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Associations of Usual Pace and Complex Task Gait Speeds with Incident Mobility Disability

Andrea L Rosso, PhD, MPH[a], **Andrea L Metti, PhD, MPH**[a], **Kimberly Faulkner, PhD, MPH**[a], **Jennifer S Brach, PhD, PT**[b], **Stephanie A Studenski, MD, MPH**[c], **Mark Redfern, PhD**[d], **Caterina Rosano, MD, MPH**[a]

[a]Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh

[b]Department of Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh

[c]Division of Geriatric Medicine, Department of Medicine, University of Pittsburgh

[d]Department of Bioengineering, Swanson School of Engineering, University of Pittsburgh

Abstract

Background/Objectives: To assess whether gait speed under complex conditions predict long-term risk for mobility disability as well as or better than usual-pace gait speed.

Design: Longitudinal cohort study

Setting/Participants: Subsample of Health Aging and Body Composition study with follow-up from 2002–2003 to 2010–2011, including 337 community-dwelling adults (mean age=78.5, 50.7% female, 26.1% black)

Measurements: Associations of gait speed measured under usual-pace, fast-pace, dual-task and narrow-path conditions with mobility disability, defined by any self-reported difficulty walking ¼ mile assessed annually, were tested by Cox proportional hazard models adjusted for demographic and health characteristics. Models were fitted for each walking condition and R^2 statistics were used to compare predictive value across models. Models were repeated for persistent mobility disability, defined as at least two consecutive years of mobility disability.

Results: Mobility disability occurred in 204 (60.5%) participants over the 8-year follow-up. There was a lower hazard of developing mobility disability with faster gait speed under all conditions. Hazard ratios, confidence intervals, and r^2 of gait speed predicting mobility disability

Corresponding Author: Andrea L Rosso, 5137 Public Health, 130 DeSoto St, Pittsburgh PA 15261, alr143@pitt.edu.
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Rosso – Study design and concept, data analysis and interpretation of data, preparation of manuscript
Metti – data analysis, preparation of manuscript
Faulkner – data acquisition, preparation of manuscript
Brach – preparation of manuscript
Studenski – preparation of manuscript
Redfern – preparation of manuscript
Rosano – Study design and concept, interpretation of data, preparation of manuscript
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were very similar across all four walking conditions (r^2 range 0.22–0.27), but were strongest for dual-task gait speed (HR (95% CI), r^2 of fully adjusted models: 0.81 (0.75, 0.88), 0.27). Results were comparable for persistent mobility disability (r^2 range 0.26–0.28).

Conclusion: Slower gait speed under both usual-pace and complex conditions may be clinical indicators of future risk of mobility disability. These results support the call for increased use of gait speed measures in routine geriatric care.

Keywords

Gait Speed; Fast Pace; Dual Task; Mobility Disability

Introduction

The ability to walk moderate distances outside of the home is necessary for completion of many essential activities, including shopping and accessing healthcare[1–3]. Community mobility promotes physical function, social engagement, independent living, and higher quality of life[4–8]. Several indicators for future risk of mobility disability have been proposed, but few can be easily measured in the clinic.

A minimum gait speed is necessary for successful community mobility[2, 3] and gait speed as measured in the clinic under simple, usual-pace conditions is a strong and independent predictor of mobility disability. However, usual-pace gait speed tests may not be the best indicator for changes in community mobility. Community mobility occurs in the context of complex community environments and therefore, requires cognitive resources and behavioral flexibility to address environmental challenges such as terrain characteristics, attentional demands, and postural transitions[1]. Usual-pace gait speed tests do not appear to capture these complexities, but physical (e.g. fast-pace, narrow-path) or cognitive (e.g. dual-task) challenges can be added to increase the ecological validity of walking tasks and to unmask early, subtle changes in walking. Few studies have examined the value of complex locomotor tasks in predicting disability. A previous study found that failure on complex locomotor tasks (e.g. inability to generate responses to the cognitive component of a dual-task or inability to speed up during fast pace conditions) was associated with incident mobility disability over 3 years[9] but did not assess gait speed under complex conditions as a predictor. However, a dichotomous indicator of success or failure on these tasks may be more proximal to disability onset whereas slower gait speed during the tasks could be an earlier indicator of subtle changes leading to longer-term risk of mobility disability.

