Sleep Medicine 30 (2017) 105–112

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Validation of the Flinders Fatigue Scale as a measure of daytime fatigue

Kate Cameron [a], Paul Williamson [a], Michelle A. Short [a, b], Michael Gradisar [a, *]

[a] School of Psychology, Flinders University, South Australia, Australia
[b] Centre for Sleep Research, University of South Australia, South Australia, Australia

ARTICLE INFO

Article history:
Received 24 August 2016
Received in revised form
22 November 2016
Accepted 25 November 2016
Available online 3 December 2016

Keywords:
Fatigue
Insomnia
Daytime functioning
Psychometrics
Sleepiness

ABSTRACT

Study objectives: To clinically validate the Flinders Fatigue Scale (FFS) as a brief measure of daytime fatigue, and to derive cut-off scores to classify fatigue severity.
Method: The FFS was administered to 439 adult volunteers from the general population, 292 adults with insomnia, 132 adults with Obstructive Sleep Apnoea (OSA) and 66 adults with Chronic Fatigue Syndrome/Myalgic Encephalomyelitis (CFS/ME), together with the Fatigue Severity Scale (FSS) and the Epworth Sleepiness Scale (ESS).
Results: A factor analysis revealed a single factor solution for the seven-item scale (67% of total variance), although a better fit was obtained for a modified six-item version (75% of total variance). Group FFS scores varied in accordance with theorised fatigue levels, with CFS/ME and insomnia samples reporting significantly higher fatigue than OSA and volunteer samples. Good convergent validity was established with the FSS for volunteer ($r = 0.67$) and CFS/ME samples ($r = 0.61$). Excellent discriminant validity with the ESS was observed for the insomnia ($r = -0.08$) and CFS/ME groups ($r = 0.03$), while a small-to-moderate correlation was found within the volunteer sample ($r = 0.29$). Cut-off scores were identified to categorise borderline (13–15), moderate (16–20) and severe (≥21) fatigue.
Conclusions: The FFS is a reliable and valid instrument to quantify subjective daytime fatigue. Sensitivity and specificity analyses indicate scores that best discriminate insomniacs and CFS/ME populations from a non-clinical population. However, it is proposed that the data can also be used to indicate the severity of fatigue by reference to these first two groups.

1. Introduction

Insomnia is a frequent health complaint brought to the attention of both primary care physicians and sleep specialists, with rates estimated at 5–10% of the population [1]. Insomnia is characterised by difficulties initiating or maintaining sleep, together with daytime impairments such as fatigue, irritability, poor attention/concentration and social or vocational dysfunction [2,3]. Research has suggested that these daytime impairments significantly reduce quality of life for those affected [4]. Indeed, it is argued that it is daytime impairments, rather than nocturnal sleep disturbances, that prompt treatment seeking for insomnia [5]. Given the central role of daytime dysfunction in insomnia, and the detrimental effects on patients' quality of life [6], it is important that daytime symptoms be measured and considered when making clinical and research-based judgments regarding insomnia diagnosis, severity and treatment efficacy [7].

Daytime fatigue is the most frequently reported daytime symptom of insomnia [8] and, therefore, is important to measure. Insomnia is typically assessed using a combination of self-report measures (eg, Insomnia Severity Index) [9], structured and semi-structured interviews [10], sleep diaries [11], and optional polysomnography [12]. Whilst these measures may gauge the presence or absence of daytime fatigue, commonly used measures do not quantify daytime fatigue severity. In response, the Flinders Fatigue Scale (FFS) was developed [13]. The authors of the FFS argued that extant fatigue scales, such as the Fatigue Severity Scale (FSS) [14] and the Multidimensional Fatigue Inventory (MFI) [15], may not be appropriate for individuals with insomnia, as they were designed for use with non-sleep disordered populations, including individuals with cancer, multiple sclerosis or systemic lupus erythematosus.

* Corresponding author. School of Psychology, Flinders University, GPO Box 2100, Adelaide, 5001, South Australia, Australia. Fax: +61 085 8201 3877.
E-mail address: michael.gradisar@flinders.edu.au (M. Gradisar).

http://dx.doi.org/10.1016/j.sleep.2016.11.016
1389-9457/© 2016 Published by Elsevier B.V.

Further, the authors posited that the construct of *fatigue* was poorly defined by these scales. This is particularly important given frequent lay confusion surrounding the meaning of the word 'fatigue' [16–18]. Fatigue is often used interchangeably with terms such as "tired" and "sleepy," however the terms are conceptually and clinically distinct. The Flinders Fatigue Scale addresses this by providing a definition of fatigue (including what it is *not*) at the beginning of the measure, thus increasing clinical validity for diagnosis and treatment [7].

Preliminary investigation into the Flinders Fatigue Scale has returned promising results, with high internal consistency in normative and insomnia samples (Cronbach's alpha = 0.86–0.91) [13], discriminant validity with the Epworth Sleepiness Scale [19], and sensitivity to treatment effects within an insomnia population. Other measures of daytime fatigue (the FSS and the MFI) have demonstrated limited success in attaining sensitivity to treatment when used with insomnia populations [24,25].

