Gait Speed Predicts Decline in Attention and Psychomotor Speed in Older Adults: The Health Aging and Body Composition Study

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Key Words

Gait speed • Attention • Psychomotor speed • Elderly community dwellers • Cognitive decline • Mobility

Abstract

Background/Aims: Gait speed is cross-sectionally associated with attention and psychomotor speed in older community dwellers. It is unclear if gait speed predicts decline in these cognitive domains over time. **Methods:** Usual gait speed (m/s) over 6 m was measured at baseline in 2,776 Health, Aging and Body Composition Study participants (mean age $\pm$ SD 73.5 $\pm$ 2.8 years, 53% women, 37% blacks). The Digit Symbol Substitution Test (DSST) was administered at baseline and after 5 years to assess attention and psychomotor speed. We used multivariate logistic regression models to calculate the risk of DSST 5-year decline [>1 SD from mean change (9 points)] across quartiles of gait speed, adjusting for demographics, weight, physical activity, comorbidities, depression and Modified Mini-Mental State Examination. **Results:** After 5 years, 389 (17.1%) participants declined in DSST. Compared to those in the highest quartile of gait speed (>1.35 m/s), participants in the lowest quartile

(<1.05 m/s) were more likely to decline in DSST independently of the considered covariates (OR 1.74, 95% CI 1.21–2.51, adjusted p for trend across quartiles = 0.006). **Conclusions:** In this cohort of older community dwellers, gait speed independently predicted a decline in DSST after 5 years.

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Introduction

In a previous cross-sectional report from the Health, Aging and Body Composition (Health ABC) Study, gait speed was associated with cognitive function in older community dwellers [1]. This observation is consistent with other studies, which demonstrated that motor performance is longitudinally associated with dementia [2–5] and persistent cognitive impairment [6, 7]. These findings suggest that motor performance can decline before cognitive impairment is detected and that motor performance might be used to predict cognitive decline in clinical settings. However, these previous studies applied complex measures of cognitive function. We propose to use one simple test for attention and psychomotor speed:

Fig. 1. Study population. * $p < 0.001$.

the Digit Symbol Substitution Test (DSST). This test predicts cardiovascular events [8], dementia [9], death [10, 11] and white matter disease progression [12] in middle-aged and older adults, and is associated with activities of daily living disability [13]. We evaluated whether the clinical measure of usual gait speed, which is easy, inexpensive, and highly reliable and valid [14, 15], predicted decline in DSST over 5 years in well-functioning older community dwellers. We also questioned if this association was independent of the concurrent decline in global cognitive abilities as measured by the Modified Mini-Mental State Examination (3MS).

Methods

Population

Between 1997 and 1998, the Health ABC Study enrolled 3,075 Medicare-eligible nondisabled men and women aged 70–79 years from Pittsburgh, Pa., and Memphis, Tenn., USA; other household members aged 70–79 were also eligible. Exclusion criteria were difficulty walking one quarter of a mile or climbing 10 steps

without resting, or walking without an assistive device. Institutional Review Boards of the University of Pittsburgh and of the University of Memphis approved the study. The study population attrition and the sample selected for this study are shown in figure 1. Compared to the 2,276 participants with complete data for this analysis (mean age $\pm$ SD = 73.5 ± 2.8 , 47% men, 37% blacks), the 741 participants without follow-up cognitive tests were slightly older and had a higher prevalence of blacks.

Gait Assessment

Usual gait speed is a valid and reliable indicator of physical performance, and predicts incident disability, hospitalization, institutionalization, falls, fractures and death in healthy elderly persons [14–16]. Of the physical performance measures included in the Health ABC battery, usual gait speed demonstrated the strongest association with cognition [1].

Usual gait speed (m/s) over a 6-meter course was measured by centrally trained and certified examiners. The average of two trials was used. We considered gait speed as both continuous measure and quartiles of performance.

