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Walking speed in elderly outpatients depends
on the assessment method

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Abstract

Background: Walking speed is shown to be an important indicator of health status and function in older adults and part of the comprehensive geriatric assessment in clinical practice. The present study aimed to assess the influence of different assessment methods on walking speed and its association with key aspects of poor health status, i.e. the presence of low cognitive performance and cardiopulmonary disease.

Methods: In 288 community-dwelling elderly (mean age 82.2 ± 7.1 years) referred to a geriatric outpatient clinic, walking speed was assessed with the 4-meter, 10-meter and 6-minute walking test.

Results: Mean walking speed assessed with the 10-meter walking test was higher compared to the 4-meter and 6-minute walking test (mean difference (95% CI) 0.11 (0.10; 0.13) m/s and 0.08 (0.04; 0.13) m/s, respectively). No significant difference was found in walking speed assessed with the 4-meter compared to the 6-minute walking test (mean difference (95% CI) -0.03 (-0.08; 0.03) m/s). ICCs showed excellent agreement of the 4-meter with the 10-meter walking test and fair to good agreement of the 6-minute with the 4-meter as well as 10-meter walking test. The presence of low cognitive performance was negatively associated with walking speed, with the highest effect size for the 4-meter walking test. The presence of cardiopulmonary disease was negatively associated with walking speed as well, with the highest effect size for the 6-minute walking test.

Conclusions: In the clinically relevant population of elderly outpatients, walking speed and its interpretation depends on assessment method, which therefore cannot be used interchangeably in clinical practice.

Introduction

Walking underlies many physical functions and reflects the interaction of several underlying systems, such as the central and peripheral nervous system, sensory systems, muscles, bones and joints, and the cardiopulmonary system¹. A dysfunction in any system may slow walking speed. Therefore, walking speed is an important indicator of health status and function and can be used as a 'vital sign'²⁻⁴. It has been shown that walking speed associates with aspects of poor health status or outcomes in older adults, such as mortality⁵⁻⁸, mobility impairment^{7,9,10}, falls^{8,11}, presence of cognitive impairment^{2,13} and cardiopulmonary diseases^{7,14-16}, hospitalization and nursing home placement^{5,8,11,17}. Cut-off values for walking speed are used for prediction of aforementioned health outcomes and underpin clinical decision making.

Walking speed is often measured in clinical practice as part of a comprehensive geriatric assessment (CGA)¹⁸ and in clinical research¹⁹. It is a quick and easy measure and is not limited to specific equipment. Furthermore, it is a valid, sensitive and specific measure with high interrater and test-retest reliability²⁰⁻²³. Currently, there are many methods to assess walking speed varying in pace (i.e. normal or as fast as possible), static or dynamic start and walking distance or time. Previous research showed conflicting results regarding methodologically induced variance in assessed walking speed in elderly^{24,25}. This hampers comparison of different studies and may affect clinical interpretation of walking speed^{23,26}.

In this study, we assessed the influence of different assessment methods on walking speed in a clinically relevant population of community-dwelling elderly referred to a geriatric outpatient clinic. Walking tests varied in distance or time and static or dynamic start. Furthermore, we examined the association of walking speed assessed by different methods with the presence of low cognitive performance and cardiopulmonary disease as key aspects of poor health status influencing walking speed.

Methods

Setting

This cross-sectional study included 299 community-dwelling elderly referred to a geriatric outpatient clinic in a middle-sized teaching hospital (Bronovo Hospital, The Hague, the Netherlands) for a CGA between October 2010 and January 2012. CGA was performed during a 2-hour visit including questionnaires and measurements of physical and cognitive performance. Trained nurses or medical staff performed all tests. Medical charts were evaluated retrospectively. As this study is based on regular medical care, the need for individual informed consent was waived. In the present analyses, 11 (3.7%) patients were excluded due to missing data on all three walking tests (10 due to physical impairments and 1 due to time constraints), resulting in 288 patients.

Outpatient characteristics

Patients completed questionnaires, which provided information on age, gender, marital status, living arrangements, smoking and alcohol use. Body Mass Index (BMI) was calculated by dividing body weight in kilograms by the square of the height in meters. Medical charts were used to determine use of medication and presence of diseases, i.e. hypertension, myocardial infarction, chronic obstructive pulmonary disease (COPD), malignancy, diabetes mellitus, rheumatoid arthritis, (osteo)arthritis and Parkinson's disease. Multimorbidity was defined as having two or more diseases. The presence of cardiopulmonary disease was defined as having one or more diseases and risk factors relating to the cardiovascular and/or pulmonary system, i.e. hypertension, myocardial infarction and COPD. Depressive symptoms were assessed by the Hospital Anxiety and Depression Scale (HADS)²⁷; a depression subscore higher than 8 out of 21 points indicated depressive symptoms. Cognition was assessed through the Mini-Mental State Examination (MMSE)²⁸. A relative MMSE score was calculated by dividing the total MMSE score by the maximal possible MMSE score multiplied by 30. The presence of low cognitive performance was defined as scoring below the clinically used cut-off value of 24 points²⁹. Physical functioning was assessed by handgrip strength, the Short Physical Performance Battery (SPPB)³⁰ and questionnaires about walking difficulties and the use of a walking aid.