In this study, we assessed whether performance on complex walking tasks involving both physical (fast-pace and narrow-path) and cognitive (dual-task) challenges predicted greater risk for incident mobility disability (self-reported inability to walk ¼ mile) compared with usual-pace gait speed. We hypothesized that these complex walking tasks would be more strongly related to risk for mobility disability compared to usual-pace walking.

Methods

Sample

We utilized data from the Health Aging and Body Composition (Health ABC) study which enrolled community-dwelling black and white adults in Pittsburgh and Memphis from 1997–1998. Participants were 70–79 years old upon entry to the study and free of self-reported difficulties in performing activities of daily living, walking a quarter mile, or climbing 10 steps without resting. Men and black participants were oversampled. Dual-task walking was completed as part of an ancillary study (n=426) at the Pittsburgh site during the 2002–2003 study visit[10] which serves as the baseline for these analyses.

Of the 426 participants in the dual-task ancillary study, 337 participants were included in our analytic sample. Participants were excluded if they were unable to complete any walking task (n=89), had mobility disability at baseline (n=47), or did not have at least two follow-up measures for mobility disability between baseline and the final visit in 2010–2011 (n=35; categories not mutually exclusive). Participants who were included in these analyses did not significantly differ on demographic or comorbid characteristics from those not included.

All participants provided written informed consent and all protocols were approved by the local institutional review boards.

Walking Tasks

For all walking tasks, participants began before the start line and time was measured in seconds from the first footfall over the start line to the first footfall after the finish line. Walk times were recorded and converted to gait speed (m/s).

Usual-pace gait speed was measured over a 20 m walkway. Fast-paced walking was completed on the same 20 m walkway, with participants being asked to “walk as fast as you can”.

The dual-task paradigm used a concurrent visuospatial task as previously described[10, 11]. Briefly, participants were given a time of day prompt and were asked to visualize the time of day as displayed by the hands on an analog clock. Participants responded ‘same’ or ‘different’ based on whether the hands of the clock would be on the same side of a line passing through the 12 and 6 on the clock face or on different sides. The dual-task was completed while participants walked along a 20-meter corridor at usual-pace. Performance on the cognitive portion of the task was recorded; accuracy was high at 93%, so was not controlled for in these analyses.

For the narrow-path walking, participants were instructed to walk within a 6 m long and 20 cm wide path marked by tape[12]. Participants were asked to walk at a comfortable pace and not step on or outside of the lines. Participants were given up to three attempts to complete the task without stepping outside of the lines. If they were unable to complete the task without stepping out, they were excluded from these analyses.

Mobility Disability

Participants were asked every six months through the 2010–2011 visit if they had any difficulty walking a quarter mile, about 2 or 3 blocks, due to a health or physical problem[12]. Mobility disability was reported annually at in-person visits. Onset of mobility disability was defined as first onset of any reported difficulty. Persistent mobility disability was defined as at least two consecutive years with mobility disability.

Covariates

Variables associated with mobility[13] were considered as potential covariates. Demographic variables were recorded at study baseline and all other variables were assessed concurrently with the walking tasks. Demographic data including age, race, sex, and education were self-reported. Chronic diseases, including coronary heart disease (CHD), hypertension, and diabetes, were assessed through self-report, physician diagnoses, recorded medications and laboratory data. Isokinetic quadriceps strength was measured as average maximum torque on a dynamometer (125 AP, Kin-Com, Chattanooga, TN). Weak muscle strength was defined by gender-specific cut-offs for quadriceps strength (<97 Nm for men and <62 Nm for women)[14]. Poor vision was based on self-report of fair, poor, or very poor, with glasses or contact lenses if they wore them. Poor lung function was based on previously reported[15] gender-specific cutoffs for forced vital capacity as measured by spirometry (<3,066 mL for men and <2,127 mL for women) and was collected one year prior to our analytic baseline. Knee pain was self-reported for either knee most days in the past 30 days. Obesity was defined by a body mass index (BMI) greater than or equal to 30 kg/m^2. Global cognitive function was tested by the Modified Mini Mental Status Exam (3MS)[16]. Processing speed was assessed by the Digit Symbol Substitution Test (DSST)[17]. Cognitive testing were not completed at the 2002–2003 visit, so we took 3MS and DSST scores from one year prior to our analytic baseline. Depressive symptoms were assessed by the Center for Epidemiologic Studies Depression Scale (CES-D) short form[18]. Recurrent falls were defined as at least two falls reported in the past year.

Statistical Analyses

Descriptive statistics assessed differences between those who developed any mobility disability during the 8-year follow-up and those who did not by t-tests for continuous variables and chi-square tests for categorical ones.

