Fatigued, but Not Frail: Perceived Fatigability as a Marker of Impending Decline in Mobility-Intact Older Adults

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OBJECTIVES: To evaluate perceived fatigability as a predictor of meaningful functional decline in non-mobility-limited older adults.

DESIGN: Longitudinal analysis of data from the Baltimore Longitudinal Study of Aging (BLSA).

SETTING: National Institute on Aging, Clinical Research Unit, Baltimore, Maryland.

PARTICIPANTS: Men and women aged 60 to 89 participating in the BLSA with concurrent perceived fatigability and functional assessments and follow-up functional assessment within 1 to 3 years (N = 540).

MEASUREMENTS: Perceived fatigability was ascertained using the Borg rating of perceived exertion (RPE) after 5 minutes of treadmill walking at 1.5 miles per hour. Functional assessments included usual and fast gait speed, the Health, Aging and Body Composition physical performance battery (HABC PPB) and reported walking ability. Reported tiredness and energy level were examined as complementary predictors. Covariates included age, age squared, race, follow-up time, and baseline function. Meaningful decline was defined as 0.05 m/s per year for usual gait speed, 0.07 m/s per year for fast gait speed, 0.12 points/year for HABC PPB, and 1 point for walking ability index.

RESULTS: Over a mean 2.1 years, 20–31% of participants declined across functional assessments. Fatigability was associated with a 13–19% greater likelihood of meaningful decline in all measures ($P = .002$– $.02$) per 1-unit RPE increase. After considering tiredness and energy level separately, findings were essentially unchanged, and neither was associated with gait speed or physical performance decline. In contrast, each separately predicted decline in reported walking ability independent of fatigability ($P = .03$ and $P < .001$, respectively).

CONCLUSION: Routine assessment of fatigability may help identify older persons vulnerable to greater-than-expected functional decline. **J Am Geriatr Soc 64:1287–1292, 2016.**

Key words: fatigability; mobility decline; aging

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Fatigue is among the most common presenting complaints in older adults,[1,2] yet it is likely that biological onset of the fatigue process precedes perception and may be interpreted as normal aging. Several treatable and manageable conditions may initiate or exacerbate fatigue,[1,3] including fatigue itself.[4,5] Fatigue is frequently a prodromal symptom of more-serious illnesses,[6–8] which further argues for the importance of early identification. The central response to fatigue—slowing down or reducing activity, often in subtle ways—not only accelerates deconditioning, but also complicates recognition of fatigue because persons tend to equilibrate activity levels to avoid, diminish, or delay fatigue.[9,10]

The concept of fatigability, performance deterioration or perceived exertion while performing a standardized activity, has recently emerged,[9] and a few performance-based measures have been developed and validated.[2,11] Greater fatigability has been concurrently associated with greater frequency of fatigue symptoms (e.g., unusual tiredness and lower energy levels) in the past month[11] and poorer physical performance.[2,4,11] Whether fatigability can help identify persons at greater risk of mobility decline, that is, greater than would be expected for a given age, sex, and functional level, is unknown yet important to ascertain because early recognition may be important in arresting or slowing the decline process.[1]

This study evaluated the association between a validated measure of fatigability, specifically, perceived exertion while performing a standardized activity, which has been labeled perceived fatigability,[11] and the likelihood of

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meaningful decline in usual and fast gait speed, physical performance, and self-reported walking ability within the subsequent 1 to 3 years in mobility-intact men and women aged 60 to 89 participating in the Baltimore Longitudinal Study of Aging (BLSA). Given that simply asking about unusual tiredness or energy level may also be informative,[12–14] the analysis examined perceived fatigability with and without consideration of reported tiredness and energy level. To evaluate whether fatigability differentially predicts functional decline in younger-old versus older-old adults, the main analyses were repeated in two age strata (60–74 and 75–89).

