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Assessing Fatigability in Mobility-Intact Older Adults

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Abstract

OBJECTIVES—Evaluate criterion validity of two measures of fatigability defined as performance deterioration or perceived effort to perform a standardized task.

DESIGN—Cross-sectional analysis of data from the Baltimore Longitudinal Study of Aging (BLSA).

SETTING—National Institute on Aging, Intramural Research Program, Clinical Research Unit, Baltimore, Maryland.

PARTICIPANTS—Six hundred five men (53.7%) and women (aged 65–97) participating in the BLSA eligible for endurance walk testing without a walking aid.

MEASUREMENTS—Fatigability was assessed using (1) completion status and lap times from a 400m-walk performed “as quickly as possible” and (2) perceived exertion rating using the Borg scale (range 6–20) following 5 minutes of treadmill walking at 1.5mph (0.67m/s). Criterion measures include self-report of tiredness, level of weakness and energy in past month and walking ability and objective measures of usual and fast gait speed, time to complete 10 chair stands and grip strength. Co-variates include age, race, sex, obesity, smoking status and walking activity.

RESULTS—Among mobility intact older persons, 23% exhibited performance deterioration (i.e., slowed or stopped) during the 400m-walk and 1/3 reported more than very light exertion following a 5-minute slow walk. Slowing was strongly associated with self-reported fatigue and walking ability, but weakly associated with performance-based mobility measures. High perceived exertion was associated with tiredness and weakness and reported and observed mobility deficits.

CONCLUSION—Slowing down may have low sensitivity for identifying fatigability in older persons, but ascertaining perceived exertion during a defined workload shows promise. In seemingly healthy, motivated individuals, fatigue and fatigability were common and may impact socially meaningful mobility behaviors. Assessment of fatigability in well-elderly examinations may help identify threats to independent functioning earlier in the decline process.

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Keywords

fatigue; fatigability; performance measures; validation; mobility

INTRODUCTION

Fatigue is a common complaint among older persons with increasing fatigue considered to underlie the activity reduction^{1,2} and functional decline frequently observed in older age.^{3,4} Prevalence estimates range widely and although some studies report fatigue increases with age⁴ others find no strong age relationship.⁵ Although fatigue is associated with most end-stage diseases and is an independent risk factor for mortality,^{4,6} there exists little empirical evaluation of the relationship between fatigue and functional status of older adults with a few notable exceptions.⁷⁻⁹

The paucity of research and inconsistent findings stem from the lack of a uniform definition and approach to measuring fatigue. Assessments vary from a few items extracted from depression screening instruments¹⁰ to disease-specific questionnaires¹¹ and task-specific scales.⁷ Unbiased ascertainment of general fatigue is plagued by how individuals typically respond to symptoms; that is, by reducing activity to remain below their fatigue threshold.³ Thus, reported fatigue levels may be similar even when the intensity of activity that brings on fatigue differs substantially.

The fifth Bedside-to-Bench conference, “Idiopathic Fatigue and Aging,” identified development of fatigue measurement tools as instrumental for further understanding of factors that contribute to fatigue and fatigability, a newly defined construct, and the role that fatigability plays in disablement.¹³ In this context, fatigue refers to a perceived lack of physical energy and weariness and fatigability reflects: (i) perceived inability to continue an activity at the same intensity with resultant performance deterioration and (ii) the degree of fatigue experienced in relation to performing a standardized activity.^{1,3}

This study evaluates the criterion-related validity of two newly developed performance-based fatigability measures. The first targets performance deterioration assessed as marked slowing or inability to complete a fast pace 400m-walk; the second targets degree of fatigue experienced or analogously, perceived exertion during a standardized activity – walking 1.5mph (0.67m/s) on a treadmill for 5 minutes. To test concurrent validity, we examined the association between each fatigability measure and reported fatigue symptoms such as tiredness, weakness and low energy. For predictive validity, we examined the association with reported walking ability and measured performance including usual and fast gait speed, time to complete 10 chair stands and grip strength.

