ORIGINAL ARTICLE

Measurement properties of a telephone version of the Modified Fatigue Impact Scale among individuals with a traumatic spinal cord injury

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Study design: Cross-sectional.

Objectives: To validate a telephone-administered version of the Modified Fatigue Impact Scale spinal cord injury (MFIS-SCI) scores among individuals with a traumatic SCI 6 months post discharge from rehabilitation.

Setting: GF Strong Rehabilitation Center in Vancouver, British Columbia, Canada.

Methods: Data from 42 participants who were ≥ 19 -years-old with a confirmed American Spinal Injury Association Impairment Scale classification of A, B, C or D resulting from a traumatic SCI, and 6 months post discharge from rehabilitation were analyzed. The internal consistency was ascertained using Cronbach's alpha. Support for validity was provided by conducting correlations between the 21-item MFIS-SCI and Fatigue Severity Scale (FSS), and the Center for Epidemiological Depression Scale (CESD). A receiver operating characteristic (ROC) curve was constructed. Sensitivity, specificity and likelihood ratios were calculated to assess the diagnostic accuracy.

Results: Cronbach's alpha was 0.97. Correlations between the MFIS-SCI and FSS ($r=0.69$, $P<0.01$), and CESD ($r=0.64$, $P<0.01$) were in the *a priori* hypothesized direction and magnitude. The area under the ROC curve was 0.78 (95% confidence interval = 0.65–0.92). At the optimal cutoff score of 24.5, both the sensitivity and specificity were 0.67. The positive and negative likelihood ratios were 2.03 and 0.49, respectively.

Conclusion: There is support for the validity of the MFIS-SCI scores and it should be considered for the comprehensive measurement of the impact of fatigue in persons with a traumatic SCI.

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Keywords: Modified Fatigue Impact Scale; validity; internal consistency; spinal cord injury; fatigue

INTRODUCTION

Fatigue is prevalent among individuals with spinal cord injury (SCI) and it may be severe enough to act as a barrier to daily function.^{1–3} Fatigue is a complex construct that has physical, cognitive and psychosocial dimensions.⁴ Studies suggest that it can be attributed to weaker muscles that are susceptible to fatigue as a result of nerve damage, underuse, overuse, immobilization⁵ and fatigue-causing medications⁶ after SCI. Moreover, fatigue among individuals with SCI has been reported to be linked with depression leading to diminished participation in social and recreational activities, and overall quality of life.^{4,7,8}

Clinicians and researchers require valid and reliable measures of fatigue to guide interventions and to reduce its impact. Owing to the subjective nature of fatigue, self-report questionnaires serve as useful and efficient methods to assess it. The Fatigue Severity Scale (FSS) is the only measure of fatigue to have been validated for individuals with SCI.⁸ Although the FSS screens for the severity and frequency of fatigue, it does not provide a comprehensive understanding of the impact of fatigue. The Modified Fatigue Impact Scale (MFIS)

is a multidimensional scale that captures information regarding the impact of fatigue on an individual's life. The objective of this study was to validate a telephone-administered version of the MFIS among individuals with a traumatic SCI at 6 months post discharge from rehabilitation.

MATERIALS AND METHODS

Design/sample

This methodological cross-sectional work represents data from a single point in time of a larger longitudinal study of fatigue. Subjects were recruited after discharge from the GF Strong Rehabilitation Center, the main rehabilitation facility for SCI in British Columbia, Canada. The eligibility criteria included: (1) traumatic SCI (paraplegia or tetraplegia) with a confirmed American Spinal Injury Association Impairment Scale classification of A, B, C or D, (2) ~ 6 months post discharge from rehabilitation, (3) ≥ 19 years old and (4) ability to speak and read English.