Outcome

Attention and psychomotor speed were assessed with the DSST [17]. The DSST is a paper-and-pencil task that requires copying as many novel symbols corresponding to numbers as

Table 1. Baseline characteristics of the cohort and decliners in DSST, for the whole sample and by quartiles of baseline gait speed

	Total sample (n = 2,776)	Usual gait speed				p value
		<1.05 m/s (n = 607)	1.06–1.19 m/s (n = 556)	1.20–1.34 m/s (n = 562)	≥1.35 m/s (n = 551)	
Decline in DSST >1 SD (9 points)	389 (17.1)	119 (5.2)	101 (4.4)	90 (4.0)	79 (3.5)	0.011
Age, years	73.5 ± 0.05	73.8 ± 1.1	73.6 ± 0.2	73.4 ± 1.2	73.2 ± 1.2	<0.001
Men	1,079 (47.4)	192 (31.6)	236 (42.4)	287 (51.5)	364 (66.1)	0.172
Black	845 (37.1)	356 (58.6)	237 (42.6)	145 (25.8)	107 (19.4)	<0.001
Education >12 years	1,025 (45.1)	191 (8.4)	234 (10.3)	278 (12.2)	322 (14.2)	0.001
Weight, kg	75.6 ± 0.3	77.8 ± 0.6	74.6 ± 0.6	74.4 ± 0.6	75.4 ± 0.6	0.011
Physical activity, kcal/week	1,129.7 ± 42.4	739.9 ± 80.9	985.4 ± 80.5	1,131.1 ± 80.1	1,702.5 ± 80.9	<0.001
DSST score	37 ± 0.29	31.2 ± 0.5	36.5 ± 0.6	39.2 ± 0.6	41.2 ± 0.6	<0.001
3MS score	91.1 ± 0.15	89.0 ± 0.3	90.8 ± 0.3	92.2 ± 0.3	92.5 ± 0.3	<0.001
Depressive symptoms (CES-D)	4.5 ± 0.1	4.8 ± 0.2	4.7 ± 0.2	4.6 ± 0.2	3.7 ± 0.2	0.001
Hypertension	1,350 (59.3)	412 (67.9)	336 (60.4)	318 (56.6)	284 (51.5)	<0.001
Diabetes	309 (13.6)	108 (17.8)	76 (13.7)	72 (12.8)	53 (9.7)	0.001
COPD	245 (10.8)	89 (14.7)	48 (8.7)	50 (8.9)	58 (10.6)	0.003
Cardiovascular comorbidity	626 (27.5)	192 (31.6)	148 (26.6)	148 (26.3)	138 (25.0)	0.059

Data are numbers with percentages in parentheses or means ± standard error of the mean. CES-D: Center for Epidemiologic Studies of Depression Scale; COPD = chronic obstructive/restrictive pulmonary disease.

possible in 90 s. The score ranges from 0 (worst performance) to 90 (best performance).

Confounders

Demographics (age, gender and race), education (years of school, ≤12 versus >12 years [18]), weight and physical activity were measured at baseline. Self-reported physical activity was estimated as total kilocalories/week spent in walking and exercise [19], and has been shown to predict cognitive decline in the elderly [20]. Health conditions associated with cognitive decline in the elderly included: depressive symptoms (10-item Center for Epidemiologic Studies of Depression Scale [21]) [22]; hypertension (blood pressure ≥140/90 mm Hg or self-report of physician diagnosis and treated hypertension) [23]; diabetes [self-report of physician diagnosis, hypoglycemic medication use, or fasting glucose ≥126 mg/dl (≥7.0 mM)] [24]; cardiovascular comorbidity (defined as having at least one of the following prevalent cardiovascular diseases: myocardial infarction, angina, congestive heart failure, stroke or peripheral arterial disease) [25]; prevalent chronic obstructive/restrictive pulmonary disease [26].

Global cognition was assessed with the 3MS [27], which is a semi-structured interview for comprehensive evaluation of cognitive functions, and may be more sensitive to mild cognitive change than the traditional Mini-Mental State Examination [27]. Score ranges from 0 (worst performance) to 100 (best). Scores below 80 indicate poor cognitive function, and a decrease of 5 points or more over time indicates significant cognitive decline [28].