An important facet yet to be investigated is whether the Flinders Fatigue Scale discriminates between good sleepers and clinical sleep-disordered samples. A more convincing demonstration that the FFS is validly measuring the construct of fatigue is to show that the FFS can discriminate between different populations who have distinct profiles of fatigue and sleepiness. The present study therefore includes community volunteers, insomnia, Obstructive Sleep Apnoea (OSA) and Chronic Fatigue Syndrome/Myalgic Encephalitis samples, as they have distinct daytime fatigue/daytime sleepiness profiles. For example, the volunteer sample is predicted to demonstrate neither elevated nor reduced levels of daytime fatigue or daytime sleepiness. Hence this population was of interest as both a comparative group and to aid in the development of normative data. Individuals with insomnia frequently report high levels of daytime fatigue, but not necessarily sleepiness [20–22]. Individuals with OSA provide an interesting and valuable comparison group as the hallmark daytime symptom of OSA syndrome is excessive daytime sleepiness [23,24]. However, while OSA patients experience elevated levels of fatigue compared to healthy controls [23], it is lower than that experienced by insomnia patients [25]. Lastly, CFS/ME is characterised by persistent fatigue which is unrelated to exertion and not substantially alleviated by rest [26]. CFS/ME is accompanied by a range of other symptoms such as impaired memory/concentration, muscle pain (myalgia), unrefreshing sleep and post-exertional malaise [26]. Despite high levels of fatigue and unrefreshing sleep, CFS/ME patients do not consistently present with elevated levels of daytime sleepiness [27]. Hence the CFS/ME population is postulated to report elevated levels of fatigue and only moderate levels of sleepiness. This profile is very similar to that of the insomnia sample and hence the CFS/ME group was included to assess whether the FFS was sensitive to the fatigue experienced by fatigued populations other than insomniacs.

In summary, the primary aim of the present study was to examine the discriminant validity and the sensitivity of the Flinders Fatigue Scale by comparing FFS scores across four samples theorised to differ in fatigue and sleepiness profiles. It is hypothesised that fatigue will be significantly higher in the insomnia and CFS/ME samples than the OSA and volunteer samples. It is further hypothesised that the FFS will display convergent validity with another measure of fatigue (the Fatigue Severity Scale) and divergent validity with the Epworth Sleepiness Scale. A factor analysis of the FFS will be undertaken, and clinical cut-off scores will be established.

2. Method

2.1. Participants and procedure

Four samples were used for the present study. The community volunteer and CFS/ME samples were recruited specifically for this study via advertisements and snowball sampling methods. Participants included those over 18 years of age who resided within Australia. These participants completed online or paper versions of all measures. Insomnia and Obstructive Sleep Apnoea patients were recruited from patients attending the Repatriation General Hospital Sleep Clinic in Adelaide, South Australia for assessment and treatment of suspected insomnia or OSA. Study measures were administered as part of a pre-treatment questionnaire battery.

All participants completed the Flinders Fatigue Scale, the Epworth Sleepiness Scale and the Insomnia Severity Index. All samples, except the insomnia group, completed the Pittsburgh Sleep Quality Inventory, and only the community volunteers and CFS/ME samples completed the Fatigue Severity Scale. Note that only participants with complete Flinders Fatigue Scale scores were included in the sample descriptions. Data were collected in 2009.

2.1.1. Community volunteers

The volunteer sample consisted of 439 adult volunteers ($M = 39.86$ years, $SD = 19.42$ years). Of those who reported their gender, there were 98 (33%) males and 199 (67%) females. Of the 362 participants with valid PSQI scores, 54% (n = 195) had a PSQI total score > 5, indicating poor sleep quality [28]. This sample was recruited via a snowball sampling method [29].

2.1.2. Chronic Fatigue Syndrome/Myalgic Encephalomyelitis (CFS/ME) sample

There were 66 respondents with CFS/ME ($M = 41.92$ years, $SD = 14.96$ years; 10 (26%) males, 28 (74%) females; 13.8% good sleepers, 86.2% bad sleepers). Subjects were recruited via advertisements placed at chronic illness support groups or online CFS/ME support group websites and forums. Subjects were classified as suffering CFS/ME if they reported they had been formally diagnosed with either condition by a physician or other medical practitioner.

2.1.3. Insomnia sample

The insomnia sample consisted of 292 untreated adults ($M = 48.84$ years, $SD = 16.41$ years; 99 (34%) males, 193 (66%) females) who were diagnosed with primary insomnia according to DSM-IV-TR criteria [2] on the basis of on a clinical interview, self-report measures (such as the Insomnia Severity Index and the Daytime Feelings and Functioning Scale) [30], information from a 7-day sleep diary and overnight polysomnography. Daytime impairment was indicated by a Daytime Feelings and Functioning Scale score >9 or an Insomnia Severity Index >14.

2.1.4. Obstructive Sleep Apnea sample

The OSA sample consisted of 132 adults ($M = 52.99$ years, $SD = 14.64$ years; 88 (67%) males, 44 (33%) females) who were diagnosed with OSA on the basis of overnight polysomnography demonstrating an Apnea-Hypopnoea Index (AHI) of 15 or greater and who reported daytime impairment, in accordance with ICSD-2 criteria [31].

Research involving the community volunteer and CFS/ME samples was approved by the Flinders University Social and Behavioural Ethics Committee. Approval was provided by the Flinders University Social and Behavioural Ethics Committee and the Repatriation General Hospital Ethics Committee for the research pertaining to the Insomnia and Obstructive Sleep Apnea samples.

2.2. Measures

2.2.1. Flinders Fatigue Scale (FFS)

The FFS is a seven-item self-report scale which measures various characteristics of fatigue experienced over the past 2 weeks [13].