METHODS

Participants

The study population consisted of 605 men (53.7%) and women aged 65 to 97 years participating in the Baltimore Longitudinal Study of Aging (BLSA), a continuous enrollment cohort study of normative aging. Eligibility at enrollment is restricted to persons free of cognitive impairment, functional limitations, chronic diseases and cancer within the past 10 years. Participants receive regularly scheduled comprehensive health, cognitive and functional evaluations over a three day visit to the BLSA clinical facility. Visits occur every four years for persons under age 60, biannually for persons aged 60 to 79 years and annually for persons aged 80 and older. Participants in the current study were seen between March 2007 and May 2011.

The performance deterioration sample consists of 588 BLSA participants eligible for the Long Distance Corridor Walk (LDCW; described below) and non-dependent on a walking aid. The perceived exertion sample consists of 470 BLSA participants seen after July 2007 when the slow treadmill walk was implemented and constitutes a subsample of the performance deterioration group. Seventeen persons in the perceived exertion sample were not administered the LDCW due to health-related exclusion (n=7) or clinic administrative issues (e.g., shortened visit, staffing limitations) that precluded testing (n=10).

Fatigability Measures

Performance deterioration was assessed using the LDCW, a two-stage, self-paced endurance walk test performed over a 20m course. Stage one consists of a 2.5-minute walk in which participants are instructed to walk at their usual pace; stage two follows immediately and consists of a 400m-walk done “as quickly as possible at a pace that can be maintained”.^{14,15} The BLSA version collects individual lap times for ten 40m laps during the 400m component. Persons eligible for the LDCW who: (1) were unable to begin the 400m-walk after completing the first stage, (2) were unable to complete 400m without stopping or (3) exhibited marked slowing over the ten laps were considered to exhibit *performance deterioration*. Marked slowing was defined as an increase in lap time between the second and ninth laps of at least 6.5%. The second and ninth laps were used to minimize the effect of a faster than average starting and ending pace in anticipation of the finish. The value of 6.5% showed the best discrimination between persons reporting low and high energy level in the past month (see below).

Perceived exertion

Immediately following a slow paced 5-minute walk (1.5 mph; 0.67 m/s) performed on a treadmill at zero percent grade participants are asked to rate their perceived exertion using the Borg RPE scale ranging from 6 to 20, where 6=no exertion at all, 9=very light, 11=light, 13=somewhat hard and 20=maximal exertion.¹⁶ The speed of 0.67 m/s was selected because it distinguishes frail from non-frail individuals¹¹ and is sufficiently low demand to minimize participant exclusion. All persons non-dependent on walking aids were included. Given the low demand nature of the task, high fatigability was defined as an RPE 10 which corresponds to perceived exertion just exceeding very light. For comparison, ratings of 11 or greater are considered in the training range.¹⁷

Fatigue Measures

Measures of fatigue were examiner-administered and reference the past month and cover perceived tiredness, weakness and energy level. All measures were dichotomized with cutpoints selected to identify between 20 and 30 percent as having each symptom, with the exception of tiredness where due to limited dispersion 42.5% were identified as having tiredness. Persons reporting they “felt unusually tired during the day” all, most or some (versus none) of the time were considered to exhibit tiredness. Participants rating their weakness level as 3 or greater on an 11-point scale where zero equals not weak at all and 10 very weak were coded as reporting weakness. Those rating their usual energy level as 6 or lower on an 11-point scale where zero represents no energy at all and 10 the most energy ever had were considered to have low energy. A second energy item comes from the Short Form-12,¹⁸ in which persons reporting they had “a lot of energy” some, a little or none (versus all, most or a good bit) of the time were treated as expressing low energy.

