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Mobility Stress Test Approach to Predicting Frailty, Disability, and Mortality In High Functioning Older Adults

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Abstract

Background—A major challenge to developing primary preventive interventions for frailty and disability in older adults is lack of validated simple clinical tools to identify high-risk individuals without overt signs of poor health.

Objectives—To examine the validity of the Walking While Talking test (WWT), a mobility stress test, to predict frailty, disability and death in high functioning older adults.

Design—prospective cohort study.

Setting—Community sample.

Participants—631 community-residing adults age 70 and older participating in the Einstein Aging Study (mean follow-up 32 months). High functioning status at baseline was defined as absence of disability, dementia, and normal walking speeds.

Main outcome measures—Hazard ratios for frailty, disability, and all-cause mortality. Frailty was defined as presence of three out of the following five attributes: weight loss, weakness, exhaustion, low physical activity and slow gait. We also compared predictive validity of WWT with Short Physical Performance Battery (SPPB) for study outcomes.

Results—218 subjects developed frailty, 88 disability, and 49 died. Each 10 cm/s decrease in WWT speed was associated with increased risk of frailty (Hazard ratio 1.12, 95% CI 1.06 to 1.18), disability (Hazard ratio 1.13, 95% CI 1.03 −1.23), and mortality (Hazard ratio 1.13, 95% CI 1.01 – 1.27). Most associations remained robust even after accounting for potential confounders and gait speed. Comparisons of HR and model fit suggest that WWT may better predict frailty whereas SPPB may better predict disability.

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Conflict of Interest:

Conclusion—Mobility stress tests such as the WWT are robust predictors of risk of frailty, disability, and mortality in high functioning older adults.

Keywords

Mobility; Frailty; Disability; Mortality; Gait

INTRODUCTION

Presence of disability in older adults is associated with loss of independence, institutionalization, and death.[1] Even a small reduction in disability may translate into large health care savings and improvements in the physical, emotional and social well-being of seniors.[2] The concept of "frailty" is used to identify older adults at high risk for disability and death.[3, 4] Frailty is characterized by low physiological reserves and vulnerability to illness and other stressors. While many frailty and disability specific interventions have been proposed,[5] almost none target older adults before the onset of these conditions. Interventions aimed at preventing rather than treating frailty and disability are likely to have a greater impact on the overall health of the population.[2]

A major challenge to developing primary preventions for frailty and disability is the difficulty in identifying high-risk individuals among older adults without overt signs of poor health. Stress tests are routinely used to predict risk of conditions such as ischemic heart disease and may provide a new diagnostic strategy to reveal reduced functional reserves, not apparent on routine clinical evaluation, in high functioning elderly. The 'Walking While Talking' (WWT) test, a cognitive-motor divided attention task that requires individuals to walk while reciting alternate letters of the alphabet, may help unmask latent mobility abnormalities by increasing the complexity of the walking condition. [6] The WWT test predicts falls, [6, 7] but its utility to predict other health outcomes is not known.

We undertook this prospective cohort study to determine the predictive validity of WWT for risk of developing frailty, disability, and all-cause mortality in high functioning older adults.[8] We compared WWT to the Short Physical Performance Battery (SPPB). While predictive validity of SPPB for disability is established,[9] there is limited information on its role in predicting frailty or mortality. We hypothesized that the WWT would reveal latent mobility abnormalities, which in turn would predict adverse outcomes.

METHODS

Study Population

We undertook a prospective cohort study nested within the Einstein Aging Study (EAS). The primary aim of the EAS is to identify risk factors for dementia. Study design has been reported.[10] In brief, potential participants (age 70 and over) identified from Bronx County population lists were contacted by letter explaining the purpose and nature of the study, and then by telephone. Participants who gave verbal consent on the telephone were invited for in-person evaluation at our research center. Exclusion criteria included severe impairments in auditory (unable to follow questions asked in a loud voice) or visual function (corrected vision <20/400), bed bound, and institutionalization. Additional exclusion criteria for this study included presence of dementia diagnosed at consensus case conferences,[10] disability (defined below),[11] or slow gait (1.5 standard deviations below age- and sex-specific mean values established in our cohort[12]). Written informed consents were obtained at enrollment according to protocols approved by the local institutional review board. Clinical assessments were completed at baseline and at yearly follow-up visits. In between visits, participants were contacted by telephone every 2-3 months.