Sample items include "Did fatigue cause you distress?" and "How severe was the fatigue you experienced?" The 7 items are summed to provide a total fatigue score ranging from 0 to 31, with higher scores indicating greater fatigue. The scale is prefaced by an explicit definition of fatigue "We are interested in the extent that you have felt **fatigued** (tired, weary, exhausted) over the last **two weeks**. We **do not** mean feelings of **sleepiness** (the likelihood of falling asleep)." Total FFS scores were available for all participants.

2.2.2. Fatigue Severity Scale (FSS)

The FSS [14] is a nine-item self-report scale which is designed to measure a person's fatigue in a variety of situations (eg, "My motivation is lower when I am fatigued" "Fatigue causes frequent problems for me"). Patients rate their level of agreement with the statements. Total fatigue is the sum of all items with a possible score range of 9–63. Scores of 36 or more are considered indicative of elevated levels of fatigue [14]. The FSS has been used to measure fatigue in conditions such as Multiple Sclerosis (MS), Chronic Fatigue Syndrome (CFS) and Systemic Lupus Erythematosus (SLE) and has demonstrated good internal consistency ($\alpha = 0.81$ [14], $\alpha = 0.93$ [32]). The FSS has also demonstrated concurrent validity with fatigue rated on visual analogue scales and is able to discriminate between MS or SLE patients and healthy patients [14]. Total FSS scores were available for 433 participants from the volunteer sample and 65 CFS/ME patients.

2.2.3. Daytime sleepiness – Epworth Sleepiness Scale (ESS)

The Epworth Sleepiness Scale [17] is a well-established eight-item self-report measure which assesses daytime sleepiness. The ESS requires respondents to indicate how likely they would be to fall asleep or doze in various situations (eg, "sitting and reading"). ESS scores range from 0 to 24 with higher scores indicating greater levels of daytime sleepiness. ESS scores higher than 10 are considered to indicate excessive levels of daytime sleepiness [17]. The ESS has consistently demonstrated acceptable reliability with sleep-disordered populations (eg, $\alpha = 0.88$) [19]. Total ESS scores were available for 436 participants from the volunteer sample; 132 OSA patients, 289 insomnia patients, and 66 CFS/ME patients.

2.2.4. Insomnia severity – Insomnia Severity Index (ISI)

The presence and severity of insomnia was assessed using the Insomnia Severity Index (ISI) [10]. This measure was used as a screening measure for the volunteer and CFS/ME samples and as part of a broader assessment of insomnia in the sleep-disordered samples. The ISI is a seven-item self-report measure which assesses the subjective symptoms and consequences of insomnia, as well as the degree of concern or distress produced by those difficulties. The seven items are summed to produce a total score ranging from 0 to 28, with higher scores indicating more severe insomnia. Scores >7 are suggestive of subthreshold insomnia [10]. The measure has demonstrated good psychometric properties including internal consistency ($\alpha = 0.74$), concurrent validity with sleep efficiency variables and sensitivity to changes with treatment [9]. The ISI is also consistent with the diagnostic criteria outlined in the DSM-IV-TR. [9].

2.2.5. Sleep quality – Pittsburgh Sleep Quality Index (PSQI)

Sleep quality was assessed by the Pittsburgh Sleep Quality Index (PSQI) [28], which assesses frequency of sleep disturbance and subjective sleep quality (eg, "During the past month, how often have you had trouble sleeping because you cannot get to sleep within 30 min?" "During the past month how would you rate your sleep quality overall?"). The 19 items produce seven factors, which when summed produce a global PSQI score. The PSQI has good psychometric properties, with a sensitivity of 90% and a specificity of 87% of distinguishing between good and poor sleepers [28]. A clinical cut-off of >5 is indicative of poor sleep quality [28]. Total PSQI scores were available for 362 participants from the volunteer sample; 132 OSA patients and 58 CFS/ME patients.

2.3. Statistical analyses

The factor structure of the FFS was tested using an exploratory factor analysis. Pearson correlations were conducted to assess the convergent and divergent validity of the FFS with the FSS and ESS. The differences in fatigue between diagnostic groups was tested using a between groups one-way analysis of variance (ANOVA). Finally, the sensitivity and specificity of the FFS and cut-off scores to determine borderline, moderate and high levels of fatigue were analyzed using the Youden's J statistic.

3. Results

A between-groups one-way ANOVA was conducted to explore age differences in the diagnostic groups. Results revealed a significant main effect of diagnosis, $F(3,845) = 25.18$, $p < 0.001$. Post hoc t-tests revealed that participants with comorbid OSA and insomnia were significantly older ($X = 52.99$ years, $SD = 14.64$) than all other diagnostic groups. Further, the insomnia group ($X = 48.84$ years, $SD = 16.41$) was significantly older than both the ME/CFS group ($X = 41.92$ years, $SD = 14.96$) and the community sample ($X = 39.86$ years, $SD = 19.42$). However, as age explained less than two percent of the variance in fatigue on the FFS, $r(849) = -0.13$, $p < 0.001$, age was not entered as a covariate in subsequent analyses.