Walking Ability and Physical Performance Measures

Reported walking ability was determined from responses to a set of questions beginning with, “Because of a health or physical problem, do you have any difficulty walking a quarter

of a mile that is about 2 or 3 blocks, without stopping?" Those reporting difficulty were asked whether they had a little, some or a lot of difficulty or were unable to walk. Persons expressing no difficulty were asked how easy it is to walk a quarter of a mile – very, somewhat, or not so easy – followed by whether they have any difficulty walking one mile and the ease of walking one mile if no difficulty was reported.¹⁹ Responses were combined to create a walking ability index ranging from 0 to 9, where 0 represents unable to walk ¼ mile and 9 indicates walking one mile is very easy.²⁰ Performance-based evaluations included usual and rapid gait speed assessed over a 6m course with the fastest of two trials used for analysis, 10 repeated chair-stands with stands per second the unit of analysis and grip strength using the highest value of up to three trials on each side.

Covariates

Covariates encompass socio-demographic factors including age, sex and self-identified black or non-black race and behavioral factors known to impact functional performance including smoking history dichotomized as current or recent smoker (smoked regularly within the past 10 years) versus never or former smoker (stopped smoking for at least 10 years), obesity defined as a body mass index of 30 kg/m² or greater derived from measured weight and height and recent walking activity.

Statistical Analyses

For the primary analyses, the odds of reporting each fatigue symptom by both measures of fatigability were determined from logistic regression analyses controlling for age, sex, race, smoking, obesity and recent walking activity. Reported walking ability and the performance measures were examined as continuous variables with adjusted mean values compared by fatigability status using least square means controlling for age, sex, race, smoking, obesity, recent walking activity and height for grip strength only. Perceived exertion following the slow treadmill walk was also examined as a continuous measure using logistic regression to examine likelihood of fatigue symptoms associated with a unit change and linear regression to evaluate the associations with reported and observed functional performance. Analyses were conducted using SAS software version 9.1 (SAS Institute Inc., Cary, NC).

RESULTS

Population characteristics for the performance deterioration and perceived exertion samples are presented in Table 1. Persons exhibiting fatigability on either measure were generally older, more likely to be women and less likely to have done any brisk walking in the past two weeks.

Performance Deterioration

Of the 588 participants in the *performance deterioration* sample, 134 (22.8%) met criteria for marked slowing. Of this group 10 did not continue on to the 400m-walk after the 2.5-minute usual pace walk, 31 stopped the 400m-walk before completion and 93 slowed between the second and ninth laps at least 6.5%. Those exhibiting performance deterioration had higher rates of fatigue symptoms, including tiredness, weakness and low energy in the past month (Table 2) and poorer reported walking ability (Table 3), independent of age, race, sex, obesity, smoking history and walking activity. These relationships held when persons who stopped were excluded from the analyses (data not shown). Differences in physical performance were less striking with only usual gait and chair stand speed achieving statistical significance (Table 3). In analyses excluding the 41 persons who stopped, no differences in any physical performance test emerged (data not shown).

Perceived Exertion

Of the 470 participants in the perceived exertion sample, 149 (31.7%) had a Borg RPE 10 following a 5-minute walk at 1.5 mph (0.67 m/s) on a treadmill at zero percent grade.

Overall, Borg scores ranged from 6 to 18 with 9 as the median. Persons reporting an RPE 10 were 60 to 100% more likely to report fatigue symptoms than those with ratings below 10 (Table 2). They also reported a lower average walking ability and demonstrated poorer usual and fast pace walking and repeated chair-stand and grip strength performance (Table 3; $p < .001$ for all).

Using Borg RPE as a continuous measure, each additional point was associated with a 15% increase in the likelihood of reporting each fatigue symptom (all $p < .005$ adjusted for age, sex, race, obesity, smoking history and walking activity). There was also a strong relationship with the functional outcomes with each additional point associated with a reduction of 0.19 points on the walking ability index, 0.021 and 0.028 m/s for usual and fast gait speed respectively, 0.014 chair stands per second and 0.46 kg of grip strength (all $p < .001$ adjusted for age, sex, race, obesity, smoking history, walking activity and height for grip strength only).