Outcomes

Study outcomes included frailty, disability, and all-cause mortality. Using the Cardiovascular Health Study criteria[3], the frailty endpoint was reached when participants met at least three out of the following five attributes: unintentional weight loss (>10% per year), muscle weakness (poor grip strength[3]), self-reported exhaustion, [13] low physical activity, and slow gait.[12] During clinic visits and interim telephone interviews, participants were assessed for disability with a validated scale.[8, 11] Disability was operationalized as needing assistance or inability to perform any one of seven activities of daily living: bathing, walking inside home, chair rise, dressing, feeding, toileting and grooming. To exclude transient disability episodes, our criteria required that disability duration was at least 6 months or that there was major functional decline that resulted in change in living situation (such as nursing home placement). Participants' proxies reported deaths via telephone or mail. Death reports were confirmed by linkage to the Social Security Death Index. Deaths reported until February 2011 was included.

WWT and other mobility measures

Speed (cm/s) during normal pace walking and WWT was measured using a computerized walkway with embedded pressure sensors (GAITRite, CIR systems, Havertown, PA) in a quiet well-lit room. Participants wore comfortable footwear and did not have any attached monitors.[14] Participants walked for two trials each for normal pace and WWT conditions on a walkway with 15 feet (457.2 cm) recording surface till July 2008. Following which, assessments were done for one trial on a walkway with 20 feet (609.6 cm) recording surface. For WWT, participants started walking when asked by the assistant while reciting alternate letters of the alphabet (e.g.; a, c, e.) paying equal attention to their walking and talking to avoid task prioritization. [15] The order of the initial letters on WWT was randomly varied between 'A' and 'B' to minimize practice effects.[16] Start and stop points were marked by white lines on the floor, and included three feet (four feet for longer walkway) from the edge of the recording surface to account for initial acceleration and terminal deceleration. The GAITRite system has excellent validity and test-retest reliability.[10, 14] The correlation for gait speed measured on the two walkways in 20 participants was excellent (Pearson r = 0.94). Reliability between two consecutive walking trials was excellent (r = 0.96). Mean WWT time over 20 feet was 13.01 ± 8.11 seconds.

The SPPB includes tests of balance, gait speed, and chair rise.[17] A categorical score in each of the three areas (0–4) and a summary score is determined (0–12, higher better). The SPPB can be completed in five minutes.

Covariates

Presence of depression, diabetes, heart failure, hypertension, angina, myocardial infarction, strokes, Parkinson's disease, chronic obstructive lung disease, and arthritis was used to calculate a summary illness index.[10, 18] Self-reported falls in last 2 months was recorded. Study clinicians consulted medical records, family members or physicians to verify or obtain further details. General cognitive status was assessed by the Blessed-Information-Memory concentration test.[19]

Data analysis

Analysis of variance for continuous variables and χ^2 tests for categorical variables were used to test differences in baseline characteristics by outcome status. Crude outcome rates were calculated per 1000 person-years. Cox proportional hazard models were used to assess hazard ratios (HRs) for disability, frailty, and all-cause mortality in separate models. The association of predictors (WWT, gait speed and SPPB) with study outcomes was