A Chi square test was used to examine gender differences in diagnostic subgroups. Results revealed significant differences in the proportion of males in each diagnostic group, χ^2 (3) = 52.79, $p < 0.001$, with the comorbid OSA/insomnia group consisting of 67% males, the insomnia group 34%, community sample 33%, and ME/CFS group 26%. A two-way between groups ANOVA was conducted to examine the effect of sex on FFS scores and to determine whether sex and diagnostic group interacted in their effect on fatigue. Results indicated no main effect of sex, $F(1,759) = 1.56$, $p = 0.21$, and no interaction between sex and diagnostic group on fatigue, $F(3,759) = 0.47$, $p = 0.70$. As such, sex was not entered as a covariate in subsequent analyses.

3.1. Internal consistency and factor structure

An exploratory factor analysis revealed a single factor that explained 67.4% of the variance for the Flinders Fatigue Scale using the total sample. Analysis by group revealed single factors explaining variances of 61.2% (volunteer sample), 60.1% (insomnia sample) and 51.3% (CFS/ME sample). However, the factor loading on item 7 ("How much was your fatigue caused by poor sleep?") was noticeably poorer (0.27) than the other items (ranging from 0.57 to 0.83). Hence another factor analysis was run retaining only the first 6 items of the scale. This returned stronger results, with the single factor explaining 74.8% of the variance (volunteer sample 67.3%; insomnia sample 67.3%; CFS/ME sample 59.7%). Data for the six-item version was not calculable for the OSA sample since individual FFS item scores were not available. While results from analyses using the seven-item version are reported here to enable comparisons with the results from the Gradisar et al. study [13], analyses using the six-item version are provided in the Supplementary file.

The internal consistency of the Flinders Fatigue Scale for each sample was 0.88 for the community volunteer sample, 0.86 for the insomnia sample and 0.75 for the CFS/ME sample. Both internal consistency and factor analysis could not be assessed for the OSA sample since individual FFS item scores were not available from the database.

3.2. Convergent validity

The convergent validity was assessed by correlating the total scores of both fatigue measures for the community volunteer and CFS/ME samples only, since the Fatigue Severity Scale was only administered to these samples. Total Flinders Fatigue Scale scores were strongly and positively correlated (all $p < 0.001$) with total Fatigue Severity Scale scores for both the volunteers ($r = 0.67$) and CFS/ME ($r = 0.61$) samples, suggesting both fatigue instruments were measuring similar constructs within both samples.

3.3. Discriminant validity

Correlations between total Epworth Sleepiness Scale (ESS) scores and total Flinders Fatigue Scale scores were conducted to assess discriminant validity. No significant correlation was found between the Flinders Fatigue Scale and the ESS for the insomnia ($r = -0.08$, $p = 0.16$) and CFS/ME samples ($r = 0.03$, $p = 0.84$), suggesting good discriminant validity between these two measures of sleepiness and fatigue when administered to clinically fatigued populations. In contrast, small-to-medium correlations were found between the ESS and the FFS scores for the sleep apnea ($r = 0.29$, $p = 0.001$) and volunteer samples ($r = 0.38$, $p < 0.001$) indicating slight overlap between these two measures when administered to populations that typically exhibit lower fatigue. This pattern of results was replicated when analyses were repeated with the Fatigue Severity Scale, with no significant correlation found within the clinically fatigued sample (CFS/ME) ($r = -0.13$, $p = 0.30$), but a modest correlation between the two measures was evident in the volunteer sample ($r = 0.39$, $p < 0.001$).

When the community volunteer sample was split into good and poor sleepers (ie, PSQI greater than five versus PSQI scores of five or less), correlations between the sleepiness measure and both fatigue measure followed the same pattern. Within the good sleepers, the ESS was moderately positively correlated with both the FFS ($r = 0.35$, $p < 0.001$) and the FSS ($r = 0.41$, $p < 0.001$). However, the relationship of the ESS to each of the fatigue measures was small-to-moderate amongst the poor sleepers, with correlations between the ESS and the FFS ($r = 0.18$, $p = 0.02$) and the FSS ($r = 0.28$, $p < 0.001$). This trend supports findings observed within the clinical groups that the higher the level of fatigue, the greater the distinction between fatigue and sleepiness.

3.4. Differences between diagnostic subgroups

3.4.1. Flinders Fatigue Scale

Participant scores on the FFS were normally distributed. A one-way between groups ANOVA was conducted to compare FFS scores across groups. A main effect for group was found [$F(3, 926) = 158.96$, $p < 0.001$, $\eta^2 = 0.34$]. Post-hoc comparisons with Tukey HSD revealed that the CFS/ME group had significantly higher mean FFS scores ($M = 23.59$, $SD = 4.81$) than the insomnia group ($M = 18.89$, $SD = 6.46$). Furthermore, both groups had significantly greater FFS scores than the sleep apnoea ($M = 10.48$, $SD = 6.11$) and volunteer groups ($M = 11.09$, $SD = 6.23$). The latter two groups did not differ from each other ($p = 0.76$). All significant comparisons were significant at $p < 0.001$. Thus, the FFS is able to distinguish populations on the basis of their theoretically proposed fatigue levels.

3.4.2. Flinders Fatigue Scale cut-offs

The sensitivity and specificity of the FFS to discriminate individuals with insomnia diagnoses and CFS/ME diagnoses from a non-clinical population were examined in order to identify clinical cut-off scores for excessive fatigue. Sensitivity and specificity values are shown in Fig. 1, below at each potential cut-off score on the FFS along with the associated Youden's J statistic [33]. The J statistic is a single index that ranges from −1 to 1. A score of zero indicates a cut-off with no predictive value (ie, when the test would give the same proportion of positive outcomes irrespective of whether one had a diagnosis or not). A score of 1indicates a cut-off score with perfect predictive value (ie, there would be no false positives or false negatives). As such, Youden's J can be seen as an index of discriminability with higher values indicative of sensitivity and specificity being maximized.