Study Design and Statistical Analysis

Differences in baseline characteristics across quartiles of baseline gait speed were tested with the Mantel-Haenszel χ^2 test for trend (dichotomous variables) and ANOVA (continuous variables). A decline in the DSST of >1 SD (9 points) from the mean score change (baseline to follow-up) was the outcome. We used logistic regression to calculate the risk of decline in DSST score across quartiles of gait speed. The highest quartile (fastest gait speed) was the reference category. The trend across quartiles was also tested. A first model was adjusted for age and baseline DSST. In a second model, demographics and education were forced in, and gait speed and the other baseline covariates were included with a backward procedure (p out = 0.05). A third model was further adjusted for 3MS 5-year change. A parsimonious logistic regression model included demographics, education, and those covariates which independently predicted the decline in DSST in the previous models. The interaction between gait speed and gender and race was tested in separate models and gender-stratified analyses were also examined. We also repeated the analysis excluding participants with baseline 3MS scores <80. Multicollinearity between baseline variables (in particular 3MS and DSST scores) was estimated with the variance inflation factor. The small values of the variance inflation factor (close to 1) excluded the risk of multicollinearity [1]. We also performed a sensitivity analysis considering a decline of >1.5 SD (14.4 points) in DSST as a dichotomous outcome. We repeated the analyses using linear regression models, with continuous values of gait speed as independent variable, and change in DSST over time as an outcome. The adjustment for covariates paralleled the one used for the logistic regression.

Table 2. Risk of decline in DSST [>1 SD (9 points) from mean change] over 5 years, across quartiles of usual gait speed (m/s)

Quartiles of gait speed, m/s	Model 1			Model 2		
	OR	95.0% CI	p value	OR	95.0% CI	p value
≥ 1.35	1			1		
1.20–1.34	1.221	0.875–1.704	0.239	1.180	0.838–1.662	0.342
1.06–1.19	1.533	1.103–2.131	0.011	1.413	1.000–1.995	0.050
≤ 1.05	1.979	1.425–2.748	<0.001	1.849	1.293–2.645	0.001
Trend			<0.001			0.006

Logistic regression models: model 1 is adjusted for age and baseline DSST; model 2 is adjusted for age, gender, race, education, weight, physical activity, high blood pressure, diabetes, cardiovascular comorbidity, chronic obstructive/restrictive pulmonary disease, Center for Epidemiologic Studies of Depression Scale, baseline DSST and baseline 3MS.

Fig. 2. Risk of decline in DSST [>1 SD (9 points) from mean change] over 5 years, across quartiles of usual gait speed (m/s). Logistic regression model, adjusted for age, gender, race, education, weight, physical activity, cardiovascular comorbidity, high blood pressure, diabetes, chronic obstructive/restrictive pulmonary disease, depressive symptoms, baseline DSST, baseline 3MS, and change in 3MS over time.

Results

After 5 years, 389 (17.1%) participants had declined at least 1 SD (9 points) in the DSST score. The prevalence of DSST decline linearly decreased across increasing quartiles of baseline gait speed (table 1). Participants with faster gait were more likely to be older, of black eth-

nicity, to have a greater education, a lower weight and to be more physically active. Greater 3MS scores, a lower depression score and a lower comorbidity score were associated with increasing gait speed. The risk of DSST decline was greater across quartiles of gait speed after adjusting for age, baseline DSST and for other covariates (table 2). Further adjustment for 3MS 5-year change did not modify the results (OR 1.74, 95% CI 1.21–2.51, for the lowest versus the highest quartile of gait speed) (fig. 2). Other variables that were significantly associated with DSST decline were: demographics, education, diabetes and chronic obstructive/restrictive pulmonary disease, baseline DSST, baseline 3MS and 3MS 5-year change. Parsimonious models including only the covariates that were associated with the outcome yield similar results. Neither the interaction term between gait speed and gender ($p = 0.398$), nor the one between gender and race ($p = 0.215$) were significant. In gender-stratified analyses, associations were similar in men and women and the trends were similar to those observed in the whole sample. Results were also similar among those with 3MS scores ≥ 80 at baseline ($n = 2,114$, mean age 73.5 ± 2.8 years, 988 men, 719 blacks).

In linear regression models adjusting for all the baseline characteristics and for the 3MS 5-year change, each 0.2 m/s difference in baseline gait speed was associated with a 5-year DSST decline of 0.07 points (standardized $\beta = -0.072$, $p = 0.001$). The sensitivity analysis using a DSST 5-year decline of >1.5 SD from the mean change confirmed the association between baseline gait speed and DSST decline. One hundred and seventy-nine participants (7.9% of the sample) had a DSST 5-year decline of >1.5 SD. Those in the lowest quartile of gait speed had

a significantly greater risk of experiencing a DSST 5-year decline of >1.5 SD compared to those in the highest quartile (age-adjusted OR 1.57, 95% CI 1.0–2.49, p for trend = 0.077). Adjustment for other covariates yielded similar results.

