1.01 m/s and ranged from 0.13 to 2.03 m/s, and the average ambulatory gait speed was 0.76 m/s, ranging from 0.37 to 1.21 m/s (Fig. 1). The correlation between clinical and ambulatory gait speed measurement was moderate ($\rho = 0.36$, $P < .001$) (Suppl. 1, available at <https://academic.oup.com/ptj>).

Figure 2 shows the associations between both clinical and ambulatory gait speed measurement (m/s) and 13 health outcomes (ascertained by z score) after adjustment by potential confounders. Clinical gait speed was associated with 7 health outcomes (BMI, number of chronic conditions, self-rated health, upper and lower-body strength, physical health status, and cognitive state), and the ambulatory gait speed was associated with 6 health outcomes (BMI, waist circumference, self-rated health, lower-body strength, physical health status, and cognitive state).

The significant associations between measures of gait speed and the health outcomes converged in 5 of the 13 health outcomes studied (Fig. 2); however, the strength of associations was singly different between measures. Habitual gait speed was associated with lower BMI ($B = -0.18$ [95% CI = -0.33 to -0.04] and -0.46 [95% CI = -0.79 to -0.13] for clinical and ambulatory, respectively). By contrast, habitual gait speed was associated with better self-rated health ($B = 0.06$ [95% CI = 0.04 to 0.09] and 0.08 [95% CI = 0.01 to 0.14] for clinical and ambulatory, respectively) and cognitive state ($B = 0.08$ [95% CI = 0.01 to 0.16] and 0.22 [95% CI = 0.05 to 0.39] for clinical and ambulatory, respectively). Similarly, it was associated with higher lower-body strength ($B = 0.49$ [95% CI = 0.35 to 0.62] and 0.37 [95% CI = 0.05 to 0.67] for clinical and ambulatory, respectively) and physical health status ($B = 1.01$ [95% CI = 0.63 to 1.37] and 1.56 [95% CI = 0.72 to 2.40] for clinical and ambulatory, respectively). Moreover, clinical gait speed was associated with chronic conditions ($B = -0.05$, 95% CI = -0.08 to -0.02) and upper-body strength ($B = 0.19$, 95% CI = 0.01 to 0.38), and ambulatory gait speed was associated with waist circumference ($B =$

Table 1.
Characteristics of Participants^a

Characteristic	Value
Age, y	71.6 (5.2)
Primary studies or lower, no.	251 (58.2)
Tobacco smoking, no.	
Never	245 (56.7)
Former	162 (37.5)
Current	25 (5.8)
Alcohol consumption, no.	
Never	134 (31.0)
Former	25 (5.8)
Current	273 (63.2)
Average intensity of daily activities, METs	1.6 (0.2)
Clinical gait speed, m/s ^b	1.01 (0.3)
Ambulatory gait speed, m/s ^c	0.76 (0.1)
BMI, kg/m ²	28.7 (4.6)
Waist circumference, cm	100.1 (11.4)
Systolic blood pressure, mmHg	131.0 (17.7)
Diastolic blood pressure, mmHg	80.9 (10.6)
Chronic conditions, no ^d	0.6 (0.7)
Self-rated health, score ^e	2.8 (0.8)
Exhaustion, score ^f	3.2 (1.6)
Upper-body strength, kg ^g	25.7 (8.4)
Lower-body strength, no. repetitions ^h	11.9 (3.4)
Physical health status, SF-12 physical component score	45.5 (10.0)
Mental health status, SF-12 mental component score	51.1 (10.3)
Cognitive status, RCS score ⁱ	7.5 (2.1)
Self-rated cognitive status, Subjective cognitive decline score ^j	2.4 (0.9)

^aN = 432. Values are mean (SD) or n (%). BMI = body mass index; METs = metabolic equivalents of task; RCS = rapid cognitive screen; SCD = subjective cognitive decline.

^bMeasured over 2.44-m distance.

^cMeasured by the Intelligent Device for Energy Expenditure and Activity monitor.