Although these analyses demonstrate that the Flinders Fatigue Scale is effective in discriminating between a non-clinical population and clinical populations where fatigue is an issue, it is important to note that the FFS is not designed as a screening tool for these clinical groups. Its main purpose is to measure fatigue in the general population. Nevertheless, it is suggested that this very data can be used to indicate the severity of fatigue by reference to these first two groups. Specifically, any given fatigue score can be described in terms of the proportion (or percentage) of people with insomnia and CFS/ME that attain that score or lower on the FFS. In other words, this is the false negative rate (ie, 1 − sensitivity). For example, an FFS score of five equates to a level of fatigue experienced by three percent of insomniacs and zero percent of those with CFS/ME. In contrast, a score of 16 equates to a level of fatigue experienced by 24% of insomniacs and six percent of those with CFS/ME while a score of 19 corresponds with fatigue experienced by 44% of insomniacs and 12% of those with CFS/ME. Table 1 shows the values for the false negative rate and the true negative rate (ie, specificity) at each level of the FFS.

Typically scores within one standard deviation of the mean indicate a range of scores for that population that reflect the “average” range. In a standard normal distribution, scores outside this “average” range correspond with the lowest (and highest) 16% of scores. Hence, cut-off scores on the FFS whereby 16% of insomniacs and those with CFS/ME would reflect a score that is indicative of having fatigue similar to those with insomnia or CFS/ME, respectively. Thus, from Table 1, among those with insomnia, an FFS score of 13 or higher corresponds with those showing an “average” level of fatigue for those with insomnia. Similarly, among those with CFS/ME, an FFS score of 21 or higher corresponds with those showing an “average” level of fatigue for those with CFS/ME. For the higher cut-off of 21, this corresponds with the maximal Youden's J score ($J = 0.78$) indicating that the FFS best discriminates those with CFS/ME from the non-clinical population at a score of 21. However, the best FFS score ($J = 0.54$) for discriminating those with insomnia from the non-clinical population is 16. As such, it is recommended that three cut-off scores are recommended as shown in Table 2.

4. Discussion

The Flinders Fatigue Scale is a brief instrument developed to clinically evaluate fatigue in patients with insomnia complaints, and to measure treatment outcomes. The current study provides empirical support regarding the psychometric properties of the scale in samples of sleep disordered, clinically fatigued, and community volunteer populations, as well as a clinical cut-off score. Specifically, the FFS displayed satisfactory internal consistency and its convergent validity was demonstrated by significant correlations with another measure of fatigue − the Fatigue Severity Scale. Furthermore, the FFS displayed adequate discriminant validity when administered to clinically fatigued populations, returning non-significant correlations with a measure of sleepiness − the

Epworth Sleepiness Scale. Finally, the FFS demonstrated sensitivity to fatigue differences between diagnostic subgroups.

4.1. *Factor structure*

An initial exploratory factor analysis showed the Flinders Fatigue Scale to be composed of a single factor explaining 67% of the variance. However, factor loadings suggested that the seventh item of the FFS did not load highly on this factor. Interestingly, removal of the seventh item did not significantly affect the levels of fatigue reported by each sample, nor produce different patterns of differences in fatigue between the groups (please see Supplemental analyses). Hence, although the six-item version is theoretically more robust, in practice, no meaningful difference was apparent between the six- and seven-item versions.

4.2. *Discriminant validity*

Administering the Flinders Fatigue Scale to sleepy (ie, OSA) and chronically fatigued (ie, CFS/ME) samples provided discriminant validity data for the FFS. Analyses revealed that the CFS/ME sample was significantly more fatigued than insomnia, OSA, and volunteer samples, while individuals with insomnia reported higher fatigue than the OSA and volunteer groups. That the FFS scores were consistent with each group's theorised level of fatigue suggested good discriminant validity for the scale.

The Flinders Fatigue scale displayed acceptable discriminant validity with the Epworth Sleepiness Scale when administered to the two clinically-fatigued populations (ie, insomnia and CFS/ME). This is a valuable quality of the scale, considering it is designed for use with a population where these two symptoms may often be confused. Small-to-medium correlations were found between the ESS and the FFS in the community volunteer and OSA samples. This is consistent with suggestions that Obstructive Sleep Apnea patients experience moderate levels of daytime fatigue in conjunction with feelings of sleepiness [34]. Further, these results highlight that, in non-clinical samples, experiences of fatigue and sleepiness often co-occur. Finally, that the OSA sample reported significantly lower levels of fatigue compared to the clinically fatigued samples demonstrates the scale's construct validity.