Walking speed

Walking speed was assessed with the 4-meter, 10-meter and 6-minute walking test. Patients wore non-slip socks during the 4- and 10-meter walking test and their regular shoes during the 6-minute walking test. The walking tests were performed without walking aid, unless the patients were not able to.

The 4-meter walking test was assessed as part of the SPPB and was performed twice. Patients started from standing position and were instructed to walk at their preferred speed over a length of 5 m, without slowing down before the 4-meter line. Time was measured using a hand-held stopwatch from the moment the first foot passed the starting line until the moment the first foot passed the 4-meter line completely. The shortest time was used for analysis.

The 10-meter walking test was performed twice and patients were instructed to walk at their preferred speed over a length of 15 m. Time was started at 2.5 m and stopped at 12.5 m, resulting in a steady state measurement over 10 m. Time was measured using a hand-held stopwatch and the shortest time was used for analysis.

The 6-minute walking test was performed once and patients were instructed to walk as far as possible, without running, for 6 min. The test started from standing position and stopped after 6 min or if patients could not walk further. Patients walked down a corridor of 15 m and the number of times patients walked down the corridor was recorded manually plus any

residual distance. A Dynaport Hybrid (McRoberts BV, The Hague, The Netherlands), a tri-axial accelerometer positioned on the lower back using an elastic strap at the height of the second lumbar vertebra, was used as a second measure of total walking distance. The number of turns was established off line by custom written software using Matlab (The MathWorks Inc., Natick, Massachusetts, U.S.A.). Subsequently, the counted turns were multiplied by 15 and the reported residual distance was added. For the current analysis, the total distance calculated using the Dynaport Hybrid was used for further analysis. As the 6-minute walking test was only performed between October 2010 and March 2011, data was available in 70 patients, of which 7 (12.9%) patients were not able to finish the test due to fatigue or shortness of breath.

Statistical analysis

Continuous variables with Gaussian distribution are presented as mean and standard deviation (SD), otherwise as median and interquartile range (IQR) or as number (n) and percentage (%). Paired samples t-tests were used to assess the systematic error, i.e. the mean difference, between the different methods to assess walking speed, i.e. 4- versus 10-meter, 4-meter versus 6-minute and 10-meter versus 6-minute walking test. Absolute agreement was assessed by the 95% limits of agreement (95% LOA), which were calculated by the mean difference \pm 1.96 SD^{31,32} and visualized using Bland-Altman plots. Relative agreement was assessed by the Intraclass Correlation Coefficient (ICC_{3,1})³³. The ICC values were interpreted as excellent (0.75 or higher), fair to good (0.40 to 0.75) or poor (0.40 or lower)²⁵. The association of cognitive performance and cardiopulmonary diseases with walking speed assessed by three different walking tests was tested using linear regression analysis with adjustments for age and gender. Data was analysed using SPSS version 20.0 for Windows (SPSS Inc., Chicago, USA). P-values below 0.05 were considered statistically significant.

Results

Outpatient characteristics

The characteristics of the elderly outpatients are shown in Table 1. Mean age (SD) was 82.2 (7.1) years and 35.1% were men.

Comparison of walking speed assessed with different methods

Mean differences between walking speed assessed with different walking tests are presented in Table 2 and visualized in Figure 1. Walking speed assessed with the 10-meter walking test was significantly higher compared to the walking speed assessed with the 4-meter and 6-minute walking test. Walking speed assessed with the 4-meter and 6-minute walking test were not significantly different. The 95% LOA of the comparison of the 4-meter and 10-meter walking test was lower than the 95% LOA of the comparison of the 6-minute walking test and the 4-meter walking test and the 95% LOA of the comparison of

the 6-minute walking test and the 10-meter waking test. The ICC between the 4- and the 10-meter walking test was excellent. The ICCs between the 4-meter and 6-minute walking test and between the 10-meter and 6-minute test were fair to good.

Table 1 Characteristics of elderly outpatients referred to a geriatric outpatient clinic.