individually examined in basic models adjusting for demographic factors (age, sex and education) as well as in fuller models that also included potential confounders (medical illness index, medication count, Blessed test score, and previous falls). Since gait speed is a key criterion for frailty,[3, 20] it was not examined as a predictor in the frailty analysis. We report gait and WWT speed as 10 cm/s difference.[14] To enhance clinical utility, we also examined various WWT speed cutscores as predictors of study outcomes. Time to event was from enrollment to interview at which frailty or disability was diagnosed, or date of death in mortality analysis, and to final contact or visit for remaining participants. Frailty was diagnosed only in-house and not on the telephone as it required in-person assessments.[3] To compare predictors, we computed HR corresponding to one standard deviation (SD) unit difference in the predictors at baseline with each outcome in fully adjusted models. The proportional hazards assumptions held for all outcomes. To identify which test best predicted outcomes, we used Akaike Information Criterion as the goodness-of-fit measure to compare best model fit. All statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, N.C.).

RESULTS

Study population

This study began on August 2004 and the first telephone interview was administered in December 2004. Study follow-up ended April 2011. Of the 816 EAS participants seen during this 81-month period, at enrollment 31 were diagnosed with dementia, 25 were disabled, 100 had slow gait, and 29 had missing information. Excluded participants were older (81.5 vs. 79.9 years, $p < 0.001$), had worse Blessed[19] scores (3.4 vs. 1.9, $p < .001$), and walked slower (mean speed 65.9 vs.100.5 cm/s, $p < .001$) than the 631 eligible participants.

Of the 631 participants, 594 (93%) completed one or more telephone interviews. Major causes for attrition included awaiting study visit and loss of contact. The 594 participants had 1801 in-house and 6599 telephone assessments (mean follow-up 32 ± 18 months). Mean number of in-house and telephone interviews was 3.0 and 11.1, respectively. Table 1 presents baseline characteristics of the sample. Average age was 79.9 years. There were 246 men (39%) and 385 women (61%). The mean gait speed was 100.5 ± 17.8 cm/sec, WWT speed 70.5 ± 25.5 cm/sec, and SPPB score 9.9 ± 1.7. Correlation of gait speed with SPPB (Pearson $r = 0.53$) and WWT ($r = 0.51$) was moderate, and lower correlation was seen between SPPB and WWT ($r = 0.32$).

Frailty

One subject met frailty criteria[3] at baseline and 164 lacked follow-up visits. There were no significant differences on baseline performance on WWT and SPPB in subjects with and without frailty follow-up. Of the remaining 473 participants, 218 developed frailty (incidence rate 202/1000 person years). Median time to frailty was 14 months. WWT speed (HR per 10 cm/s change 1.12, 95% CI 1.06 to 1.18) and SPPB (HR per 1-point decrease 1.15, 95% CI 1.06 to 1.24) predicted frailty (Table 2, fully adjusted models).

Examined simultaneously in fully adjusted models, effects of WWT speed and SPPB on incident frailty remained significant. HR corresponding to 1 SD unit lower scores in WWT and SPPB are 1.28 (95% CI 1.11 to 1.48) and 1.19 (95% CI 1.04 to 1.37), respectively. Model comparisons indicated that WWT had better fit (lower scores better) compared to SPPB (Table 2).

Disability

Out of the 594 nondisabled participants with follow-up, 88 developed disability (incidence rate 55/1000 person years). Median time to disability was 25.2 months. WWT speed (HR 1.13, 95% CI 1.03 to 1.24), SPPB (HR 1.23, 95% CI 1.08 to 1.40) and gait speed (HR 1.15, 95% CI 1.01 to 1.32) predicted disability in fully adjusted models (Table 2). Exclusion of disability events in the first 12 months did not materially change results (data not shown).

Examined simultaneously in fully adjusted models, SPPB (HR 1.19, 95% CI 1.02 to 1.39) but not gait speed (HR 0.98, 95% CI 0.82 to 1.16) predicted incident disability, while the effect of WWT became borderline significant (HR 1.10, 95% CI 0.99 to 1.22). Model comparisons indicated that SPPB followed by WWT had better fit than gait speed in the full models.

