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Psychometric Properties of the Brief Fatigue Inventory in Community-Dwelling Older Adults

Melissa J. Shuman-Paretsky, M.A.[a], **Janna Belser-Ehrlich, B.A.**[a], and **Roee Holtzer, Ph.D.**[a,b]

[a]Ferkauf Graduate School of Psychology, Yeshiva University, United States

[b]Department of Neurology, Albert Einstein College of Medicine, Yeshiva University, United States

Abstract

Objective—To investigate the psychometric properties of the Brief Fatigue Inventory (BFI) in community-dwelling older adults.

Design—Cross-sectional validation study.

Setting—Community-based longitudinal cohort aging study in Westchester County, New York.

Participants—Subjects (N=302) were non-demented older adults (mean age 76.44 years, 54% female).

Interventions—Not applicable.

Main Outcome Measures—BFI total, severity, and interference summation scores.

Results—A Principle Component Analysis (PCA) yielded two factors: fatigue severity and interference, explaining 65.94% of the variance. Both factors had good reliability, with Cronbach's α values of 0.867 for fatigue interference and 0.818 for fatigue severity. Higher fatigue scores were associated with older age and worse physical and cognitive functions.

Conclusions—Fatigue is a common and debilitating symptom in the aging population. The current study provides novel findings in validating and establishing a bi-dimensional factor structure for the BFI in older adults. Severity and interference were differentially related to important health outcomes; therefore, utilizing these subscales in addition to the total BFI scaled score is recommended with older adults. Because of its relatively short administration time and established psychometric properties, the BFI can be successfully incorporated into longitudinal studies and clinical trials.

Corresponding Author: Roee Holtzer, Ph.D. Ferkauf Graduate School of Psychology and Department of Neurology, Albert Einstein College of Medicine, Yeshiva University, NY, USA. Phone: 718 430-3962; Fax: 718 430-3960; roee.holtzer@einstein.yu.edu.

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Keywords

Fatigue; aging; psychometrics; questionnaires

Fatigue is a common symptom reported by 27%–50% of community-dwelling older adults (1) and 98% of long-term care older adults (2). Fatigue has been shown to predict decreased mobility (3) and instrumental activities of daily living (IADL's) (4). It has also been to shown to predict an increased risk of functional decline, hospitalization (5), future home care (6), and incident disability (7–10). Therefore, it is critical to assess fatigue using reliable and valid instruments that can be administered in a variety of settings including rehabilitation and medical facilities, clinical trials, and longitudinal studies.

Previous studies assessing fatigue in older adults used scales that examined tiredness and interference with daily activities (5, 8–12). It is noteworthy, however, that the impact of fatigue on important psychosocial outcomes such as lifestyle, social relationships, and mood have not been reported (13, 14).

The Brief Fatigue Inventory (BFI) is a brief screening tool designed to assess the severity and impact of fatigue on daily functioning. Its simple, easy-to-understand language and limited administration time (~10 minutes) (15) make it an ideal measure for older adults. Originally designed for use in English-speaking patients with cancer (16–17), the BFI has been validated in multiple languages (16, 18–26) and used in other samples including individual with rheumatoid arthritis (27) and community-dwelling adults (15, 28, 29). However, the BFI has not yet been validated in adults over the age of 65.

The original validation study found that the BFI had a uni-dimensional factor structure with excellent reliability and internal consistency (15). While some studies validating translated versions of the BFI have confirmed this uni-dimensional structure (15, 19–22, 24, 25), more recent studies have suggested that a bi-dimensional factor structure is more appropriate. Specifically, a recent study validating a Chinese version yielded a bi-dimensional factor structure consisting of severity and interference subscales (23). Similarly, studies of patients with rheumatoid arthritis found convergent validity for a bi-dimensional factor structure (30) and evidence that these BFI subscales were differentially related to clinical outcome measures (27).

The current study aimed to determine the reliability, validity, and factor structure of the BFI in community-dwelling older adults. We further evaluated whether fatigue severity and interference were differentially related to physical, sociodemographic, and cognitive outcome measures.