Cox proportional hazard models were fitted separately to assess the risk of developing either mobility disability or persistent disability as a function of four predictor variables at baseline: 1) usual-pace gait speed, 2) fast-pace gait speed, 3) narrow-path gait speed, and 4) dual-task gait speed. Models were repeated with adjustment for basic demographic characteristics (age, gender, and race) and then for health characteristics that were associated with mobility disability in bivariate analyses (diabetes, CES-D scores, obesity, knee pain, low FVC, 3MS scores). Model fit and proportionality assumptions were tested. R^2 values are reported from all fully adjusted models to allow comparison of predictive value across models including different gait speed predictors.

All analyses were completed in SAS 9.4.

Results

Participants were 78.5 (SD=2.9) years of age on average, 50.7% were female, and 26.1% were black. By the end of the 8 year follow-up, 204 (60.5%) of the participants developed mobility disability and 131 (38.9%) developed persistent mobility disability. Individuals with incident mobility disability were more likely to be female, have diabetes, be obese, have knee pain, and have low pulmonary function (Table 1). Those who developed mobility disability also had higher depressive symptoms (Table 1).

Gait speed under all four conditions were correlated with one another, but not perfectly so (range of Spearman r: 0.53–0.80; all p<0.0001). The strongest correlation was between fast-pace and dual-task gait speeds.

In bivariate analyses, individuals who developed incident mobility disability had 9–13% slower gait speed under all conditions compared to those who did not (Figure 1). Cox proportional hazard models indicated a lower hazard of developing mobility disability with faster gait speed under all conditions (Table 2). These associations were robust to adjustment for demographic and health characteristics. Adjusted hazard ratios and confidence intervals were very similar across all four walking conditions, but were slightly stronger for dual-task gait speed compared to usual pace (HR (95% CI) of fully adjusted models: usual-pace = 0.84 (0.78, 0.90) and dual-task = 0.81 (0.75, 0.88)). Very similar results were obtained for persistent mobility disability (Table 2). The proportion of the variance of the outcome explained was similar across gait speed measures with marginal differences between all gait conditions for both outcomes (r^2 range for any mobility disability=0.22–0.27; r^2 range for persistent mobility disability=0.26–0.28).

Discussion

In a sample of community-dwelling older adults, we found that gait speed under both usual-pace and complex conditions was associated with greater risk for developing mobility disability over the next 8 years. Contrary to our hypothesis, usual-pace gait speed may provide sufficient predictive ability for future mobility disability compared to more complex walking tasks, while having the advantage of being easier to obtain in the clinic. Our results suggest that adding physical or cognitive challenges only marginally improves the predictive power of gait speed for mobility disability. Results were remarkably similar for persistent mobility disability as for any mobility disability.

A previous study indicated that failure on complex walking tasks under narrow (stepping out of the 25 cm width) and fast-pace (not accelerating by at least 0.1 m/s) conditions was predictive of 3-year incidence of self-reported mobility disability[9]. In contrast, failure on the dual-task condition (not generating any verbal response) was not associated. These failures may be more proximal to disability onset and may not provide an opportunity to capture the early, subtle signs of walking limitations that may be captured by measuring gait speed, as was done in our analyses. Further, failure on the tasks was not compared with the predictive value of usual-pace gait speed in those analyses[9]. A pooled analysis of over 27,000 participants in seven cohort studies previously demonstrated the effectiveness of usual-pace gait speed as a predictor of 3-year incidence of self-reported mobility disability[19]. Usual-pace gait speed is also predictive of objectively measured mobility disability over 21 months of follow-up[20]. We extend these previous results by showing that usual-pace gait speed can be predictive of incident mobility disability for up to 8 years and that dual-task walking may have a slightly higher predictive value. Of note, our models using gait speed along with demographic and health characteristics to predict mobility disability all had r^2 values below 0.29, suggesting that there are other, unmeasured contributors to mobility disability onset in our cohort. These contributors likely include environmental, behavioral, and social factors[21].