METHODS

Participants

The study population consisted of 540 men and women aged 60 to 89 participating in the BLSA who reported no difficulty walking one-quarter of a mile and had perceived fatigability and functional assessment at baseline and follow-up functional assessment 1 to 3 years later. The BLSA is a continuous enrollment cohort established in 1958 with age-specific preferred follow-up schedules of 1 year for persons aged 80 and older and 2 years for persons aged 60 to 70. The fatigability assessment was fully implemented in September 2007, and data were available for this study through December 2014. Some participants had multiple eligible visits; whenever this occurred, the two visits closest to 2 years (730 days) apart were selected. An additional 240 participants with a qualifying initial visit did not have a qualifying follow-up visit. Of this group, 30 had died, 16 had achieved a study endpoint of dementia or severe debility, 51 were seen outside of 1 to 3 years later, 88 were not seen but were not overdue, and 55 were overdue. This group did not differ from the analytical sample of 540 with regard to sex distribution (49.2% vs 50.0% male), mean age (71.4 vs 72.2, $P = .17$), mean usual gait speed (1.16 vs 1.14 m/s, $P = .45$), or mean fatigability score (8.75 vs 8.77, $P = .91$). Recent targeted recruitment of individuals aged 70 and older with no chronic diseases, mobility limitation, or cognitive impairment[15] has enriched the BLSA cohort with exceptionally healthy older adults, which facilitates investigation of early markers of impending decline in overtly well-aged individuals. Examination visits take place at the National Institute on Aging Clinical Research Unit in Baltimore, Maryland, and typically occur over 3 days. The National Institute of Environmental Health Sciences internal review board approved the BLSA study protocol, and all participants provided written informed consent.

Data Collection

Perceived Fatigability

Perceived fatigability was assessed using the Borg rating of perceived exertion (RPE)[16] immediately after walking for 5 minutes on a treadmill at 1.5 miles per hour (0.67 m/s) at 0% grade.[11] Holding on to handrails was discouraged but permitted as a safety precaution. A large chart with the Borg rating levels from 6 to 20 hung on the wall to the left of the treadmill in full view of participants. In addition to numerals, word anchors were provided for odd numbered ratings. For example, 7 was labeled "very, very light," 9 "very light," 11 "fairly light," and 13 "somewhat light." In examining the distribution, it became evident that participants preferentially selected exertion levels with word anchors. Of the 237 who selected 6 or 7, 75% selected 7; likewise, of the 161 who choose 8 or 9, 79% choose 9. Also, fewer than 9% rated their exertion as 12 or greater. For the main analysis, the full RPE rating from 6 to 20 was examined, but given the distribution, an alternative four-category (6–7, 8–9, 10–11, ≥12) measure was also evaluated. The 15-point Borg RPE is considered to be a valid indicator of exertional effort and has been found to have excellent test–retest reliability in a variety of testing conditions and populations.[17]

Physical Function

Usual and rapid gait speeds were assessed over a 6-m course with participants asked to walk at their usual walking pace for two trials and then as fast as they could for two trials. Total time recorded to the hundredth of a second was divided into 6 to obtain usual and rapid gait speed in meters per second. The fastest of each trial was used in the analyses.

The HABC PPB is a composite measure of physical performance[18] derived from the Short Physical Performance Battery[19] with four components: usual gait speed as described above, time to stand up from and sit back down on an armless chair five times, ability to hold three progressively more-challenging balance-related stances (semi-tandem, full tandem, single leg) for up to 30 seconds each, and ability and time to walk a narrow (20-cm wide) 6-m course. Each test was scored on a ratio scale with maximal performance as the denominator and actual performance as the numerator. Maximal performance is 2.0 m/s for usual gait speed, 5 seconds for five chair stands, and 90 seconds for the standing balance test. For the narrow walk, three attempts were permitted to walk without stepping on or outside the taped lines marking the 20-cm width more than twice. If two or more attempts were successful, the fastest was used, with 2.0 m/s considered maximal. If all three attempts failed, a score of 0 was assigned. Any performance exceeding the defined maximum was assigned a score of 1.0 for that test. The HABC PPB score constitutes the sum of these four ratio scores, for a maximum total of 4.0.