Methods

Participants—Community-dwelling older adults were recruited from a longitudinal cohort study entitled "Central Control of Mobility in Aging" (CCMA). The primary aims of this study are to determine cognitive and brain predictors of mobility performance, mobility decline, and disability in aging. CCMA participants are followed longitudinally at yearly intervals. Potential participants were aged 65 and older and identified from a population list of lower Westchester County, New York. The sample in the present study consisted of participants who were recruited and enrolled to the CCMA cohort between June 2011 and January 2013. Participants were first contacted by mail and then by telephone inviting them to participate. Eligibility was assessed using a structured telephone interview consisting of verbal consent, a brief medical history questionnaire, mobility questions (31), and validated cognitive screens to exclude dementia (32, 33). During this period, 514 phone interviews were completed, and 417 individuals were determined to be eligible for participation. Exclusion criteria were inability to speak English, inability to ambulate independently, dementia, significant loss of vision and/or hearing, current or past history of neurological or psychiatric disorders, currently receiving hemodialysis, or recent/anticipated medical procedures that could affect mobility. After completing the telephone interview, eligible participants were scheduled for two three-hour visits at the research center. During study visits, participants received comprehensive neuropsychological, cognitive, psychological, and mobility assessments, as well as a structured neurological examination. The BFI questionnaire was administered during the first study appointment. Of the 417 individuals deemed eligible for participation, 93, declined participation or did not attend their scheduled appointment. A total of 324 people completed the protocol and 321 of these participants completed the BFI. The sample was frozen in order to preserve the integrity of the data. At the time of the data freeze, an additional 19 subjects were excluded due to incomplete BFI surveys and/or relevant outcome data. Thus, 302 participants were formally analyzed for the current study. Written informed consent was obtained at clinic visits according to study protocols approved by the institutional review board. These procedures have been previously described (34, 35).

Measures

The Brief Fatigue Inventory (BFI)—The BFI is a 9-item, 11-point rating scale developed to assess subjective fatigue. The first three questions measure fatigue severity from 0, indicating "no fatigue," to 10, indicating "as bad as you can imagine," at current, usual, and worst levels. The following six questions assess fatigue interference with daily activities including general activity, mood, walking ability, normal work (both inside and outside the home), relations with other people, and enjoyment of life. Response options range from 0, indicating "does not interfere," to 10, indicating, "completely interferes." Higher scores on the BFI correspond to greater self-reported levels of fatigue. The time period for all questions is over the past 24 hours (15). Factor analysis for the original validation study found the scale to be uni-dimensional (6.9). Reliability was excellent with an internal consistency coefficient of 0.96 for scale items (15).

Quantitative Gait Assessment—Participants were asked to walk on a computerized mat with embedded pressure sensors (GAITRite, CIR systems, Havertown, PA) in a quiet, well-lit room. The walkway dimensions are 8.5 m×0.9 m×0.01 m (*L*×*W*×*H*) with an active recording area of 6.1 m×0.61 m (*L*×*W*) (35). The smaller active recorded area is designed to ensure that acceleration and deceleration will not influence gait measurement. Participants walked for a single trial under two separate conditions: (1) normal walk (NW), and (2) walking while reciting alternate letters of the alphabet (WWT). Test-retest reliability for gait speed is excellent in our own (r=.96) (36) and other research settings (Interclass Correlation Coefficient ≥.80) (37). The WWT task is an attention-demanding dual-task condition that requires the participants to pay equal attention to their walking and talking (34, 35, 38–40). Furthermore, WWT performance is a significant predictor of falls and of increased risk of frailty disability and mortality (41). Consistent with our prior studies (42,43,34) and in light of the high test-retest reliability and statistical robustness of gait speed, single trials were used to assess gait in the NW and WWT conditions. This practice protocol has been previously described (34, 35, 41).