^dCoronary heart disease, stroke, asthma, rheumatism, cancer, hip fracture, Parkinson or dementia/Alzheimer disease.

^eScore ranges from 1 (fair) to 5 (excellent).

^fScore ranges from 1 (<2 d/wk) to 8 (5–7 d/wk).

^gMeasured by handgrip dynamometer.

^hMeasured by 30-second chair stand test.

ⁱMeasured by the Rapid cognitive screen test. Score ranges from 0 (worst) to 10 (best).

^jMeasured by the Subjective cognitive decline test. Score ranges from 1 (no) to 4 (yes, that worries me seriously).

-0.74 , 95% CI = -1.36 to -0.12) (Suppl. 2, available at <https://academic.oup.com/ptj>).

Tables 2 and 3 show the association of clinical and ambulatory gait speed tertiles with health outcomes.

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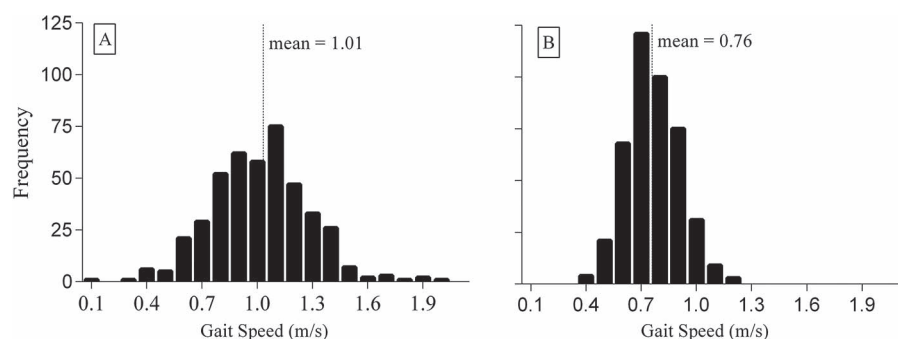


Figure 1. Clinical (A) and ambulatory (B) gait speed of participants ($n = 432$). The vertical bars show the frequency of participants and their corresponding gait speed according to the method used.