Discussion

In this cohort of older adults from the community, usual gait speed measured over a short course predicted a decline in a test of attention and psychomotor speed over 5 years. A relatively small baseline difference in gait speed, 0.3 m/s, was associated with an almost twofold increased risk of declining in attention and psychomotor speed. The ability of gait speed to predict the decline in attention and psychomotor speed was independent of both baseline and 5-year change in global cognitive status as measured with the 3MS.

Prior related studies considered comprehensive cognitive assessments, such as the diagnosis of dementia or a persistent cognitive impairment, as outcomes [2–7]. However, dementia is a complex diagnosis, reached often by consensus using criteria that are not entirely agreed upon, and represents a late stage in cognitive decline, when preventive strategies are no longer effective and treatment options are not yet available. The early detection of a decline in attention and psychomotor speed may represent an important goal for clinical practice: a lower DSST score predicts incident dementia [9], cardiovascular events [8] and death [10, 11], and white matter disease progression [12] in middle-aged and older adults, and it is associated with activities of daily living disability [13]. A recent investigation, conducted with computerized gait analysis, demonstrated that a summary measure derived from a factorial analysis and accounting for gait speed, step length and double support time was associated with a subsequent decline in attention, psychomotor speed and verbal fluency in community-dwelling seniors [29]. We were able to demonstrate that decline in attention and psychomotor speed can be predicted by usual gait speed alone as measured with a stopwatch over a short course. This is a reliable and valid test which can be easily repeated in every clinical setting and even in a home environment. We were also able to control for various possible confounders of the association between gait and attention and psychomotor speed decline, including lifestyle habits and comorbidities previously demonstrated as predictors of cognitive decline in the elderly, such as the level of physical activity [20] or diabetes,

which have been reported to specifically predict a decline in the DSST [24]. The predictive role of gait speed was also independent of baseline and concurrent change of global cognition.

Increasing evidence supports the notion that physical and cognitive functions decline concurrently over time [30, 31], and that both may share common etiologies, such as brain small-vessel disease [12]. The findings of the present study suggest that gait impairment can become evident before cognitive function starts to decline or before this decline can be detected. Therefore, initial gait impairment might represent a useful tool for the early detection of the consequences of brain small-vessel disease in older adults.

Strengths of our study include the population-based sample, the longitudinal design and the large number of available covariates. The well-functioning population allowed us to focus on the association between physical and cognitive performances reducing the influence of concurrent declines in other physiologic systems. The DSST has a high sensitivity to changes in high levels of cognition [32]. Some limitations have to be acknowledged. First, though the good level of global functioning of this cohort represents an advantage, it could also constrain the inference of our results. Second, the available cognitive battery was limited, which is however not uncommon in large epidemiologic studies where the focus is not specifically on cognition. Third, the definition of decline in DSST was somewhat arbitrary. Generally accepted cutoffs have never been set for this test, despite the large use in geriatric epidemiology. Our cutoff point had the advantage to be weighted on this specific population. Moreover, 1 SD of the concurrent decline in 3MS, in this cohort, was 5 points, which is generally the expression of global cognitive decline [28]. Selecting a different cutoff for the DSST (1.5 SD) showed a consistently increased risk of decline in DSST in slow walkers, compared to participants in the highest quartile of gait speed. The lack of statistical significance of the trend is probably due to a reduced power, because only 7% of the sample had a decline in DSST greater than 1.5 SD. This low prevalence of participants who experienced such a relevant decline (1.5 SD) was not surprising, considering the initially physically and cognitively well-functioning population. Finally, considering the net change in DSST between baseline and follow-up as an outcome, the results consistently identified the independent role of usual gait speed in the prediction of attention and psychomotor speed decline.

In conclusion, usual gait speed over a short course predicted a decline in attention and psychomotor speed over 5 years in a well-functioning sample of older community dwellers. The predictive role of gait speed was independent of baseline and concurrent change in global cognition. In clinical practice, the measure of usual gait speed over a short course is easy, quick and inexpensive. It should therefore be considered as an essential tool in the routine clinical evaluation of older persons, independent of whether they report mobility complaints.

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