Measurement

The MFIS and modification for SCI (MFIS-SCI). The MFIS, originally designed for the multiple sclerosis (MS) population, is a 21-item questionnaire

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consisting of 10 physical (pMFIS), 9 cognitive (cMFIS) and 2 psychosocial (psMFIS) items related to fatigue.⁹ Individuals rate their fatigue over the past 4 weeks on a scale of 0 (never) to 4 (almost always). The scores are summed, yielding a total score of 0 to 84 with higher scores indicating higher impact of fatigue. The scores of the MFIS have been shown to be reliable and valid for assessing fatigue related to MS.⁹

Based on our clinical experience and feedback from individuals with SCI we modified the MFIS (MFIS-SCI-Appendix A) because not all the items were deemed relevant. Three individuals with SCI and two physiatrists with SCI experience reviewed the content, response categories and language of the items. The response range of the scale was changed from 'past 4 weeks' to 'past week' because the medical status of patients with SCI may change significantly in 4 weeks compared with 1 week. Three items (4, 13 and 20) from the original scale were deleted because the content did not reflect the SCI experience. For example, item 13 'my muscles have felt weak' was deleted. Three new items (5, 15 and 19) were added as they more closely represent the SCI experience. Phrases 'away from home' and 'at home or at work' were removed from items 9 and 16 of the original scale, respectively, to generalize the items to a wider spectrum of SCI patients who are discharged from rehabilitation into the community or into an assisted care facility.

Procedure

Demographic and medical data collected by chart review included: age, sex, education level, marital status, cause of injury, days since injury, days since discharge, level of injury and the American Spinal Injury Association Impairment classification.

The MFIS-SCI and the validity measures were completed over the telephone by a trained research assistant. A sheet with the questionnaires' response options was mailed to the subjects before data collection. Subjects were asked to use the sheet as a reference while providing a response to each question.

The local Ethics Board approved the study. We certify that all applicable institutional regulations concerning the ethical use of human volunteers were followed during the course of this research.

MFIS-SCI. The MFIS-SCI is a 21-item questionnaire (Appendix A), which is scored from 0 to 84, with higher scores indicating higher impact of fatigue. The MFIS-SCI has 11 cognitive (cMFIS-SCI), 7 physical (pMFIS-SCI) and 3 psychosocial (psMFIS-SCI) items. The cMFIS-SCI, pMFIS-SCI and psMFIS-SCI are scored from 0 to 44, 0 to 28 and 0 to 12, respectively.

Validity measures. The validity measures were selected because they enable us to pose and test hypotheses based on previously determined literature and because they have been validated in sample of individuals with SCI.^{7,8}

The FSS is a 9-item scale designed to measure the frequency and severity of fatigue.¹⁰ The FSS has three items related to physical fatigue, three items related to psychosocial environment and the rest are generic.¹¹ Participants rate their degree of agreement on a scale of 1 (strongly disagree) to 7 (strongly agree). Scores are averaged and the total score ranges from 1 to 7, with higher scores representing higher fatigue severity. A cut FSS score of ≥ 4 has been suggested to signify severe fatigue.¹⁰

The center for epidemiological depression scale (CESD): is a 20-item questionnaire designed to assess depression symptoms in the general population.¹² It captures data regarding the frequency of feelings and behaviors related to depression over the past week. The items are scored from 0 (rarely or none of the time) to 3 (most or all of the time). Four items are reverse scored. An overall score is generated by adding up the scores for all the items, with higher scores suggesting higher level of depression symptoms.

Statistical analysis

Means, s.d.s and frequencies were derived to describe the sample and the MFIS-SCI scores. Mean (s.d.) MFIS-SCI scores were also calculated by demographics. We assessed the floor and ceiling effects of the MFIS-SCI scores by observing whether $\geq 20\%$ of the scores occurred at the scoring extremes of the measure's distribution.¹³

Cronbach's alpha was derived to assess the internal consistency of the total MFIS-SCI scale and the three subscales. Item-by-item deletion was conducted to observe changes in the value of alpha. We hypothesized that the Cronbach's alpha would be ≥ 0.80 , which suggests excellent internal consistency.¹⁴

Validity of the MFIS-SCI scores and its subscales was investigated by correlating it with the FSS and CESD. The Pearson's correlation coefficient was used because all the outcome measures were approximately normally distributed. A correlation value $r > 0.75$ designates excellent to good relationship, and between $r = 0.75$ – 0.50 represents good to moderate relationship.¹⁵ We hypothesized that the MFIS-SCI and its subscales would have a positive correlation of $r > 0.50$ with the validity measures.