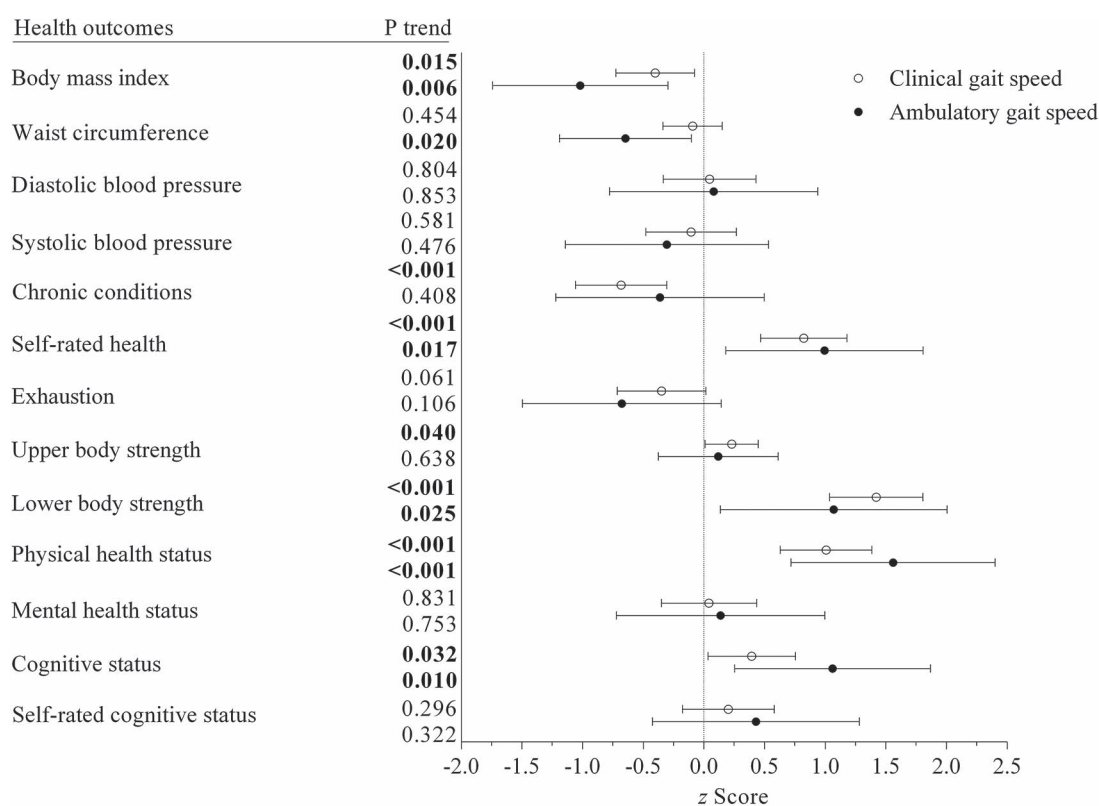


Figure 2. Forest plot showing the associations of clinical and ambulatory gait speed measures (m/s) with health outcomes (z score) in older adults ($n = 432$). White and black points represent unstandardized regression coefficient, and error bars indicate 95% confidence interval for each health outcome transformed in z score (body mass index, waist circumference, systolic and diastolic blood pressure, chronic conditions, self-rated health, exhaustion, upper- and lower-strength, physical and mental health status, and cognitive status and self-rated cognitive status). Lineal regressions were adjusted for sex, age, educational level, body mass index (except for body mass index variable), tobacco smoking (never/former/current), alcohol consumption (never/former/current), and intensity of daily activities. Data in bold are statistically significant.

Table 2.
Associations Between Clinical Gait Speed and Health Outcomes in Older Adults^a

Health Outcomes	Tertile 1 (<0.9 m/s); n = 155	Tertile 2 (0.9–1.1 m/s); n = 152	Tertile 3 (>1.1 m/s); n = 125	P _{trend}
BMI, kg/m ²	Ref.	−0.43 (−1.31 to 0.45)	−1.52 (−2.47 to −0.58) ^b	0.002
Waist circumference, cm	Ref.	−0.17 (−1.83 to 1.49)	−1.22 (−3.02 to 0.57)	0.192
Diastolic blood pressure, mmHg	Ref.	−0.01 (−2.43 to 2.41)	0.01 (−2.60 to 2.62)	0.996
Systolic blood pressure, mmHg	Ref.	−0.99 (−4.95 to 2.97)	−0.96 (−5.23 to 3.32)	0.647
Chronic conditions, no. ^c	Ref.	−0.08 (−0.24 to 0.09)	−0.26 (−0.44 to −0.08) ^b	0.005
Self-rated health, score ^d	Ref.	0.20 (0.03 to 0.37)	0.01 (0.18 to 0.53) ^b	<0.001
Exhaustion, score ^e	Ref.	−0.17 (−0.52 to 0.19)	−0.18 (−0.56 to 0.21)	0.346
Upper-body strength, kg ^f	Ref.	0.49 (−0.62 to 1.60)	1.24 (0.04 to 2.43) ^b	0.044
Lower-body strength, no. repetitions ^g	Ref.	1.98 (1.18 to 2.79) ¹	2.79 (1.94 to 3.64) ^b	<0.001
Physical health status, Short Form 12 Physical component score ^h	Ref.	2.88 (0.68 to 5.08) ¹	4.79 (2.38 to 7.19) ^b	<0.001
Mental health status, Short Form 12 Mental component score ⁱ	Ref.	−0.34 (−2.68 to 1.97)	0.06 (−2.47 to 2.59)	0.980
Cognitive status, score ^j	Ref.	0.37 (−0.08 to 0.82)	0.26 (−0.23 to 0.74)	0.271
Self-rated cognitive status, score ^k	Ref.	0.03 (−0.18 to 0.24)	0.07 (−0.16 to 0.30)	0.553

^aN = 432. Data are unstandardized regression coefficient (95% CI). Linear regression model was adjusted by sex, age, educational level, body mass index (except for body mass index variable), tobacco smoking (never/former/current), alcohol consumption (never/former/current), and intensity of daily activities. P_{trend} was estimated by modeling the categories of tertile-transformed variables as continuous variables. Data in bold are statistically significant (P < .05). BMI = body mass index; CI = confidence interval; RCS = rapid cognitive screen; SCD = subjective cognitive decline.