	All (N=288)
Demographics	
Age, years	82.2 (7.1)
Men, n (%)	101 (35.1)
Widowed, n (%)	117 (41.3)
Independent living, n (%) ^a	236 (83.1)
Current smoking, n (%) ^c	22 (16.1)
Excessive alcohol use, n (%) ^a	9 (3.2)
Health characteristics	
BMI, kg/m ^{2b}	25.9 (4.5)
Multimorbidity, n (%) ^{†b}	103 (37.5)
Cardiopulmonary disease, n (%) ^{‡b}	169 (61.0)
Number of medication, median (IQR) ^a	5 (3-7)
HADS depression ^{‡c}	30 (23.4)
MMSE, points ^a	27 (24-29)
Physical functioning	
<i>Measured</i>	
Handgrip strength, kg	25.4 (8.0)
SPPB score, points; median (IQR) ^a	7 (5-9)
<i>Self-reported, n (%)</i>	
Walking difficulties	218 (76.8)
Use of walking aid	167 (58.6)
Walking speed	
4-meter walking speed, m/s ^a	0.72 (0.27)
10-meter walking speed, m/s ^b	0.84 (0.28)
6-minute walking speed, m/s ^d	0.75 (0.26)

Variables are presented as mean (standard deviation) unless indicated otherwise. Data available in ^an=280-283, ^bn=275-279, ^cn=137, ^dn=70. ^aDefined as >14 units per week for females or >21 units per week for males. [†]Defined as having ≥2 diseases, including hypertension, myocardial infarction, chronic obstructive pulmonary disease, malignancy, diabetes mellitus, rheumatoid arthritis, (osteo)arthritis and Parkinson's disease. [‡]Defined as having ≥1 cardiopulmonary diseases; hypertension, myocardial infarction and chronic obstructive pulmonary disease. [‡]Present with a depression subscore >8 on the Hospital Anxiety and Depression Scale. Abbreviations: BMI, body mass index; IQR, interquartile range; SPPB, Short Physical Performance Battery; MMSE, Mini Mental State Examination.

Table 2 Comparison of walking speeds assessed with different walking tests.

Walking test	Mean difference, m/s	95% LOA	p value	ICC	95% CI
4 m – 10 m	-0.11	-0.13; -0.10	<0.001	0.79	0.44; 0.90
4 m – 6 min	-0.03	-0.08; 0.03	0.34	0.64	0.48; 0.76
10 m – 6 min	0.08	0.04; 0.13	<0.001	0.71	0.52; 0.82

Data is presented in intraclass correlation coefficients and mean differences obtained from paired samples t-tests. Abbreviations: LOA, limits of agreement; ICC, intraclass correlation coefficients; CI, confidence interval.