Walking ability index score was determined from responses to a series 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 denying difficulty were asked how easy it was for them to walk one-quarter of a mile—very, somewhat, or not so easy—followed by whether they had any difficulty walking 1 mile and the ease of walking 1 mile if no difficulty was reported. Responses were combined to create a walking ability index ranging from 0 to 9, where 0 represents unable to walk one-quarter of a mile and 9 indicates that walking 1 mile is very easy.[11,20]

Reported Tiredness and Energy Level

Tiredness and energy level were assessed using an interviewer-administered questionnaire. For tiredness, the question (and response code) was, "In the past month, on average how often have you felt unusually tired during the day: all (3), most (2), some (1), or none (0) of the time?" For energy level, the question was, "During the past month, what category best describes your usual energy level, using a scale from 0 to 10, where 0 is no energy at all and 10 is the most energy you have ever had?

Covariates

Covariates included age, age squared (to account for accelerated decline with increasing age), sex, self-defined race as black or nonblack (because few nonblack BLSA participants identify as other than Caucasian), time between functional assessments, and baseline value of the function evaluated.

Statistical Analyses

Meaningful functional decline was largely defined on the basis of previous research.[21,22] Because a reference time period was not identified, the value signifying small decline was used and treated as an annual rate. Meaningful decline was defined as a loss of 0.05 m/s per year for usual gait speed and 0.12 points/year for the HABC PPB. Meaningful loss of fast gait speed (not evaluated previously[21,22]) was defined as 0.07 m/s per year to yield a rate of decline similar to that observed for usual gait speed in the current study. For the walking ability index, a loss of 1 or more points constituted meaningful decline.[20] Because persons reporting difficulty walking one-quarter of a mile were excluded at baseline, the walking index ranged from 4 to 9.

Odds of meaningful decline for each functional measure associated with perceived fatigability over the full range from 6 to 20 were determined from logistic regression analyses controlling for the covariates noted above in all analyses. To evaluate whether asking about unusual tiredness or energy level is also informative, responses to those questions were included in separate analyses with the covariates and full range of perceived fatigability. Given the response distribution of fatigability ratings (described above), a four-category version was also examined. Analyses were conducted using SAS version 9.3 (SAS Institute, Inc., Cary, NC).

To evaluate whether perceived fatigability predicts meaningful decline in young-old and old-old adults, additional analyses were conducted separately in persons aged 60 to 74 (n = 312) and those aged 75 to 89 (n = 228).

RESULTS

Participant characteristics are shown in Table 1 according to perceived fatigability category. The mean age was 73 and was higher with increasing fatigability. Percentage reporting tiredness at least some of the time was greater, mean energy level lower, and mean baseline levels of all physical function measures worse with increasing fatigability. The percentage of men was proportionately lower with increasing fatigability category, but race and follow-up time did not differ.

Over a mean 2.1 years of follow-up, 20% to 31% of the study population experienced meaningful decline in the functional areas assessed. Each unit increase in fatigability was associated with a 13% to 19% greater likelihood of meaningful decline for usual and fast gait speed, physical performance, and walking index (P = .002 to .02), which did not change materially after considering tiredness or energy level, neither of which predicted decline in any objective performance assessment (all $P \geq .10$) (Table 2). In contrast, tiredness (odds ratio (OR) = 1.53, 95% confidence interval (CI) = 1.04–2.25, P = .03) and energy level (OR = 0.78, 95% CI = 0.68–0.89, $P < .001$) predicted decline in subjectively assessed walking ability independent of fatigability.

The four-category version of perceived fatigability performed well, but not substantially better than the full range measure. The ORs were higher after merging response levels, but significance levels were essentially unchanged.