Stairs Negotiation—Time to ascend and time to descend three steps were calculated as separate outcome variables. Timing started after participants lifted their leading foot and stopped after both feet were flat on the third step. Longer time in seconds to ascend or descend stairs is indicative of worse performance. Participants were allowed to use handrails to steady themselves and were asked whether they had any difficulty. This procedure has been validated for use in older adults with excellent test-retest reliability and predictive validity. Specifically, longer stair negotiation time predicted functional decline, operationally defined as a decrement in activities of daily living (ADL's) in longitudinal studies (44–46).

The Short Physical Performance Battery (SPPB) was used to assess mobility. A summary score (0–12) is based on the summation of categorical scores (0–4) in three physical performance areas: standing balance, chair rise, and walking speed (47, 48). Higher scores on the SPPB indicate better mobility. The SPPB can be completed in 5 minutes and has been recommended for use as a primary outcome measure in clinical trials (49, 50). It has also been shown to predict frailty and disability (41).

Neuropsychological Measures—The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (51, 52) was used as a measure of overall cognitive functioning with higher index scores indicating better performance. The Trail Making Test, Forms A and B (53), was used to assess attention and executive functions with longer completion time indicative of worse performance.

Health Variables and Questionnaires—A Global Health Status (GHS) summary score (range 0–10) was calculated using dichotomous rating (presence or absence) for: diabetes, heart failure, hypertension, angina, myocardial infarction, depression, stroke, Parkinson's disease, chronic obstructive lung disease, and arthritis (54). A higher GHS score is indicative of a greater number of chronic health conditions. The Geriatric Depression Scale (GDS) (55) was administered to screen for depression. Higher GDS scores correspond to a greater number of depressive symptoms. Participants also completed The Activities of Daily Living-Prevention Instrument (ADL-PI) (56), which measured 15 ADL and 5 physical function domains. A higher score is indicative of greater functional impairments.

Statistical Analysis

Construct validity was evaluated using a principal-components analysis (PCA) with an oblique rotation as previous studies suggested that items on this scale were related (15). The minimum eigenvalue for extraction was set at 1. Statistical significance for the factor loadings was set at 0.5 (57, 58). Communalities were analyzed and values above 0.5 were considered adequate (58). The resulting correlation matrix was examined to ensure that all variables were sufficiently related ($r \geq 0.3$), but not so highly related ($r \geq 0.9$) to suggest multicollinearity. The Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's test of sphericity, and the determinant were also assessed.

Cronbach's α was used to establish internal consistency. Further, analyses were conducted to examine the correlation coefficients between items to determine whether the deletion of any items would increase the Cronbach's α coefficient (Cronbach's α at 0.7 was considered acceptable). The correlation of each item to the total scale was also considered, with 0.3 set as the minimal acceptable standard (57, 58).

Relationships between the separate factor scores of the BFI with gait, balance, cognition, and demographic variables were explored using Pearson correlations for continuous variables and Spearman correlations for dichotomous variables. Partial correlation coefficients investigated the relationships when controlling for depression, a common confound often related to fatigue (59). Significant α was set at 0.05; all p values were two-tailed. Data were inspected descriptively and graphically, and model assumptions were formally tested.

Statistical analyses were performed using SPSS version 19 (IBM, Somers, NY).

Results

See Table 1: Demographic Characteristics

Demographic characteristics are summarized in Table 1. A total of 302 healthy older adults participated in the present study. Mean age was 76.44 ± 6.98 years and 54% were female. Mean years of education were 14.51 ± 2.98 and the majority of participants were Caucasian (89.4%).

See Table 2: Characteristics of Brief Fatigue Inventory

Means, SDs, and ranges for individual items on the BFI, as well as the summation index scores are listed in Table 2. There was a slight positive skew consistent across all items. The mean of the individual items on the scale ranged from 0.47 to 3.95 and scores for all individual items ranged from 0–10.

See Table 3: Construct Validity, Principal Components Analysis (Direct Oblimin)

Construct validity was established using a Principle Component Analysis (PCA) with an oblique rotation. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO = 0.868) was well above the acceptable limit of 0.5 (57). Bartlett's test of Sphericity X^2 (35) = 1381.922, $P < 0.001$ and the determinant of 0.010 indicated correlations between items were sufficiently large to run a PCA.