Mortality

Forty nine subjects died during the study follow-up (incidence rate 25 per 1000 person year). WWT (HR 1.14, 95% CI 1.01 to 1.28), gait speed (HR 1.38, 95% CI 1.13 to 1.69) and SPPB (HR 1.25, 95% CI 1.06 to 1.47) were all associated with the risk of mortality (Table 2, fully adjusted models). Model comparisons indicated that gait speed had better fit than SPPB or WWT.

WWT cutscores

Table 3 shows WWT velocity cutscores as predictors of frailty and disability. WWT cutscores did not predict mortality (data not shown).

DISCUSSION

In this prospective study of a large, well-characterized cohort of community residing high functioning older adults with normal walking speeds, WWT was a strong predictor of major health outcomes supporting the mobility stress test approach. The WWT test by cognitively stressing locomotion demands might help capture dysfunction early. Each 10 cm/s change in WWT speed was associated with a 12% increased risk of developing frailty, 13% risk of disability, and 13% risk of mortality. Most associations remained robust even after accounting for several potential confounders including gait speed. The risks associated with WWT speed categories (Table 3) provide a clinically useful assessment of health risk. For instance, participants with the WWT speed less than 70 cm/sec (mean WWT speed) had a 93% increased risk of developing frailty and a 82% increased risk of developing disability compared to participants with WWT speed greater than 70 cm/s.

All participants, representing a wide range of education and cognitive performance, completed WWT supporting feasibility. The choice of test, WWT or SPPB, will depend on clinicians' needs. Both WWT and SPPB predicted all our study outcomes. Comparisons of HR and model fit suggest that WWT may better predict frailty whereas SPPB may better predict disability. The shorter WWT (mean 13 seconds) is a reliable and valid alternative to SPPB (5 minutes) in busy clinical settings.

Gait speed is reported to contribute most of the explanatory power of SPPB for disability.[17] In our high functioning cohort, gait speed predicted disability but not when examined with WWT and SPPB. This study corroborates the longitudinal association of SPPB with disability and mortality in older adults,[9] and extends its role to predicting incident frailty building on cross-sectional associations reported in our cohort.[8]

Limitations

These results are preliminary and need cross-validation in other cohorts. Our definition of high functioning status is similar to previous studies,[9] but we excluded subjects with slow gait using local norms.[12] Cutscores such as 70 cm/s are used to define slow gait,[21] but are not generally based on normative data and bias against oldest participants. Unlike normal walking speed, WWT and SPPB are not used to define frailty reducing diagnostic circularity. Visual impairment was not included as a covariate as it did not predict falls, which are closely related to our study outcomes, in our cohort.[14] Visual loss is not well established as a predictor of our study outcomes. Furthermore, our parent study criteria excluded more severe cases of visual loss. Nonetheless, as with any observational study, the risk of unmeasured or residual confounding remains a possibility. We used quantitative techniques, but WWT speed can be easily measured using a stopwatch.[6] While the predictive validity might be improved by considering errors on WWT, it will make it more difficult to apply in clinics. Alternate letters recitation at rest was not available to calculate dual task cost on WWT. The need for instrumented methods may limit the use of other variables such as gait variability in clinical practice but should be studied in research settings.[14] Other WWT versions (walking while counting numbers or names[7]) are not equivalent in their stressor effects, and their predictive validity for health outcomes should be defined.

Our results suggest that WWT is a robust and valid predictor of frailty, disability, and mortality in high functioning older adults. Given the expected increase in absolute number of older adults with frailty and disability, developing primary preventive approaches is a national health priority.[22] Our findings can guide clinical practice and research. In primary care clinics or community health screening, the quick and simple WWT can be used by clinicians or health workers to identify high-risk older individuals without overt signs of poor health to initiate investigations, rehabilitative interventions, and plan frequency of follow-up to monitor function. The findings could help researchers plan primary preventions for frailty and disability.