Except for usual gait speed, rates of meaningful functional decline were higher in older-old than young-old persons (Table 3), but perceived fatigability predicted

Table 1. Baseline Characteristics According to Rating of Perceived Exertion (RPE)

Characteristic	RPE 6–7, n = 270	RPE 8–9, n = 161	RPE 10–11, n = 94	RPE ≥ 12, n = 48	Unadjusted *P*-Value for Trend
Age, mean ± SD	71.1 ± 7.5	73.8 ± 7.5	74.4 ± 7.6	78.2 ± 6.5	<.001
Male, %	54.9	50.3	42.6	39.6	.01
Black, %	22.7	21.7	29.8	25.0	.34
Unusual tiredness, %	33.3	33.5	42.6	64.6	<.001
Energy level, mean ± SD	7.87 ± 1.42	7.73 ± 1.47	7.34 ± 1.47	6.50 ± 1.83	<.001
Usual gait speed, mean ± SD	1.22 ± 0.20	1.16 ± 0.20	1.06 ± 0.19	0.99 ± 0.22	<.001
Fast gait speed, mean ± SD	1.86 ± 0.34	1.75 ± 0.31	1.58 ± 0.33	1.47 ± 0.32	<.001
Health, Aging and Body Composition Physical Performance Battery score, mean ± SD	3.01 ± 0.36	2.83 ± 0.50	2.74 ± 0.44	2.36 ± 0.72	<.001
Walking index, mean ± SD	8.58 ± 0.97	8.25 ± 1.24	7.80 ± 1.51	7.52 ± 1.66	<.001
Years of follow-up, mean ± SD	2.10 ± 0.33	2.07 ± 0.31	2.04 ± 0.36	2.03 ± 0.41	.06

SD= standard deviation.

Table 2. Association Between Perceived Fatigability Rating and Clinically Meaningful Functional Decline with and without Consideration of Reported Tiredness and Energy Level (N = 540)

Function	Usual Gait Speed	Fast Gait Speed	Health, Aging and Body Composition Physical Performance Battery	Walking Index
Meaningful decline, %	30.9	28.9	20.4	25.0
OR (95% CI) *P*-value[a]				
Fatigability	1.19 (1.07–1.32) .002	1.13 (1.02–1.25) .02	1.17 (1.05–1.30) .004	1.14 (1.04–1.26) .008
Fatigability[b]	1.20 (1.08–1.33) <.001	1.12 (1.01–1.25) .03	1.16 (1.05–1.29) .006	1.12 (1.02–1.24) .02
Tiredness	0.71 (0.48–1.07) .10	1.20 (0.81–1.78) .36	1.09 (0.72–1.65) .69	1.53 (1.04–2.25) .03
Fatigability[c]	1.18 (1.06–1.31) .002	1.12 (1.01–1.25) .03	1.17 (1.05–1.30) .005	1.11 (1.00–1.23) .04
Energy level	0.96 (0.83–1.10) .54	0.95 (0.83–1.09) .45	1.00 (0.86–1.16) .99	0.78 (0.68–0.89) <.001
Fatigability category	1.42 (1.13–1.79) .003	1.28 (1.02–1.60) .03	1.42 (1.13–1.79) .003	1.31 (1.06–1.62) .02

[a] Adjusted for age, age squared, sex, race, time between baseline and follow-up visit, and baseline value of the physical function assessed. Odds ratios (ORs) indicate the likelihood of meaningful decline per one-unit increase in perceived fatigability.
[b] Using the same model described in "a" but with the addition of tiredness. ORs, 95% confidence intervals (CIs), and *P*-values are for fatigability and tiredness in the same model.
[c] Using the same model described in "a" but with the addition of energy level. ORs, 95% CIs, and *P*-values are for fatigability and energy level in the same model.

Table 3. Association Between Perceived Fatigability Rating and Clinically Meaningful Functional Decline Stratified According to Age Group

Age	Usual Gait Speed	Fast Gait Speed	Health, Aging and Body Composition Physical Performance Battery	Walking Index
Meaningful decline, %				
60–74, n = 312	28.9	25.3	12.2	18.0
75–89, n = 228	33.8	33.8	31.6	34.7
OR (95% Confidence Interval) *P*-Value[a]				
60–74	1.24 (1.08–1.44) .003	1.23 (1.05–1.43) .009	1.36 (1.14–1.62) <.001	1.15 (0.99–1.32) .07
75–89	1.12 (0.95–1.30) .17	1.06 (0.92–1.23) .40	1.07 (0.93–1.22) .34	1.13 (0.99–1.30) .07

[a] Adjusted for age, age squared, sex, race, time between baseline and follow-up visit, and baseline value of the specific physical function assessed. Odds ratios (ORs) indicate likelihood of meaningful decline per 1-unit increase in perceived fatigability.

meaningful decline only in the younger group. This association was specific to the performance tests (usual gait speed OR = 1.24, fast gait speed OR = 1.23, physical performance OR = 1.36). The overall association with walking index decline was not retained in either age group ($P = .07$ for both) after age stratification.