Factor analysis revealed a bi-dimensional factor structure (see table 3). Both factors had eigenvalues over Kaiser's criterion of 1 and together explained 65.94% of the variance. It is notable that an orthogonal rotation yielded an equivalent factor structure (data not shown). The first factor consisted of items related to fatigue interference with factor loadings ranging from 0.597 to 0.861. The second factor consisted of items related to fatigue severity and loadings ranged from 0.806 to 0.872.

Both subscales demonstrated good reliability. Internal consistency, as measured by Cronbach's α of 0.818 for the severity subscale and 0.869 for the impact subscale, was good. All items contributed positively to the subscales, with corrected-item-total correlations ranging from 0.621 to 0.746 for the interference subscale and 0.584 to 0.791 for the severity subscale. The communalities and correlation matrices indicated that all items were sufficiently related ($r \geq 0.3$), but not so highly related ($r \geq 0.9$) to suggest multicollinearity.

See Table 4: BFI relationships to outcome measures

Important demographic outcome measures, including reported instrumental activities of daily living impairment, depressive symptoms, and medical comorbidities, were significantly associated with BFI total, severity, and interference scores (see table 4).

Worse physical performance was significantly associated with higher subjective scores of fatigue. Poor balance, gait, and chair rise performance, as measured by the SPPB, was associated with higher subjective ratings of BFI total, impact, and severity scale scores. Longer time to climb stairs and slower gait velocity in the single task condition (NW) were associated with higher BFI total, impact, and severity scores. Slower gait velocity in the dual task condition (WWT) was significantly associated with BFI total and interference but not with severity scores.

Longer time to complete the Trail Making Test form B (TMT-form B) was associated with higher BFI total and severity, but not interference scores. The relationships between the BFI total and subscale scores with the remaining cognitive measures were not significant.

Discussion

This was the first study to examine the psychometric properties of the BFI in community-dwelling older adults. We established a reliable bi-dimensional structure that captured two distinct aspects of fatigue—severity and interference. The BFI interference subscale was more closely related to demographic variables such as age and medical illness co-morbidity, while the BFI severity subscale was more closely related to physical and cognitive dual-task measures.

Though this bi-dimensional factor structure is consistent with a few recent studies (23, 27, 30), it differs from the original validation study (15). This maybe attributed, in part, to differences in study populations. Previous studies that found a uni-dimensional factor structure were limited to cancer patients (15, 28) and translated versions of the scale (16, 19–22, 24, 25). Older adults and patients with cancer may have fundamental differences in their experience and ratings of fatigue (4, 14), leading to variations in factor structure. Differences in factor structure for translated versions could be due to differences in language and styles of reporting symptoms across cultures. The current study demonstrated that the bi-dimensional factor structure is most appropriate with a community-dwelling, English speaking, relatively healthy cohort of older adults.

Higher subjective ratings of fatigue, as measured by the total and separate BFI summation scores (severity and interference) had significant relationships in the expected direction with sociodemographic, functional, and cognitive outcome measures (6, 11, 36, 37). Earlier studies investigating fatigue in older adults were based on self-report measures that were limited to mobility tiredness (8, 11) or assessment instruments that had not been validated in aging (2). The current study validated the BFI in a community based aging population and extended previous findings (42, 43, 44–46) by establishing its relationship with important functional and health outcomes.

Our findings also revealed that BFI scores were associated with specific cognitive functions. Higher total and severity fatigue scores were related to poorer performance on Trails B, a neuropsychological test that assesses aspects of executive functions including working memory, task switching, and speed of processing. Additionally, this study found a relationship between increased subjective reports of fatigue with greater executive control, as measured by a dual-task walking paradigm validated for use with the aging population (42, 43, 60). The relationship between these outcomes provides further evidence that perceptions of fatigue and measures of executive control may be related (61, 62). Previous studies that demonstrated a similar relationship between subjective ratings of fatigue and performance on measures of executive functions (63, 64) were limited to populations with MS (64, 61) or a history of stroke (63). The current study extends these findings to a healthy, community-dwelling, aging population.