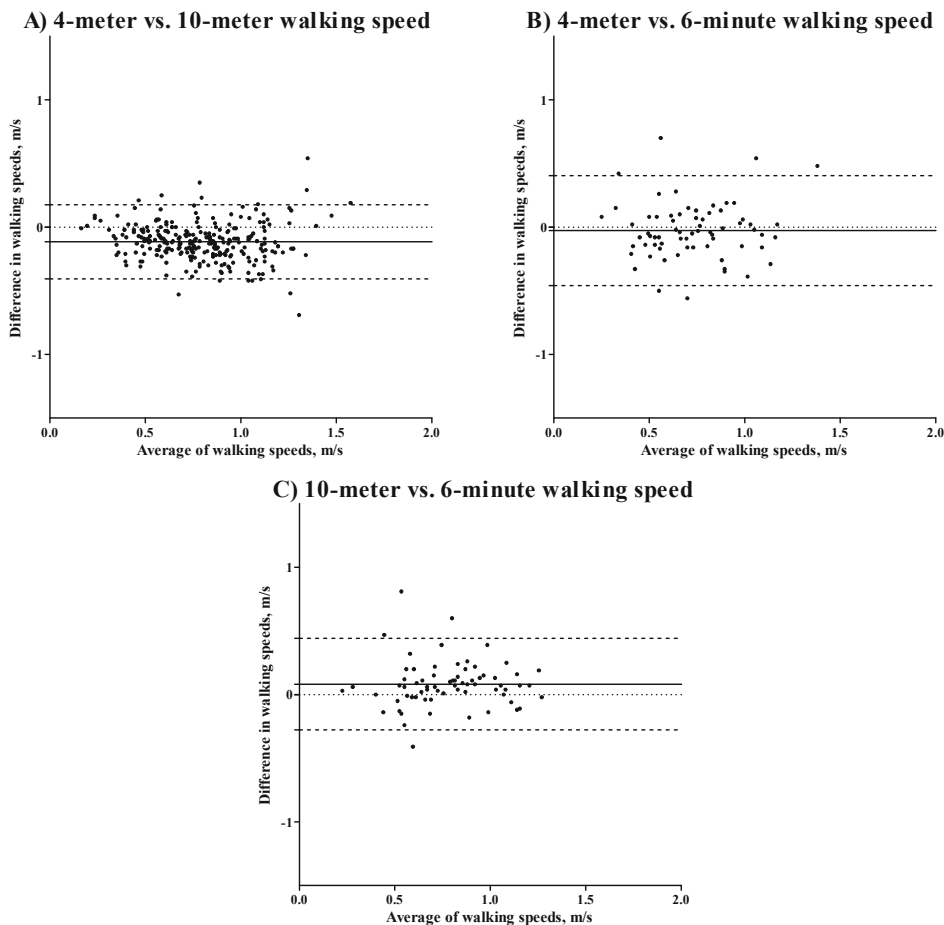


Figure 1 Bland-Altman plot representing the comparison between a) the 4-meter and 10-meter walking speeds, b) the 4-meter and 6-minute walking speeds and c) the 10-meter and 6-minute walking speeds. The solid line represents the mean difference in walking speed, while the dashed lines represent the upper and lower 95% limits of agreement (mean difference \pm 1.96 SD).

Association of underlying systems with walking speed

Table 3 shows the association of the presence of low cognitive performance and cardiopulmonary disease with walking speed assessed with different walking tests. Presence of low cognitive performance was significantly associated with a lower 4-meter walking speed and 10-meter walking speed after adjustments for age and gender, of which the 4-meter walking speed showed the highest effect size. Presence of cardiopulmonary disease was significantly associated with a lower 4-meter, 10-meter and 6-minute walking speed after adjustments for age and gender, of which the 6-minute walking speed showed the highest effect size.

Table 3 Association between cognitive performance and cardiopulmonary disease with walking speed assessed with different walking tests.

	4-meter walking speed		10-meter walking speed		6-minute walking speed	
	Beta (SE)	p value	Beta (SE)	p value	Beta (SE)	p value
Cognitive performance						
unadjusted	-0.103 (0.038)	0.007	-0.091 (0.041)	0.027	0.032 (0.071)	0.66
adjusted*	-0.103 (0.035)	0.004	-0.095 (0.037)	0.012	0.018 (0.066)	0.79
Cardiopulmonary disease						
unadjusted	-0.069 (0.034)	0.039	-0.047 (0.035)	0.185	-0.107 (0.045)	0.088
adjusted*	-0.083 (0.031)	0.008	-0.064 (0.032)	0.047	-0.111 (0.055)	0.046

Data is presented in the effect size (Beta) and standard errors (SE). Low cognitive performance is defined as scoring below the clinically used cut-off value of 24 (0=normal, 1=low); Cardiopulmonary disease is defined as having 1 or more cardiopulmonary diseases (0=absent, 1=present). *adjusted for gender and age.

Discussion

In a population of community-dwelling elderly referred to a geriatric outpatient clinic, walking speed was assessed with three different methods, i.e. the 4-meter, the 10-meter and the 6-minute walking test. Walking speed assessed with the 10-meter walking test was significantly higher compared to walking speed assessed with the 4-meter and 6-minute walking test. ICC values indicated excellent agreement for the comparison between the 4-meter and 10-meter walking test and fair to good agreement for the 4-meter and 6-minute walking test and for the 10-meter and 6-minute walking test. The presence of low cognitive performance showed the strongest association with walking speed assessed with the 4-meter walking test, while presence of cardiopulmonary disease showed the strongest association with walking speed assessed with the 6-minute walking test.

No previous studies investigated the influence of different methods to assess walking speed in a clinically relevant population of elderly outpatients with comorbidities and mobility impairments. A previous study in a homogeneous population of healthy elderly showed an excellent agreement in walking speed assessed with the 4- and 10-meter walking test²⁵, which is comparable with our results. A lower ICC value with a larger 95% LOA compared with aforementioned study, can be explained by a difference in study population and sample size. In contrast to the present results, other previous studies performed in healthy older adults and older adults with neurologic conditions reported no effect of walking distance on walking speed^{24,26}. Apart from the differences in study population, it is difficult to compare aforementioned studies due to differences in test protocols, especially in pace and static or dynamic start of the walking test.