DISCUSSION

In a mobility-intact population of older adults aged 65 years and older, the two fatigability measures, performance deterioration during a self-paced endurance walk test and perceived exertion following a slow treadmill walk, identified 23 and 32% respectively, as having high fatigability. Both performance deterioration and perceived exertion demonstrated good concurrent validity in showing consistently strong associations with each fatigue symptom. As for predictive validity, performance deterioration had a robust relationship with reported walking ability, but weak associations with the physical performance measures which were driven largely by inability to continue walking as slowing alone was not predictive. In contrast, perceived exertion exhibited a robust association with both reported and observed function whether used as a threshold or continuous measure.

Performance on the LDCW and the 400m-walk component in particular has a well-established prognostic relationship with mortality and mobility limitation^{21,22} and several studies of aging include a version of this well-tolerated assessment of exercise tolerance.¹⁴ This study found taking lap splits useful for identifying persons with high fatigability primarily manifest in a propensity to report global fatigue symptoms and diminished endurance-related walking ability. Even though a 6.5% increase in lap time best discriminated those reporting low and high energy level, persons who slowed down even 5% consistently showed a higher prevalence of fatigue symptoms, especially low energy and tiredness ($p < .01$ for both). Additionally, although persons who slowed down tended to need more time to walk 400m overall, the differential averaged just 12 seconds and was largely accounted for by age, sex and race. Thus, slowing down is distinct from an overall slower walking pace.

Perceived exertion during a low demand activity discriminated among persons reporting fatigue symptoms and those with poorer functional ability along the full range of the measure and when used as a categorical classification. The primary limitation concerns use of a treadmill which may render this specific approach impractical for some research centers and clinics. Nevertheless, the discovery that reported exertion following a low demand workload identifies persons with a low fatigue threshold, suggests that inquiring about perceived exertion following other standardizable activities warrants further consideration. For example, Schnelle and colleagues²³ found tiredness level after completing a 10-minute

corridor walk at a self-selected pace highly correlated with gait speed, physical activity and general fatigue.

The primary study limitation concerns use of a sample of generally motivated compliant individuals with no overt mobility limitations. Whether testing for fatigability in more debilitated individuals would provide meaningful information or whether the majority of such individuals could even undergo or complete testing remains to be demonstrated. Findings from Schnelle²³ in an older less robust sample found 10 out of 43 unable to complete a 10-minute walk. In the current study, among the 30 persons unable to complete the full LDCW who were seen after implementation of the treadmill test, only 15 participated in the slow treadmill walk. These observations indicate that fatigability testing may be most suitable as an early marker of diminished capacity in otherwise well-functioning individuals. To fully evaluate the potential research and clinical utility of these fatigability measures will require longitudinal investigations of their prognostic facility for relevant health outcomes.

Both assessments evaluated represent near literal interpretations of the fatigability definitions offered by Eldadah.⁵ The finding of somewhat differential associations between these fatigability constructs as operationalized in this study raise the possibility that performance deterioration and perceived exertion following a standardized activity may capture different dimensions of fatigability with performance deterioration tapping more global fatigue symptoms; whereas, high perceived exertion may tap suboptimal performance capacity. Examining these measures together in the 453 participants with both assessments, 18.5% had performance deterioration and 30.9% had high perceived exertion, yet only 8.8% met both fatigability criteria.

In summary, as early identification of impending limitation may facilitate more effective treatment, evaluation of fatigability in apparently well-functioning older adults may provide an opportunity for improved health outcomes. As noted previously, the LDCW in its original form is a valuable prognostic indicator;^{21,22} including lap split times represents a minor modification that yields an assessment of fatigability. Ascertaining perceived exertion using the Borg scale following a 5-minute slow treadmill walk, appears to provide a new meaningful and valid approach to assessing fatigability. Future studies must evaluate the degree to which these measures of fatigability predict future outcomes and functional decline, in particular.