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Table 1

Baseline variables in overall sample and by outcome groups

Variable	Overall	Developed Frailty	Developed Disability	Died
N	631	218	88	49
Age, y (mean ± SD)	79.91±5.27	80.19±4.94	82.38±5.79 **	81.77±5.82 *
Ethnicity, white %	70.2	72.5	69.3	73.5
Female, %	61.0	66.1 *	69.3	44.9 *
Education, y (mean ± SD)	14.24±3.44	14.34±3.22	14.18±3.57	13.12±3.30 **
Illness index score (mean ± SD)	1.26±1.03	1.41±1.07 **	1.41±1.16	1.84±1.42 **
Medication count (mean± SD)	3.48±2.62	3.52±2.69	3.27±2.64	3.74±3.13
Fall previous 2 months, percent	10.1	14.2	14.8	8.2
Blessed test (mean ± SD), range 0-32	1.85±1.96	1.93±1.91 *	2.182±2.01	2.06±1.70
Gait speed, cm/s	100.53±17.79	95.65±16.27 **	94.08±18.69 **	92.60±16.99 **
WWT speed, cm/s	70.49 ±25.46	66.97±24.16 **	62.27±26.26 **	64.19±22.37
SPPB, 0-12	9.91± 1.70	9.63±1.63 **	9.25±1.70 **	9.27±2.12 *

* p<0.05 (compared to participants who did not develop the outcome),

** p<0.01 (compared to participants who did not develop the outcome).

WWT: Walking While Talking test, SPPB: Short Physical Performance Battery

Table 2

Association of study predictors with frailty, disability, and death.

	Hazard ratio (95% CI, p-value) adjusted for age, gender and education	Hazard ratio (95% CI, p-value) Multivariate adjustment*	Model fit (multivariate model)**
Frailty			
WWT speed (10 cm/s change)	1.12 (1.06-1.18, p<.0001)	1.12 (1.06-1.18, p=0.0001)	2344.5
SPPB (1 point change)	1.19 (1.10-1.29, p<.0001)	1.15 (1.06-1.24, p=0.0008)	2349.9
Disability			
WWT speed (10 cm/s change)	1.13 (1.03-1.23, p=0.007)	1.13 (1.03-1.23, p=0.008)	971.3
SPPB (1 point change)	1.26 (1.11-1.44, p=0.0004)	1.23 (1.08-1.40, p=0.002)	969.4
Gait speed (10 cm/s change)	1.19 (1.03-1.36, p=0.016)	1.15 (1.01-1.32, p=0.040)	974.1
Death			
WWT speed (10 cm/s change)	1.13 (1.01-1.27, p=0.041)	1.14 (1.01-1.28, p=0.038)	541.1
SPPB (1 point change)	1.27 (1.08-1.48, p=0.004)	1.25 (1.06-1.47, p=0.009)	539.2
Gait speed(10 cm/s change)	1.43 (1.17-1.75, p=0.0005)	1.38 (1.13-1.69, p=0.002)	535.0

*Cox models including each predictor examined individually and all potential confounders (age, sex, education, medical illness index, total prescription medication count, Blessed test score, and previous falls).

**The Akaike Information Criterion (AIC) was used as the goodness-of-fit measure to compare best model fit among the study predictors. Results are shown for the multivariate adjusted final model. The smaller the value, the better the fit for the same outcome.

Table 3
WWT cutscores and risk of frailty and disability

Associations with outcomes are reported as Hazard ratios (95% CI, p-value) adjusted for age, gender and education.

WWT cutscores	Frailty	Disability
≤70 cm/s (versus >70 cm/s)	1.93 (1.47 – 2.55, p<0.0001)	1.82 (1.15 – 2.86, p = 0.010)
≤60 cm/s (versus >60 cm/s)	1.79 (1.35 – 2.36, p<0.0001)	1.35 (0.88 – 2.01, p = 0.172)
≤50 cm/s (versus >50 cm/s)	1.46 (1.06 – 2.99, p<0.0001)	1.51 (0.96 – 2.37, p = 0.072)