The lack of improved predictive power from the complex walking tasks, particularly dual-task walking, may be due in part to the relatively high cognitive function of our sample (mean 3MS score=94). We found in bivariate analyses that DSST, a measure of processing speed, and 3MS, a measure of general cognitive function, were not significantly associated with incident mobility disability. The association of cognitive function with usual-pace and dual-task gait speed is well established[22, 23] but the role of cognitive function in onset of mobility disability is less well studied. Two studies have indicated that a Folstein Mini-Mental State Examination (MMSE) score indicative of cognitive impairment (<24) is related to increased risk for self-reported mobility disability[24, 25], though one study indicated that this association was mediated through physical function[25]. A third study found no association of low MMSE scores with incident mobility disability[26]. A recent analysis utilizing cognitive assessments across multiple domains with objectively measured onset of mobility disability also found an association of cognitive function with mobility disability that was mediated through physical function[27]. Our results may not apply to those with cognitive impairment as we had few individuals with 3MS scores indicative of impairment. There is a need to repeat these analyses in a sample with a sufficient range of cognitive function to determine if these findings apply to those with lower cognitive function.

Our sample was relatively high functioning at baseline for a sample in their 70s. However, our sample did include a large proportion of individuals with risk factors for mobility disability. We did not have more detailed measures of gait, such as stance time variability, which may be more strongly related to mobility disability risk than speed alone[28, 29]. These more detailed measures of gait require instrumentation to measure and therefore, may not be as practical to implement clinically on a large scale. Finally, we only had a dual-task paradigm utilizing a visuospatial cognitive task and results may be different with other types of dual-tasks[30]. Our study benefited from a large, well-characterized cohort with a long follow-up for mobility disability that was assessed annually.

Mobility disability prevalence is estimated to be 31% in the Medicare population[31]. Mobility disability can have serious consequences for the health and well-being of older adults and should therefore, be a public health priority[32]. Early identification of those most at risk could enhance the effectiveness of prevention efforts. Usual-pace gait speed has proven to be a powerful predictor of many health outcomes in older adults, including falls[33], hospitalization[33, 34], and mortality[35]. Dual-task and fast-pace gait speed may add predictive value over usual-pace gait speed for both mobility disability and cognitive decline[36]. These results add to the growing body of evidence that gait speed represents a summary measure of health across multiple organ systems[37] and that it should be measured routinely in clinical settings as an indicator of those older adults most at risk for a number of health outcomes[38, 39].

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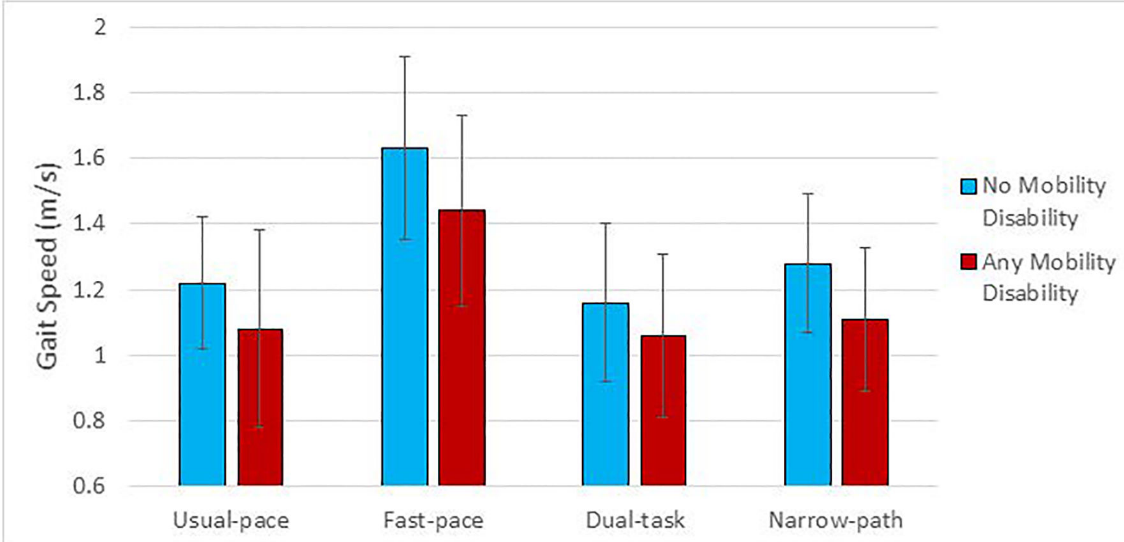

Figure 1.

Mean and standard deviation of gait speed (meters/second (m/s)) under usual-pace and complex conditions by those who did and did not develop mobility disability over 8 years of follow-up (n=337).

Table 1.

Baseline demographic, health, and gait characteristics of those who have incident mobility disability and those who remain free from mobility disability for 8 years (n=337).