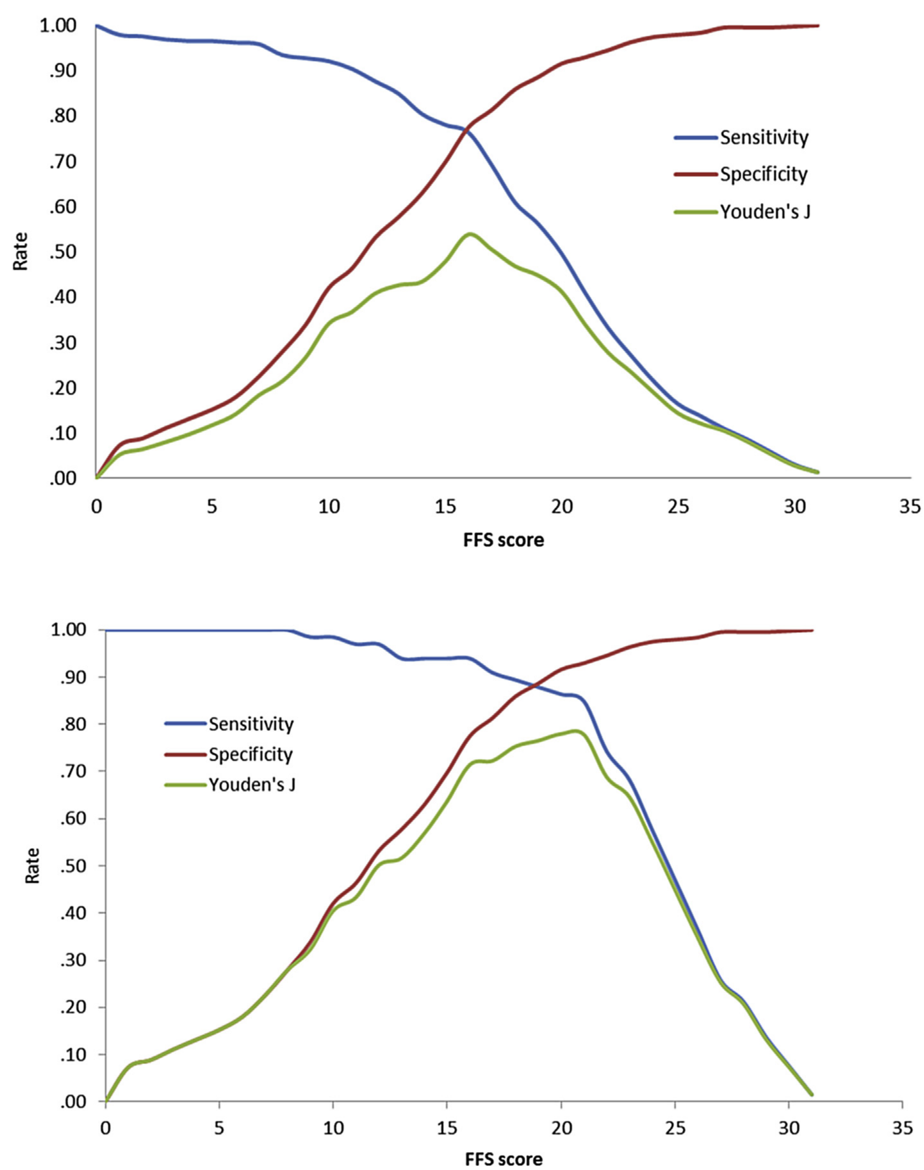

Fig. 1. Discriminating insomnia and CFS/ME, respectively, from a non-clinical population.

Table 1
True and false negative rates, and Youden's J index of discriminability, for each FFS score used as a cut-off.

FFS Score	True negative rate[a]	Insomnia sample False negative rate[b]	Insomnia sample *J*	CFS/ME sample False negative rate[b]	CFS/ME sample *J*	Fatigue Severity
0	.00	.00	.00	.00	.00	
1	.07	.02	.05	.00	.07	
2	.09	.02	.06	.00	.09	
3	.11	.03	.08	.00	.11	
4	.13	.03	.10	.00	.13	
5	.15	.03	.12	.00	.15	
6	.18	.04	.14	.00	.18	
7	.23	.04	.18	.00	.23	
8	.28	.07	.21	.00	.28	
9	.34	.07	.27	.02	.32	
10	.42	.08	.34	.02	.41	
11	.46	.10	.37	.03	.43	
12	.53	.12	.41	.03	.50	
13	.58	.15	.43	.06	.52	Borderline
14	.63	.20	.43	.06	.57	
15	.70	.22	.48	.06	.64	
16	.78	.24	.54	.06	.71	Moderate
17	.81	.31	.51	.09	.72	
18	.86	.39	.47	.11	.75	
19	.89	.44	.45	.12	.77	
20	.92	.50	.41	.14	.78	
21	.93	.59	.34	.15	.78	High
22	.95	.67	.28	.26	.69	
23	.96	.73	.23	.32	.65	
24	.98	.79	.19	.42	.55	
25	.98	.84	.14	.53	.45	
26	.98	.86	.12	.64	.35	
27	1.00	.89	.11	.74	.25	
28	1.00	.91	.08	.79	.21	
29	1.00	.94	.05	.86	.13	
30	1.00	.97	.03	.92	.07	
31	1.00	.99	.01	.98	.02	

[a] True negative rate = Specificity
[b] False negative rate = 1 – Sensitivity

4.3. Application of FFS to sleep disordered populations

Studies of sleep-disordered samples that have assessed subjective fatigue have typically employed the Fatigue Severity Scale. Whilst in the current study, the Fatigue Severity Scale demonstrated qualities similar to the Flinders Fatigue Scale, the FFS items provide information which is directly useful to the clinician (eg, the time(s) of day fatigue is typically experienced, the severity of the fatigue experienced, etc.). From a clinician's perspective, information elicited by the Fatigue Severity Scale items may not be as useful when evaluating sleep-related complaints (eg, “My motivation is lower when I am fatigued”, “Fatigue is among my three most disabling symptoms”). Similar observations have been made by Taylor et al. [35], who noted that the FSS appears to measure the impact of fatigue on functioning rather than the intensity of fatigue symptoms.