^bIndicates statistically significant differences with tertile 1.

^cCoronary heart disease, stroke, asthma, rheumatism, cancer, hip fracture, Parkinson or dementia/Alzheimer disease.

^dScore ranges from 1 (fair) to 5 (excellent).

^eScore ranges from 2 (<1 d/wk) to 8 (5–7 d/wk).

^fMeasured by handgrip dynamometer.

^gMeasured by 30-second chair stand test.

^hPhysical component score of the Short Form 12.

ⁱMental component score of the Short Form 12.

^jMeasured by the RCS test. Score ranges from 0 (worst) to 10 (best).

^kMeasures by the SCD test. Score ranges from 1 (no) to 4 (yes and worries me seriously).

Linear associations between higher means of habitual gait speed and the health outcomes studied were clearly observed; however, the number of significant linear associations was lower for the measured ambulatory gaits. Stronger associations were observed for those in the third tertile, showing that gait speeds >1.1 m/s in the clinical and >0.8 m/s in the ambulatory are more strongly associated than those in the first tertile (<0.9 and <0.7 m/s for clinical and ambulatory gait speed, respectively).

Discussion

Gait speed has been defined as the 6 vital signs in older adults, and it is almost the perfect measurement²⁸ because it may reflect functional, physiological, and mental changes in older adults. To our knowledge, this is the first study that compares the associations of clinical and ambulatory gait speed with some health outcomes in older adults. Our results suggested that the average of gait speeds from these methods could not be directly compared. Furthermore, the results indicated

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Table 3.

Associations Between Ambulatory Gait Speed and Health Outcomes in Older Adults^a

Health Outcomes	Tertile 1 (<0.7 m/s); n = 144	Tertile 2 (0.7–0.8 m/s); n = 144	Tertile 3 (>0.8 m/s); n = 144	P _{trend}
BMI, kg/m ²	Ref.	−1.47 (−2.41 to −0.53) ^b	−1.66 (−2.70 to −0.61) ^b	0.002
Waist circumference, cm	Ref.	−1.06 (−2.86 to 0.73)	−2.15 (−4.14 to −0.16) ^b	0.034
Diastolic blood pressure, mmHg	Ref.	−0.80 (−3.42 to 1.81)	0.28 (−2.63 to 3.19)	0.835
Systolic blood pressure, mmHg	Ref.	−2.87 (−7.15 to 1.40)	−2.21 (−0.14 to 0.58)	0.373
Chronic conditions, no. ^c	Ref.	−0.06 (−0.24 to 0.12)	−0.09 (0.29 to 0.03)	0.380
Self-rated health, score ^d	Ref.	0.06 (−0.13 to 0.24)	0.16 (−0.04 to 0.37)	0.117
Exhaustion, score ^e	Ref.	−0.21 (−0.59 to 0.18)	−0.22 (−0.64 to 0.21)	0.328
Upper-body strength, kg ^f	Ref.	0.03 (−1.17 to 1.23)	0.23 (−1.09 to 1.59)	0.712
Lower-body strength, no. repetitions ^g	Ref.	0.05 (−0.83 to 0.93)	0.66 (−0.34 to 1.66)	0.204
Physical health status, Short Form 12 Physical component score ^h	Ref.	3.63 (1.22 to 6.04) ^b	4.83 (2.15 to 7.51) ^b	0.001
Mental health status, Short Form 12 Mental component score ⁱ	Ref.	−1.32 (−3.85 to 1.20)	−1.41 (−4.23 to 1.40)	0.331
Cognitive status, score ^j	Ref.	0.10 (−0.39 to 0.58)	0.61 (0.07 to 1.15) ^b	0.025
Self-rated cognitive status, score ^k	Ref.	0.29 (0.07 to 0.52) ^b	0.14 (−0.11 to 0.39)	0.287