Study Limitations and Future Directions

While the factor structure and internal consistency were strong, future studies using larger samples and more advanced statistical methods, such as confirmatory factor analysis and item response theory, may be useful to fully examine the psychometric properties of the scale. Furthermore, while we were able to establish relationships between fatigue and important outcome variables, predictive validity for the bi-dimensional factor structure would provide information regarding whether these separate factors are differentially able to predict certain outcomes in older adults over time, a crucial factor in older adults who are experiencing functional and cognitive decline.

Despite significant relationships between the total and subscale BFI scores and outcome variables, the correlations were relatively weak. The magnitude of the correlations were likely due the limited range of BFI scores, as the present sample consisted of relatively healthy older adults who reported fewer fatigue symptoms. Further investigation is needed to extend these findings to a more diverse sample of community-dwelling older adults who experience more health concerns, such as those in clinical settings and residential care facilities. These older adults with greater health concerns are likely to have higher levels of fatigue symptoms, leading to stronger relationships between the subscale and total BFI scores with relevant clinical outcome measures.

Conclusions

This study established the psychometric properties of the BFI in an aging population. The scale is brief, allowing for easy integration into longitudinal studies, clinical trials, and rehabilitation facilities. We demonstrated strong support for a bi-dimensional structure for the BFI, comprised of fatigue interference and severity. The two subscales showed a differential relationship to relevant demographic, physical, and cognitive variables. This may be indicative of different constructs captured by each subscale and requires further exploration. In light of the differential relationship of fatigue severity and interference with demographic and cognitive outcome measures, we recommend both subscales scores be used in addition to the total score when working with community-dwelling older adults.

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List of Abbreviations

BFI	Brief Fatigue Inventory
CCMA	Central Control of Mobility in Aging Study
NW	Normal Walk
WWT	Walking While Talking
SPPB	Short Performance Physical Battery
RBANS	Repeatable Battery for the Assessment of Neuropsychological Status
TMT	Trail Making Test
GHS	Global Health Scale
GDS	Geriatric Depression Scale
ADL-PI	The Activities of Daily Living-Prevention Instrument
PCA	Principle Components Analysis
IADL	Instrumental Activities of Daily Living
MS	Multiple Sclerosis

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Table 1

Demographic Characteristics (N = 302)

	N (%)	M ± SD (range)
Demographic Variables		
Age (years)		76.44 ± 6.98 (65–95)
Gender		
Females	163 (54 %)	
Males	139 (46 %)	
Education (years)		14.51 ± 2.98 (5–28)
IADL		2.53 ± 3.24 (0–15)
GDS		4.72 ± 3.90 (0–21)
GHS		1.20 ± 1.01 (0–5)
0	83 (27.5 %)	
1	114 (27.7 %)	
2	76 (25.2 %)	
3	22 (7.2 %)	
4	6 (2 %)	
5	1 (0.3 %)	
Physical Measures		
SPPB		9.92 ± 1.87 (2–12)
Gait Velocity NW (cm/s)		99.54 ± 23.43 (27–170)
Gait Velocity WWT (cm/s)		70.31 ± 25.23 (14–148)
Cognitive Measures		
RBANS Total Index		92.22 ± 11.65 (65–137)
Trails A Time (Seconds)		49.72 ± 26.58 (16–300)
Trails B time (Seconds)		131.43 ± 66.75 (13–540)

Abbreviations: IADL = Instrumental Activities of Daily Living; GDS = Geriatric Depression Scale; GHS = Global Health Scale; SPPB = Short Performance Physical Battery; NW = Normal Walk; WWT = Walking While Talking; RBANS = Repeatable Battery for the Assessment of Neurological Status; Trails A = Trail Making Test (Part A); Trails B = Trail Making Test (Part B);