Walking speed assessed with the 10-meter walking test was significantly higher compared to walking speed assessed with the 4-meter walking test. The higher walking speed assessed with the 10-meter walking test can be explained by the exclusion of the acceleration phase, which is included in the 4-meter walking test, while the 10-meter

walking test measures only the steady state phase. The results showed an excellent relative agreement between the 4-meter and 10-meter walking tests by the ICC. This means a high consistency between tests, i.e. smaller difference between both assessed walking speeds compared with the differences between the patients within the group. A small range of the 95% LOA indicated a low random error and precise assessments of walking speeds.

A systematically lower walking speed assessed with the 6-minute walking test compared to the 10-meter walking test was found, which can be explained by the inclusion of the acceleration phase and the endurance needed to perform the 6-minute walking test. The difference between both assessed walking speeds is somewhat higher compared to the differences between the patients in the study population, as shown by the ICC values indicating fair to good agreement. The large range of the 95% LOA indicated a high random error and less precise assessments of walking speeds. This may be explained by the introduction of more variability due to differences in endurance between patients. Furthermore, data of the 6-minute walking tests was limited available.

We found no systematic difference between walking speed assessed with the 4-meter and the 6-minute walking test. Both tests include factors with a limiting effect on the assessed walking speed, i.e. an acceleration phase and endurance. The first factor has less effect on walking speed assessed with the 6-minute walking test, as the duration of the 6-minute walking test is longer compared with the 4-meter walking test. Endurance only has effect on the 6-minute walking test. The results showed a fair to good relative agreement between the tests, due to a somewhat higher difference between the tests compared with the differences within the group reflected by the ICC. A large range of the 95% LOA indicates a high random error and less precision between the two assessed walking speeds. An explanation for this may be the introduction of more variability due to differences in endurance as well as the lower number of patients who performed the 6-minute walking test compared to the 4-meter walking test.

The methodology to assess walking speed affects the association of cognitive performance with walking speed. In accordance with other studies performed in community-dwelling elderly and healthy elderly^{12,13,34-37}, we found an association between the presence of low cognitive performance and walking speed assessed by respectively the 4-meter and 10-meter walking test. The largest effect size was found for the walking speed assessed with the 4-meter walking test. This may be explained by the inclusion of the acceleration phase in the 4-meter walking test. Initiation of movement requires cognitive processes and therefore cognitive impairment slows walking^{13,37}, resulting in a larger effect size for the association between presence of low cognitive performance and walking speed assessed with the 4-meter walking test.

The methodology also affects the association between the presence of cardiopulmonary disease and walking speed. In accordance with previous studies showing a negative association between hypertension, myocardial infarction and COPD and walking speed^{7,14-16}, we found an association between presence of cardiopulmonary disease with a lower walking speed. The highest effect size was found for the walking speed assessed with the 6-minute walking test. This may be explained by the cardiovascular determined endurance factor, which is obviously more prominent in the 6-minute walking test.

The results found in this study are of high clinical relevance. Previous studies reported clinically meaningful changes in walking speed in community-dwelling older adults for the 4-meter walking test of 0.12 m/s³⁸. More in general, small and substantial clinically meaningful changes in walking speed were reported from 0.05 m/s and 0.10 m/s, respectively^{38,39}. In this study, we found differences in walking speeds of 0.11 m/s for the 10-meter compared to the 4-meter walking test and 0.06 m/s for the 10-meter compared to the 6-minute walking test. Especially for the 10-meter compared to the 4-meter walking test, the range of 95% LOA is small (0.10;0.13 m/s) indicating that for 95% of the patients the difference between the 10-meter and 4-meter walking test will be between these values. So, the difference between both walking tests is large and precise enough to measure clinically meaningful changes in walking speed over time at the individual level when these methods are used interchangeably, which will have direct influence on clinical decision making. Furthermore, this study emphasizes that when using cut-off values^{3,8,11,40} for clinical decision making, clinicians should be aware that they depend on the assessment method of walking speed.

The strength of this study is the large clinically relevant study population of elderly outpatients. No exclusion criteria were applied which further improves the generalizability of our results. Within the study population 64.9% were women, representing the geriatric outpatient population. Limitations were the limited availability of data on the 6-minute walking test. This could have influenced our results, as this reduces the power in the comparison of the 4- and 10-meter walking test with the 6-minute walking test and results in a methodologically induced enhancement of the 95% LOA and lower ICC values.

This study showed that in the clinically relevant population of elderly outpatients, the walking test that has been used has direct influence on the assessed walking speed as well as its validity, illustrated by the association with two major underlying systems, i.e. cognition and the cardiopulmonary system. Walking speeds assessed by different walking tests are therefore not interchangeable in this population. Clinicians assessing elderly outpatients should be aware of the effect of the used walking test on the assessed walking speed and its consequences for clinical decision making.

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