The receiver operating characteristic (ROC) curve was used to assess the diagnostic accuracy of the MFIS-SCI and to determine the optimum cutoff score indicating the presence of fatigue. In a ROC curve, 'sensitivity' or true positive rate is plotted on the y axis versus '1 – specificity' or 1 – true negative rate on the x axis for every possible cutoff score of a parameter. The area under the curve ranges from 0 to 1.0 and it is a measure of how well a measure can discriminate between groups. The closer the area under the curve value is to 1, the higher the overall accuracy of a measure. We calculated fatigue cutoff scores for the total MFIS-SCI and we did this by dividing the sample into two groups based on the FSS cutoff score of ≥ 4 . The sensitivity of the MFIS-SCI to correctly distinguish subjects who are fatigued was considered in the ROC analysis. The cutoff score for the MFIS-SCI was determined at the threshold that the sensitivity and specificity were maximized. The positive and negative likelihood ratios (LR+ and LR–) were calculated for the established cutoff score. The LR+ is the ratio between the probability of a positive test result given the presence of the condition and the probability of a positive test result given the absence of the condition: $LR+ = \text{sensitivity} / (1 - \text{specificity})$. The LR– is the ratio between the probability of a negative test result given the presence of the condition and the probability of a negative test result given the absence of the condition: $LR- = (1 - \text{sensitivity}) / \text{specificity}$. LR+ values should be > 1 , and LR– values should be between 0 and 1. The further the LR+ or LR– is away from 1, the better the test's diagnostic accuracy. Data analyses were performed using SPSS (IBM, Armonk, NY, USA) for windows version 17.

RESULTS

Our sample ($n = 42$) was mainly male ($n = 32$, 76.2%), with a mean (s.d.) age of 48.0 (19.0) years (Table 1). The mean duration since injury was 336.5 (55.0) days, and the mean duration since discharge was 187.1 (9.8) days. The majority of the sample had an American Spinal Injury Association Impairment A classification (47.6%) and cervical level injuries (52.4%).

The mean score of the total MFIS-SCI was 27.1 (18.2). Table 2 contains the mean scores for the subscales and other measures. The administration of the MFIS-SCI took about 5–10 min. A total of 28% of the sample had total MFIS-SCI scores of between 0 to 17 (floor effect) while ceiling effects (scores between 67–84) existed for 2.4% of the sample.

Cronbach's alpha was 0.97 for the total MFIS-SCI, 0.96 for the cMFIS-SCI, 0.92 for the pMFIS-SCI and 0.82 for the psMFIS-SCI. The deletion of any item from the total MFIS-SCI and the subscales resulted in very small changes in the magnitude of the Cronbach's alpha (< 0.05).

All correlations were in the *a priori* direction and magnitude and found to be significant at the 0.01 level. The correlations between FSS and total MFIS-SCI, cMFIS-SCI, pMFIS-SCI and psMFIS-SCI were 0.69, 0.57, 0.73 and 0.68, respectively. Likewise, the correlations between CESD and total MFIS-SCI, cMFIS-SCI, pMFIS-SCI and psMFIS-SCI were 0.64, 0.63, 0.66 and 0.62, respectively.

According to the FSS cutoff score, 43% of the sample were fatigued. Using the FSS cutoff score as our gold standard for determining the presence of fatigue for our sample, the area under the curve based on the ROC was 0.78 (95% CI = 0.65–0.92; Figure 1). The cutoff score

Table 1 Descriptive characteristics of the sample and mean (s.d.) MFIS-SCI scores by sample factors

Variable	Total, n = 42 no. of cases (%)	MFIS-SCI score mean (s.d.)
Sex		
Male	32 (76.2)	27.2 (17.2)
Female	10 (23.8)	26.5 (22.1)
Marital status		
Single ^a	18 (42.9)	26.4 (19.7)
Married, common law	24 (57.1)	27.5 (17.4)
Education^b		
High school or less	25 (59.6)	24.2 (19.1)
Post-secondary	16 (38.10)	30.9 (16.9)
Injury completeness		
Complete (ASIA A)	20 (47.6)	21.9 (16.4)
Incomplete (ASIA B, C and D)	22 (52.4)	31.8 (18.8)
Level of injury		
Cervical	22 (52.4)	32.7 (21.0)
Thoracic/lumbo-sacral	20 (47.6)	20.8 (12.2)
Variable	Mean (s.d.)	
Age	48.0 (19.0)	

Abbreviations: ASIA, American Spinal Injury Association Impairment; MFIS-SCI, Modified Fatigue Impact Scale spinal cord injury.