Table 2

Characteristics of Brief Fatigue Inventory (BFI)

Variable	M ± SD	Median	Range
Fatigue Severity			
Now	1.91 ± 2.28	1.00	0–10
Usual	2.31 ± 2.28	2.00	0–10
Worst	3.95 ± 3.03	4.00	0–10
Fatigue Interference			
General activity	1.04 ± 2.18	0.00	0–10
Mood	1.03 ± 2.04	0.00	0–10
Walking	0.91 ± 2.04	0.00	0–10
Normal Work	1.04 ± 2.12	0.00	0–10
Relations	0.47 ± 1.33	0.00	0–10
Enjoyment	0.77 ± 1.72	0.00	0–10
Summation Scores			
BFI total	13.43 ± 13.96	10.00	0–90
BFI severity	8.17± 6.56	7.00	0–30
BFI interference	5.26 ± 8.97	0.52	0–60

Table 3

Construct Validity: Principal Components Analysis (Direct Oblimin)

Variable	Factor 1 (Interference)	Factor 2 (Severity)	Corrected Item-Total Correlation	Cronbach's α if Deleted	Communalities
Cronbach's α	*0.867*	*0.818*			
Fatigue interference					
Relations	* .861		.621	.857	0.613
Enjoyment	* .787		.651	.848	0.611
Normal Work	* .779		.746	.830	0.672
Mood	* .759		.649	.848	0.599
General Activity	* .733		.718	.836	0.646
Walking	* .597		.651	.848	0.574
Fatigue severity					
Usual		* .872	.791	.645	0.835
Worst		* .847	.688	.760	0.743
Now		* .806	.584	.832	0.642
Eigenvalue	4.834	1.101			
% Variance	53.71%	12.23%			
% Cumulative Variance	53.70%	65.94%			

* $p < 0.05$

Table 4

Correlation Matrix Between BFI Summation Scores and Cognitive Outcome Measures Previously Validated for use with for Older Adults

	BFI Summation Scores		
	BFI Total	**BFI Severity**	**BFI Interference**
Demographic Characteristics			
Age	* .119 (0.038)	.090	* .120 (0.037)
Gender	*.103 (.073)	.119 (.038)	.042 (.465)
Education	−.037 (.527)	.006 (.914)	−.061 (.288)
IADL	† .333 (<0.001)	† .255 (<0.001)	† .332 (< 0.000)
GDS	† .451 (<0.001)	† .389 (<0.001)	† .417 (<0.001)
GHS	* .146 (0.011)	* .112 (0.053)	† .166 (0.004)
Physical Measures			
SPPB	†−.190 (0.001)	†−.195 (0.001)	†−.176 (0.002)
Velocity (NW)	†−.223 (<0.001)	†−.205 (0.001)	† −.198 (0.001)
Velocity (WWT)	* −.115 (0.053)	−.45	†−.146 (0.014)
DTC (WWT)	* .119 (0.047)	† 0.188 (0.002)	0.049
Stairs Difficulty (Up)	†.173 (0.003)	†.164 (0.004)	†.141 (0.014)
Stairs Difficulty (Down)	†.158 (.006)	†.157 (.006)	.107 (.064)
Cognitive Measures			
RBANS Total	−.046 (.423)	−.042 (.468)	−.041 (.474)
Trails A Time (Seconds)	.051 (.380)	.045 (.437)	.046 (.425)
Trails B time (Seconds)	†0.153 (0.008)	†0.162 (0.005)	*.019 (0.038)

Note: Pearson correlation values are reported. Values in parentheses are P values

Abbreviations: IADL = Instrumental Activities of Daily Living; GDS = Geriatric Depression Scale; GHS = Global Health Scale; SPPB, Short Performance Physical Battery; NW = Normal Walk; WWT = Walking While Talking; DTC = Dual Task Cost; RBANS = Repeatable Battery for the Assessment of Neurological Status; Trails A = Trail Making Test (Part A); Trails B = Trail Making Test (Part B);

* $P < 0.05$

† $P < 0.01$