^aN = 432. Data are unstandardized regression coefficient (95% CI). Linear regression model was adjusted by sex, age, educational level, body mass index (except for body mass index variable), tobacco smoking (current/former/never), alcohol consumption (current/former/never), and intensity of daily activities. P_{trend} was estimated by modeling the categories of tertile-transformed variables as continuous variables. Data in bold are statistically significant (P < .05). BMI = body mass index; CI = confidence interval; RCS = rapid cognitive screen; SCD = subjective cognitive decline.

^bIndicates statistically significant differences with tertile 1.

^cCoronary heart disease, stroke, asthma, rheumatism, cancer, hip fracture, Parkinson or dementia/Alzheimer disease.

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^fMeasured by handgrip dynamometer.

^gMeasured by 30-second chair stand test.

^hPhysical component score of the Short Form 12.

ⁱMental component score of the Short Form 12.

^jMeasured by the RCS test. Score ranges from 0 (worst) to 10 (best).

^kMeasured by the SCD test. Score ranges from 1 (no) to 4 (yes and worries me seriously).

that gait speed was associated with some physical, mental, and cognitive health outcomes, reinforcing the argument that gait speed is a powerful predictor of well-being.⁵ However, the associations between waist circumference, number of chronic conditions, and upper-body strength with clinical and ambulatory gait speed differed. Although both measurements followed a similar number and Associations Between Ambulatory Gait Speed and Health individual differences between them.

In this study, we observed large differences across the average gait speed estimates from both methods. Clinical gait speed ranged from 0.13 to 2.03 m/s, while the average ambulatory gait speed ranging from 0.37 to 1.21 m/s, suggesting that clinical gait speed can underestimate or overestimate the habitual gait speed. Previous research studied the concurrent criterion validity of the 2.44-walk test with the IDEEA device as a reference. This study showed that the walk test tends to underestimate gait

speed in older adults who walk slower but overestimates gait speed among faster participants.²⁹ In addition, on average, participants walked approximately 0.25 m/s faster in clinical settings, showing that the mean clinical and ambulatory gait speeds are strongly differentiated and suggest that these methods differ greatly when assessing gait speed. Different reasons may link to these differences: before testing, participants must undergo a process of remembrance and cognitive adjustment; the participant's potential gait speed self-selection bias and cognitive skills may influence the test result,²⁹ as could the length of the test. Older adults can perform this test at a faster pace by knowing that it is a short distance, and therefore they can maintain a fast speed during that time.²⁹ This was also observed in a recent study where the 6-m walk test showed higher average gait speed compared with ambulatory gait speed.⁷

Another possible reason may be that ambulatory gait speed included gait speed at home and outdoors. Kaye et al observed that older adults spend most of their time at home and that the gait speed in this setting was 0.61 m/s,^{8,30} showing that it may decrease the mean daily gait speed and therefore reduce the average ambulatory gait speed. Likewise, clinical gait speed may not show whether older adults take part in community ambulation because the clinical setting does not simulate the same environmental factors as occur outside the home, such as variations in terrain (slopes, curbs, or stairs), carrying loads, or traffic. Indeed, in clinical gait speed, participants were asked to walk at their usual pace, but motivation affects many clinical measurements and participants might alter their performance by moving more quickly.³¹ It may be comparable with what occurs in clinical practice with the white coat syndrome. Therefore, average gait speeds from these methods must not be directly compared.⁷

The findings of this study demonstrated the associations of gait speed for a large number of health outcomes. These findings are in agreement with previous research that showed that gait speeds are associated with important health outcomes as observed in this study: BMI,³² chronic conditions,³³ self-rated health,³⁴ muscular strength,^{35,36} health-related quality of life, and cognitive function.^{10,37} The associations between clinical gait speed and the health outcomes were similar to those observed with the ambulatory gait speed, demonstrating that gait speed may be an excellent illustration of multi-systemic well-being regardless of the setting in which it was measured.