Table 2
Recommended cut-off scores on the FFS and descriptions of how they can be interpreted.

FFS cut-off score	Interpretation
13	Borderline: About 15% of people with insomnia score below this value. Scores of 13 and above indicate a level of fatigue that would be found in the “average” person with a diagnosis of insomnia
16	Moderate: This score maximally discriminates those with insomnia for a non-clinical population. About a quarter of those with insomnia would have fatigue levels below this value
21	High: About 15% of people with Chronic Fatigue Syndrome or Myalgic Encephalomyelitis score below this value. Scores of 13 and above indicate a level of fatigue that would be found in the “average” person with a diagnosis of fatigue syndrome or Myalgic Encephalomyelitis

Sensitivity and specificity analyses indicated scores that best discriminated insomniacs and CFS/ME populations from a non-clinical population. These data were also used to classify fatigue severity by reference to these first two groups. Results showed that FFS total scores of 13–15 are indicative of borderline fatigue, scores of 16–20 suggest moderate fatigue, while total scores of 21 or more indicate severe fatigue.

4.4. Study limitations and future directions

The use of a snowball sampling method to recruit a healthy population may have resulted in bias as people with sleep or fatigue symptoms may have been more likely to participate in sleep research versus truly healthy people. This may also account for why more than half of the healthy population meet criteria for being a poor sleeper. In addition, it would be beneficial to have collected additional demographic information on the participants to allow greater description and comparison of these groups. In particular, the inclusion of measures of depressed mood would be beneficial as fatigue is a common symptom of depression and may be more prevalent among individuals with sleep disorders and health conditions, such as CFS/ME.

As a measure of daytime fatigue, some psychometric aspects of the Flinders Fatigue Scale are yet to be examined. For example, the test-retest reliability of the FFS is still unknown. Whilst this property may not be relevant to healthy populations, where fatigue levels may often vary in response to current lifestyle demands, it is important to gauge the stability of the FFS over time within clinical populations. Hence administering the FFS on multiple occasions to a sample of untreated insomnia patients would provide useful information. Furthermore, whilst sensitivity to treatment effects has been shown in insomnia patients [36–39], and individuals with Delayed Sleep Wake Phase Disorder [40], the FFS would benefit from further independent testing of its sensitivity to treatment effects in other sleep disordered groups.

Finally, factor analysis revealed the Flinders Fatigue Scale to have stronger internal consistency when the seventh item was removed. This finding was consistent for all four samples and is consistent with findings from Gradisar et al. [13]. Whilst the seventh item, which enquires about the relationship between the patient's sleep and their fatigue, may provide clinically useful qualitative information, it does not appear to be strongly related to the single factor “daytime fatigue” which emerged in the factor analysis. Consideration should be given regarding whether to retain this item as part of the calculable FFS score.

4.5. Summary

The current study has built upon preliminary psychometric testing to add further support to the strength of the Flinders Fatigue Scale as a measure of daytime fatigue in insomnia populations. The study confirms the scale's strong internal consistency, and discriminant validity against a measure of daytime sleepiness. Furthermore, the study investigated previously unknown psychometric factors and found the FFS to display good convergent validity with the Fatigue Severity Scale. The FFS also demonstrated sensitivity to predicted levels of fatigue in four clinically distinct populations – including two sleep disordered samples. Future research should be directed towards further examination of the scale's sensitivity to treatment effects within sleep-disordered populations.

Financial support

Faculty of Social Sciences, Flinders University.

Acknowledgements

The authors wish to thank the Faculty of Social Sciences, Flinders University for their financial assistance, Ben Maddock for his assistance with the on-line administration of the scales, Dr. Leon Lack for the use of data pertaining to the sleep-disordered samples, the various organisations who distributed the questionnaire and all the participants who volunteered for the study.

Conflict of interest

The authors have no conflicts of interest to declare.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2016.11.016.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.sleep.2016.11.016.