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Table 1

Participant Characteristics

Characteristic	Performance Deterioration Sample		Perceived Exertion Sample	
	Slowed ^a (n = 134)	Maintained (n = 454)	RPE 10 ^b (n = 149)	RPE < 10 (n = 321)
Age, mean (± SD)	77.9 (8.2) ^c	74.7 (7.1)	77.5 (7.4) ^c	73.9 (6.6)
Female, n (%)	85 (63.4) ^c	188 (41.4)	80 (53.7) ^c	135 (42.1)
Black, n (%)	35 (26.1)	97 (21.4)	41 (27.5)	68 (21.2)
BMI ≥ 30 kg/m ² , n (%)	40 (29.8)	100 (22.0)	43 (28.9)	70 (21.8)
Smoker ^d , n (%)	5 (3.7)	13 (2.9)	4 (2.7)	8 (2.5)
Brisk walker ^e , n (%)	22 (16.4)*	142 (31.3)	28 (18.8)*	115 (35.8)

RPE= rating of perceived exertion, SD= standard deviation

^a unable to attempt or complete a 400m walk “as quickly as possible” or increased lap time between laps 2 and 9 of at least 6.5%

^b rating on Borg scale from 6 to 20 following 5 minutes of walking on a treadmill at 1.5 mph (0.67 m/s)

^c p<.05

^d regular smoker currently or within the past 10 years

^e reports having walked at a brisk pace within the past two weeks

Table 2

Percent Reporting Fatigue Symptoms and Odds of Fatigue by Fatigability Status

Fatigue Symptoms	Performance Deterioration Sample			Perceived Exertion Sample		
	Slowed (n=134)	Maintained (n=454)	OR (95%CI) ^a	RPE 10 (n=149)	RPE <10 (n=321)	OR (95%CI) ^a
Tiredness ^b , %	57.3	37.6	1.69 (1.11 – 2.58)	56.1	34.1	1.85 (1.21 – 2.82)
Weakness ^c , %	38.2	18.1	2.17 (1.37 – 3.44)	33.1	15.0	2.08 (1.27 – 3.41)
Low Energy ^d , %	46.2	21.5	2.59 (1.66 – 4.05)	34.0	20.0	1.63 (1.02 – 2.61)
SF-12	38.2	15.4	3.03 (1.90 – 4.84)	25.8	16.1	1.62 (0.97 – 2.70)
Low Energy ^e , %						

OR= odds ratio, RPE= rating of perceived exertion, CI= confidence interval

^a adjusted for age, sex, race, walking activity, obesity and smoking history^b reports feeling unusually tired during the day some to all of the time in past month^c reports a weakness level 3 in past month where 0=not weak at all and 10=very weak^d reports a usual energy level 6 in past month where 0=no energy at all and 10=most energy ever had^e reports having a lot of energy no more than some of the time in the past four weeks from Short Form 12

Table 3

Mean Physical Functional Ability by Fatigability Status

Functional Ability	Performance Deterioration			Perceived Exertion		
	Slowed (n=134)	Maintained (n=454)	p-value ^d	RPE =10 (n=149)	RPE <10 (n=321)	p-value ^d
Walking ability score ^b	6.61	7.95	<.001	7.26	8.05	<.001
Usual gait speed ^c , (m/s)	1.05	1.10	.048	1.03	1.13	<.001
Rapid gait speed ^c , (m/s)	1.58	1.64	.088	1.55	1.69	<.001
10 chair stands ^d , (stands/s)	0.38	0.42	.023	0.36	0.43	<.001
Grip strength ^e , (kg)	31.7	31.8	.798	30.7	32.9	<.001

RPE= rating of perceived exertion

^a adjusted for age, sex, race, walking activity, obesity and smoking history^b reported walking ability index derived from a series of self-report questions can range from 0 to 9 (see text) where 0=unable to walk ¼ mile and 9=very easy to walk 1 mile^c fastest of two trials over 6m^d persons unable to complete 10 stands were assigned a value of zero^e highest value out of a maximum of three trials with each hand adjusted for height