DISCUSSION

In non-mobility-limited adults aged 60 to 89, higher RPE after slow walking (1.5 miles per hour) for 5 minutes covering one-eighth of a mile (~200 m) is associated with an increasingly greater likelihood of meaningful functional decline over approximately 2 years. This assessment of fatigability is a highly acceptable, quick, low-demand test[23] that well-trained technicians can safely administer to even very old adults who report no difficulty walking one-quarter of a mile. Because many older adults may be unaware of impending functional loss[24] possibly due to gradual activity reduction to reduce or avoid fatigue,[9,10] evaluating fatigability as part of a standard health assessment may provide valuable diagnostic information, but further research is necessary to evaluate the feasibility, utility, and effectiveness of implementing such a measure in clinical practice.

Little prior work has examined perceived fatigability as a predictor of functional decline; nonetheless, findings from the current study compare favorably with those using exertion-based performance tests, such as the 400-m and 6-minute walk tests, in estimating future risk of mobility limitation or disability. In functionally limited persons aged 70 to 89, it was found that taking rest stops during a normal pace 400-m walk predicted inability to walk 400 m 6 to 12 months later;[25] in non-mobility-limited 70-year-olds, inability and slower time to complete a fast 400-m walk predicted onset of difficulty walking one-quarter of a mile within 2 years;[24] and distance covered during a 6-minute walk in persons aged 65 and older predicted incident activity of daily living (ADL) disability within 3 years.[26] The fatigability assessment examined in the current study requires less space and time to administer, but these and other approaches[2] may be viable alternatives when a treadmill is unavailable and space and time are adequate.

Consistent with the purported limitations of typical fatigue measures,[9] responses to simple questions about unusual tiredness and energy level in the past month were not informative predictors of decline in measured performance but were nonetheless independent predictors of decline in self-reported walking ability. The few prospective studies specifically examining fatigue symptoms and functional decline have yielded mixed findings. For example, one study[12] found that persons aged 65 and older reporting tiredness had persistently worse function but no greater rate of decline over 3 years, whereas another[27] found that tiredness was associated with a higher rate of developing ADL difficulties between the ages of 70 and 78. Likewise, task-specific fatigue in 75-year-olds predicted onset of mobility and ADL disability over 5 years.[28] The current study extends these findings to non-mobility-limited individuals and loss of walking reserve, because only 20 of 135 (15%) persons with walking ability decline reported difficulty walking one-quarter of a mile at follow-up.

The age-stratified analyses revealed a critically important observation that the association between fatigability and meaningful decline was most pronounced in young-old persons (aged 60–74), who typically are on a shallower decline trajectory.[29,30] This finding suggests that older persons least likely to expect decline may benefit most from routine fatigability assessments and that such testing may be most appropriate for younger and seemingly robust older adults. The study was underpowered to definitively demonstrate the lack of association in the older group.

The primary limitation of this work concerns the generally better fitness and health status of BLSA participants than of similarly aged adults.[14,18,19] Thus, findings are most applicable to non-mobility-limited individuals with exceptional health. A second limitation concerns the perceived fatigability measure itself, which requires in-person testing and a treadmill. As noted above, viable in-person alternatives for fatigability testing exist,[2,11,24–26] and a self-report instrument, the Pittsburgh Fatigability Scale, has been recently validated.[31]

In summary, even in mobility-intact older adults, walking at a slow pace for one-eighth of a mile is frequently perceived as more than very light activity, and these gradations of feelings of exertion appear to predict mobility decline well above limitation and disability thresholds. Assessing fatigability using a standardized task and asking about perceived effort may help identify persons in the initial stages of mobility loss and restriction.

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Conflict of Interest: None.

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