However, although our results indicated that clinical and ambulatory gait speeds followed similar number and pattern associations with the health outcomes analyses, the strength of the associations was dissimilar. When both gait speeds were associated with the same health outcome, the strength of association was higher for ambulatory gait speed, except for lower-body strength and

cognitive state. It is likely that these differences exist for several reasons. On the one hand, gait speed has physiological demands (neuromotor system, cardiovascular, pulmonary, musculoskeletal, etc.) that work synergistically.³⁸ Clinical gait speed performed over 2.44 m has lower physiological demands than those needed in the real-life conditions. This may explain why some physical health outcomes, which are related to these demands, showed different strengths and numbers of associations. On the other hand, gait speed is associated with multiple factors such as behavioral factors and physical inactivity as well as the presence of pain or diseases.³⁹ These can affect the gait speed captured in real conditions more strongly; however, in walk tests of short duration, the influence of these factors is less likely.

These differences also revealed an important gap for future researchers and clinicians in relation to gait speed measurement. On the one hand, gait speed measured in clinical settings has ecological validity as a clinical marker of functional status in older adults for use in clinical and research settings.⁴⁰ However, our results indicated several differences in average gait speed and associations with several health outcomes that are unclear, and they should be explored. On the other hand, clinical gait speed is a simple, safe, inexpensive, and nonintrusive clinical and research assessment tool;³⁸ therefore, it may be more practical and feasible because of the predictive value that it provides. In view of this, researchers and clinicians should decide which method of measurement is most appropriate for their research objectives or clinical decision-making.

Limitations of this study included the monitoring time. The IDEEA device was worn for only 48 hours, because the device battery life is limited to this period. Moreover, data from this device do not differentiate between the ambulatory gait speed inside the home and outdoor gait speed. Previous research showed the importance of including the time of day when analyzing gait, because people may walk significantly faster in the morning compared with afternoon and evening hours.⁸ In our study, clinical gait speed was measured in the morning and afternoon and compared using an average ambulatory gait speed measured throughout 24 hours. In addition, clinical gait speed performed over 2.44 m has lower physiological demands than other walking clinical tests (eg, 6 or 10 m) or those needed in the real-life conditions. Likewise, it should be taken into account that clinical tests are most often performed by residents of a hospital or institution unlike ambulatory tests, which are used frequently for community-dwelling individuals. Therefore, the results of this study are limited to this distance, and comparison with results of other studies should be made with caution. Likewise, participants were community-dwelling, well-functioning older adults so the results may not be representative of the general population.

Comparing Clinical and Ambulatory Gait Speed

In conclusion, this is the first study to our knowledge that compares the associations of clinical and ambulatory gait speeds with health outcomes in older adults. To date, associations between gait speeds and health outcomes have only been studied in clinical or home settings. The results showed that the average measured clinical and ambulatory gait speeds cannot be directly compared. Furthermore, the results indicated differences in the number and strength of associations between clinical and ambulatory gait speeds. These results showed that both measurements have construct validity because they have been associated with various health outcomes; however, their predictive validity may differ. Further research should be conducted to compare their predictive validity in longitudinal designs.

Author Contributions

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Ethics Approval

The study protocol was approved by the Research Ethics Committee of the Autonomous University of Madrid, Spain.

Funding

This work was supported by grants from the Spanish Ministry of Economy and Competitiveness (DEP2013-47786-R), Autonomous University of Madrid-Santander Bank (CEAL-AL/2015-20), and Real Madrid-European University of Madrid (P2016/RM09). S. Higuera-Fresnillo and M.A. De la Cámara were supported by grants from Autonomous University of Madrid (FPI-UAM 2016); I. Esteban-Cornejo is supported by a grant from the Spanish Ministry of Economy and Competitiveness (IJCI-2017-33642); and D. Martinez-Gomez is supported by a "Ramon y Cajal" contract (RYC-2016-20546).

Disclosures and Presentations

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

DOI: 10.1093/ptj/pzz186

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