		8-Year Incident Mobility Disability		
	Total Sample n=337	**Absent n=133**	**Present n=204**	
	Mean (SD) or n (%)	**Mean (SD) or n (%)**	**Mean (SD) or n (%)**	**p-value**
Age	78.5 (2.9)	78.2 (2.8)	78.8 (2.9)	0.07
Female sex	171 (50.7%)	58 (43.6%)	113 (55.4%)	0.03
Black race	88 (26.1%)	28 (21.1%)	60 (29.4%)	0.09
≤High school education	175 (51.9%)	62 (46.6%)	113 (55.4%)	0.1
CHD	78 (23.2%)	26 (19.6%)	52 (25.5%)	0.2
Diabetes	79 (23.4%)	19 (14.3%)	60 (29.4%)	0.001
Hypertension	300 (89.0%)	115 (86.5%)	185 (90.7%)	0.2
Recurrent falls in past year	95 (28.4%)	39 (29.8%)	56 (27.6%)	0.7
CES-D score	6.4 (6.5)	5.5 (5.9)	7.0 (6.8)	0.03
3MS score	94.1 (5.0)	94.7 (5.1)	93.7 (4.9)	0.07
DSST score	40.5 (11.2)	41.0 (10.6)	40.1 (11.5)	0.5
Obesity	91 (27.1%)	15 (11.3%)	76 (37.4%)	<0.001
Low quadriceps strength	82 (26.5%)	32 (25.4%)	50 (27.3%)	0.7
Knee pain	59 (17.5%)	10 (7.5%)	49 (24.0%)	<0.001
Low pulmonary function	114 (37.4%)	33 (27.3%)	81 (44.0%)	0.003
Poor vision	96 (28.7%)	35 (26.5%)	61 (30.1%)	0.5
Years of follow-up	9.7 (2.1)	9.7 (2.4)	9.7 (2.0)	0.9
Gait Measures				
Usual-pace gait speed (m/s)	1.14 (0.27)	1.22 (0.20)	1.08 (0.30)	<0.001
Fast-pace gait speed (m/s)	1.52 (0.30)	1.63 (0.28)	1.44 (0.29)	<0.001
Dual-task gait speed (m/s)	1.18 (0.23)	1.28 (0.21)	1.11 (0.22)	<0.001
Narrow-path gait speed (m/s)	1.11 (0.25)	1.16 (0.24)	1.06 (0.25)	<0.001

SD=standard deviation, CHD=coronary heart disease, CES-D=Center for Epidemiologic Studies Depression Scale, 3MS=Modified Mini Mental Status Exam, DSST=Digit Symbol Substitution Test, Nm=Newton meter, FVC=forced vital capacity, m/s=meters/second

Table 2.

Hazard ratios (HR) per 0.1 m/s difference in gait speeds under different conditions with incidence of mobility disability over 8 years of follow-up (n=33).

	Model 1	Model 2	Model 3	
	HR (95% CI)	HR (95% CI)	HR (95% CI)	r-square
Any MD				
Usual-pace gait speed	0.82 (0.77, 0.86)	0.83 (0.78, 0.88)	0.84 (0.78, 0.90)	0.26
Fast-pace gait speed	0.82 (0.77, 0.86)	0.82 (0.77, 0.87)	0.87 (0.81, 0.93)	0.24
Dual-task gait speed	0.76 (0.71, 0.81)	0.77 (0.72, 0.82)	0.81 (0.75, 0.88)	0.27
Narrow-path gait speed	0.84 (0.79, 0.89)	0.85 (0.80, 0.91)	0.90 (0.84, 0.97)	0.22
Persistent MD				
Usual-pace gait speed	0.80 (0.75, 0.86)	0.82 (0.76, 0.88)	0.82 (0.76, 0.89)	0.28
Fast-pace gait speed	0.77 (0.72, 0.83)	0.77 (0.72, 0.83)	0.83 (0.76, 0.90)	0.28
Dual-task gait speed	0.74 (0.68, 0.80)	0.74 (0.68, 0.81)	0.80 (0.73, 0.88)	0.28
Narrow-path gait speed	0.80 (0.74, 0.86)	0.81 (0.75, 0.88)	0.86 (0.79, 0.95)	0.26

MD=mobility disability, HR=hazard ratio

Model 1 – unadjusted

Model 2 – adjusted for age, sex, race

Model 3 – Model 2 + diabetes, CES-D, obesity, knee pain, low FVC, 3MS

*r2 shown for model 3