^aIncludes widowed and divorced.

^bMissing data on one subject.

Table 2 Means (s.d.) of the outcome measures

Variable	Mean (s.d.)
MFIS-SCI total	27.1 (18.2)
cMFIS-SCI	11.6 (9.6)
pMFIS-SCI	10.6 (6.3)
psMFIS-SCI	4.2 (2.9)
FSS	3.5 (1.7)
CESD	11.2 (9.4)

Abbreviations: ASIA, American Spinal Injury Association Impairment; CESD, Center for Epidemiological Depression Scale; cMFIS, cognitive MFIS; FSS, Fatigue Severity Scale; pMFIS, physical MFIS; psMFIS, psychosocial MFIS.

for the MFIS-SCI that maximized sensitivity (67%) and specificity (67%) was 24.50. The corresponding LR+ was 2.03 and the LR- was 0.49.

DISCUSSION

The only validated measure for assessing fatigue in SCI is the FSS.⁸ The FSS is a short scale that measures the severity and frequency of physical and psychosocial fatigue. It is therefore a reasonable screening tool but does not cover cognitive fatigue, which is an important dimension of fatigue. The MFIS-SCI is a longer scale compared with the FSS, but it is a multidimensional scale that captures information about the impacts of physical, cognitive and psychosocial fatigue on daily life. As a result, the MFIS-SCI is a more comprehensive measure of fatigue that can be used to guide treatment.

To date, there is a lack of validated outcome measures that can comprehensively assess the impact of fatigue on individuals with SCI.

ROC Curve **Figure 1** ROC curve for all the cutoff scores for the MFIS-SCI. Area under the curve: 0.78 (95% confidence interval: 0.65–0.92).

The MFIS-SCI aims to capture the physical, cognitive and psychosocial impact of fatigue on daily function. In this study, we evaluated the measurement properties of the MFIS-SCI among individuals with a traumatic SCI who were discharged from rehabilitation.

The observed floor effect associated with the MFIS-SCI is contrary to studies reporting on the MS population where the MFIS had no floor effects.^{16,17} This could be partly explained by the fact that we assessed fatigue on individuals within 6 months post discharge from rehabilitation. It is reported that fatigue with SCI tends to get worse, rather than improve over time.¹⁸ If true then the observed floor effect associated with the MFIS-SCI would be expected to diminish over time. Another explanation for the difference in floor effects between the SCI and MS is that we modified some of the original items of the MFIS. Lastly, the difference could be because fatigue in MS is different than fatigue in SCI.

The internal consistency of the total MFIS-SCI and its subscales was excellent.¹⁴ Our Cronbach's values were consistent with those of the total, physical and cognitive subscales for the MS population, but our psychosocial subscale alpha was much higher.¹⁷ However, our psMFIS-SCI subscale contains one additional item. The added item (no. 19) likely increased our alpha.^{14,15}

The MFIS-SCI and its subscales all correlated with the FSS and the CESD in the *a priori* hypothesized direction and magnitude indicating support for validity. The correlation between MFIS-SCI and the FSS was relatively consistent with the reported correlations in previous studies for the MS population.^{19,20} The correlations between the pMFIS-SCI and psMFIS-SCI, and FSS were consistent with those for the MS population, whereas the cMFIS-SCI subscale had a higher correlation with the FSS compared with previous reports.²⁰ This could be owing to the fact that the cMFIS-SCI differs from the cMFIS by having one additional cognitive item (no. 5). The strong positive correlation between the MFIS-SCI and CESD supports the notion that depression is associated with fatigue with ~36% shared variation in our sample.⁶⁻⁸

The area under the curve of the ROC curve suggests that the MFIS-SCI cutoff score of 24.5 has relatively good diagnostic accuracy. In fact it is 28% better at indicating fatigue than simply flipping a coin, or that a randomly selected individual from a fatigued group has a test value larger than that for a randomly chosen individual from a non-fatigued group 78% of the time. The LR+ of 2.03 is relatively large and the LR- of 0.49 is fairly close to 0, providing additional support of the discriminating power of the MFIS-SCI. The cutoff score therefore can be used as a diagnostic threshold to identify those SCI patients who experience clinically significant fatigue. However, the generalizability of this threshold warrants additional study, and it depends on the acceptability of using the FSS as a gold standard.