References

[1] Ohayon MM. Epidemiology of insomnia: what we know and what we still need to learn. Sleep Med Rev 2002;6:97–111.
[2] American Psychiatric Association. Diagnostic and statistical manual of mental disorders, fourth edition, text revision. 4th ed. Washington, DC: American Psychiatric Association; 2000.
[3] WHO. International statistical classification of diseases and related health problems. 10th ed. Geneva: World Health Organisation; 1992.
[4] Leger D, Scheuermaier K, Philip P, et al. SF-36: evaluation of quality of life in severe and mild insomniacs compared with good sleepers. Psychosom Med 2001;63:49–55.
[5] Stepanski EJ, Koshorek G, Zorick F, et al. Characteristics of individuals who do or do not seek treatment for chronic insomnia. Psychosomatics 1989;30:421–7.
[6] Leger D, Morin CM, Uchiyama M, et al. Chronic insomnia, quality-of-life, and utility scores: comparison with good sleepers in a cross-sectional international survey. Sleep Med 2012;13:43–51.
[7] Shen J, Barbera J, Shapiro CM. Distinguishing sleepiness and fatigue: focus on definition and measurement. Sleep Med Rev 2006;10.
[8] Buysse DJ, Ancoli-Israel S, Edinger JD, et al. Recommendations for a standard research assessment of insomnia. Sleep 2006;29:1155–73.
[9] Bastien CH, Vallières A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. Sleep Med 2001;2:297–307.
[10] Morin CM. Insomnia: psychological assessment and management. New York: Guildford Press; 1993.
[11] Lineberger MD, Carney CE, Edinger JD, et al. Defining insomnia: quantitative criteria for insomnia severity and frequency. Sleep 2006;29:479–85.
[12] Reite M, Buysse DJ, Reynolds C, et al. The use of polysomnography in the evaluation of insomnia. Sleep 1995;18:58–70.
[13] Gradisar M, Lack L, Richards H, et al. The Flinders Fatigue Scale: preliminary psychometric properties and clinical sensitivity of a new scale for measuring daytime fatigue associated with Insomnia. J Clin Sleep Med 2007;3:722–8.
[14] Krupp LB, LaRocca NG, Muir-Nash J, et al. The Fatigue Severity Scale: application to patients with multiple sclerosis and systemic lupus erythematosus. Arch Neurol 1989;46:1121–3.
[15] Smets EMA, Garssen B, Bonke B, et al. The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. J Psychosomatic Res 1995;39:315–25.
[16] Shapiro CM, Flanigan M, Fleming JA, et al. Development of an adjective checklist to measure five FACES of fatigue and sleepiness: data from a national survey of insomniacs. J Psychosomatic Res 2002;52:467–73.
[17] Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. Sleep 1991;14:540–55.
[18] Hossain JL, Ahmad P, Reinish LW, et al. Subjective fatigue and subjective sleepiness: two independent consequences of sleep disorders? J Sleep Res 2005;14:245–53.
[19] Johns MW. Reliability and factor analysis of the Epworth sleepiness scale. Sleep 1992;15:376–81.
[20] Morin CM, LeBlanc M, Daley M, et al. Epidemiology of insomnia: prevalence, self-help treatments, consultations and determinants of help-seeking behaviors. Sleep Med 2006;7:123–30.
[21] Chambers MJ, Keller B. Alert Insomniacs: are they really sleep deprived? Clin Psychol Rev 1993;13:649–66.
[22] Lichstein KL, Riedel BW. Behavioral assessment and treatment of insomnia: a review with an emphasis on clinical application. Behav Ther 1994;25:659–88.
[23] Aguillard RN, Riedel BW, Kenneth LL, et al. Daytime functioning in Obstructive Sleep Apnea patients: exercise tolerance, subjective fatigue, and sleepiness. Appl Psychophysiol Biofeedback 1998;23:207–17.
[24] Chervin RD. Sleepiness, fatigue, tiredness and lack of energy in obstructive sleep apnea. Chest 2000;118. 372–179.
[25] Lichstein KL, Means MK, Noe SL, et al. Fatigue and sleep disorders. Behav Res Ther 1997;35:733–40.
[26] Fukuda K, Straus SE, Hickie I, et al. The chronic fatigue syndrome: a comprehensive approach to its definition and study. Ann Intern Med 1994;121:953–9.
[27] Neu D, Hoffmann G, Moutrier R, et al. Are patients with Chronic Fatigue Syndrome just 'tired' or also 'sleepy'? J Sleep Res 2008;17:427–31.
[28] Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193–213.
[29] Gilbert N. Researching social life. London: Sage; 1993.
[30] Gradisar M, Lack LC, Harris JK, et al. Psychometric properties of two new scales for measuring daytime functioning for insomnia [Abstract]. Sleep (Abstract Suppl) 2006;29:A339.

[31] American Academy of Sleep Medicine. International classification of sleep disorders: diagnostic and coding manual. 2nd ed. Westchester, IL: American Academy of Sleep Medicine; 2005.
[32] Valko PO, Bassetti CL, Bloch KE, et al. Validation of the fatigue severity scale in a swiss cohort. Sleep 2008;31:1601–7.
[33] Youden WJ. Index for rating diagnostic tests. Cancer 1950;3:32–5.
[34] Buysse DJ, Thompson W, Scott J, et al. Daytime symptoms in primary insomnia: a prospective analysis using ecological momentary assessment. Sleep Med 2007;8:198–208.
[35] Taylor RR, Jason LA, Torres A. Fatigue rating scales: an empirical comparison. Psychol Med 2000;30:849–56.
[36] Falloon K, Elley CR, Fernando A, et al. Simplified sleep restriction for insomnia in general practice: a randomised controlled trial. Br J General Pract 2015;65: e508–15.
[37] Lovato N, Lack L, Wright H, et al. Evaluation of a brief treatment program of cognitive behavior therapy for insomnia in older adults. Sleep 2014;37: 117–26.
[38] Kyle SD, Morgan K, Spiegelhalder K, et al. No pain, no gain: an exploratory within-subjects mixed-methods evaluation of the patient experience of sleep restriction therapy (SRT) for insomnia. Sleep Med 2011;12:735–47.
[39] Vitiello MV, McCurry SM, Shortreed SM, et al. Short-term improvement in insomnia symptoms predicts long-term improvements in sleep, pain, and fatigue in older adults with comorbid osteoarthritis and insomnia. PAIN® 2014;155:1547–54.
[40] Gradisar M, Dohnt H, Gardner G, et al. A randomized controlled trial of cognitive-behavior therapy plus bright light therapy for adolescent delayed sleep phase disorder. Sleep 2011;34:1671–80.