Evidence-based interventions are required to manage fatigue in persons with SCI. As fatigue in SCI is multidimensional, fatigue management interventions should include physical, cognitive and psychological elements.⁴ Behavioral and psycho-educational interventions such as energy management programs have been effective in reducing MS-related fatigue,²¹ and therefore might be useful in SCI as well. In addition, high-intensity exercise has been shown to reduce fatigue in persons with SCI.²² Lastly, carnitine supplements have effectively reduced fatigue in MS and chronic fatigue syndrome^{23,24} and therefore might be effective in SCI as well.

This study had a number of limitations. Our sample was predominantly young men with a broad range of American Spinal Injury Association Impairment levels and relatively recent SCI. In addition, our study sample was drawn from the SCI population in a single rehabilitation facility. Lastly, there is a possibility for reporting bias because data were collected through telephone interview therefore subjects might have under-reported undesirable outcomes (for example, higher fatigue or depression symptoms). However, because of limited or lack of hand/arm function in a select few individuals with SCI, we had to complete the questionnaires using an interview format.

CONCLUSIONS

Clinicians and researchers need reliable and valid measures for assessing fatigue in persons with SCI. Considering the excellent internal consistency, good diagnostic accuracy and support for validity, the MFI-SCI is a tool worthy of consideration for the measurement of the impact of fatigue in persons with a traumatic SCI.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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that best indicates how often fatigue has affected you in this way during the past week. If you need help in marking your responses, tell the interviewer the number of the best response. Please answer every question. If you are not sure which answer to select, choose the one answer that comes closest to describing you. Ask the interviewer to explain any words or phrases that you do not understand.

Because of my fatigue during the past week...

APPENDIX A

MFIS for SCI

Fatigue is a feeling of physical tiredness and lack of energy that many people experience from time to time. But people who have medical conditions experience stronger feelings of fatigue more often and with greater impact than others.

Following is a list of statements that describe the effects of fatigue. Please read each statement carefully, then choose the one number

<i>Cognitive subscale</i>	<i>Never</i>	<i>Rarely</i>	<i>Sometimes</i>	<i>Often</i>	<i>Almost always</i>
1. I have been less alert	0	1	2	3	4
2. I have had difficulty paying attention for long periods of time	0	1	2	3	4
3. I have been unable to think clearly	0	1	2	3	4
4. I have been forgetful	0	1	2	3	4
5. I have had difficulty paying attention for short periods of time	0	1	2	3	4
6. I have had difficulty making decisions	0	1	2	3	4
7. I have been less motivated to do anything that requires thinking	0	1	2	3	4
8. I have had trouble finishing tasks that require thinking	0	1	2	3	4
9. I have had difficulty organizing my thoughts when doing things	0	1	2	3	4
10. My thinking has been slowed down	0	1	2	3	4
11. I have had trouble concentrating	0	1	2	3	4

Cognitive subscale score _____

<i>Physical subscale</i>	<i>Never</i>	<i>Rarely</i>	<i>Sometimes</i>	<i>Often</i>	<i>Almost always</i>
12. I have had to pace myself in my physical activities	0	1	2	3	4
13. I have been less motivated to do anything that requires physical effort	0	1	2	3	4
14. I have trouble maintaining physical effort for long periods	0	1	2	3	4
15. I have trouble maintaining physical effort for short periods	0	1	2	3	4
16. I have been physically uncomfortable	0	1	2	3	4
17. I have been less able to complete tasks that require physical effort	0	1	2	3	4
18. I have needed to rest more often or for longer periods	0	1	2	3	4

Physical subscale score _____

<i>Psychosocial subscale</i>	<i>Never</i>	<i>Rarely</i>	<i>Sometimes</i>	<i>Often</i>	<i>Almost always</i>
19. I have avoided/eliminated certain tasks, activities and lifestyles	0	1	2	3	4
20. I have been less motivated to participate in social activities	0	1	2	3	4
21. I have been limited in my ability to do things	0	1	2	3	4

Psychosocial subscale score _____

Total MFIS-SCI score = _____