Further Development and Validation of the Occupational Fatigue Exhaustion Recovery (OFER) Scale

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Further Development and Validation of the Occupational Fatigue Exhaustion Recovery (OFER) Scale

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Objective: *Refinement of the Occupational Fatigue Exhaustion Recovery (OFER) scale.* ***Method:*** *The responses of 510 nurses to the OFER scale, two of whose scales contained additional items, were examined with CFA and regression analyses.* ***Results:*** *Analyses of the expanded pool of items identified three subscales of 5 items each for the renamed OFER15 scale. The subscales have high internal reliability (>.84), face, construct and discriminant validity. SEM analysis confirmed the role of recovery in mediating the relationship between acute and chronic fatigue measured with the OFER15 scale.* ***Significance:*** *The OFER15 measure is a parsimonious scale with robust psychometric properties whose subscales distinguish well between acute fatigue states and chronic fatigue traits. The intershift recovery subscale is unique among published fatigue scales. The OFER15 is suggested as a valuable new instrument for the researchers in the work-related fatigue area, and also as screening instrument in Primary Care.* (J Occup Environ Med. *2006;48:381–389*)

The epiphenomenon of fatigue is as ubiquitous as pain. As Wessely has observed:

> . . . it is not a question of whether one has fatigue or not; the experience of fatigue is an inevitable concomitant of being animate. Rather the question is: how much fatigue, and for how long?[1]

Fatigue that is acute or transient in nature and readily modified by rest and/or task moderation generally is adaptive and not inevitably stressful. By comparison, persisting with activity while already fatigued, in response to internal and/or external pressures, generally will be experienced as stressful. Thus, fatigue is stressful and stress is fatiguing and, increasingly, many researchers take the view that the overlap between fatigue and stress/distress is sufficiently great as to make any distinction between the constructs practically meaningless. High levels of the one are accompanied by the other.[2–5]

An extensive body of literature from the early work of Cannon,[6,7] Selye,[8–11] and more recently the neuro–psycho–endocrine physiology studies by Sterling and Eyer[12] and McEwen et al[13–20] have identified the neuro–psycho–endocrine processes associated with stress response. In particular, they have identified the maladaptive consequences of unremitting stressful experience, or repeated experience of high level stress without adequate recovery between episodes. These studies indicate that enduring glucocorticoid "cascade" can cause cellular damage to the activating systems themselves, particularly atrophy in the hippocampus.[18,21] Such

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damage is associated with a number of maladaptive health outcomes, including the reported characteristics of chronic fatigue.[17,22]

By comparison with acute fatigue, chronic fatigue is characterized by: ". . . inefficient action patterns; declining interest, involvement and commitment; reduced concentration and motivation; and negative emotions."[23] Recovery from this state may be uncertain, depending on the extent to which cellular level damage, particularly to the hippocampus, is reversible.[15]

On the basis of this literature of the physiology of stress/fatigue, it is arguable that identifying the adequacy of recovery between successive sequences of acute work-related fatigue is of considerable value within organizational psychology, in developing a more complete understanding of the transition from acute fatigue states to maladaptive chronic fatigue traits. In addition, it would seem logical that a more complete understanding of the mediators and moderators of this recovery process is an important requirement for an overall understanding of work-related strain; and for developing appropriate interceptive measures to protect workers from maladaptive health outcomes.

This being accepted, it is surprising that of the many dozens of fatigue measurement scales reported in the literature, only one; the Occupational Fatigue Exhaustion Recovery scale (OFER)[24] has been developed with the intent to distinguish between acute fatigue states and chronic fatigue traits and, importantly, to measure recovery from work-related fatigue between successive work shifts.

The OFER Scale

The OFER scale has been developed specifically to measure, and distinguish between, acute fatigue states and chronic fatigue traits associated with work. In addition and, importantly, it measures recovery occurring between successive work shifts. OFER has been validated in several populations, is gender-bias free, and has demonstrated robust psychometric properties, including a satisfactory fit of data in confirmatory factor analysis (CFA) of its structure.[24]

The OFER instrument comprises three subscales; chronic and acute fatigue and intershift recovery. The chronic fatigue subscale (OFER-CF) contains items that capture the construct as a complex of mental, physical, and emotional components (including a depressive element) that is consistent with the observed and reported characteristics of persistent fatigue. The acute fatigue subscale (OFER-AF) comprises items based on the Bartley & Chute perspective of fatigue as an "incapacitation"; an inability and/or unwillingness to engage with normal nonwork activities (including self-chosen pleasure activities) as a direct consequence of previous activity.[25] The intershift recovery subscale (OFER-IR) contains items intended to measure the extent to which acute work related fatigue (OFER-AF) is perceived to have been recovered, or dissipated, by the time the next work shift is commenced.

However, the OFER scale is open to criticism. Although easy to administer, its 15 items are disproportionately allocated between the three subscales, with the important Intershift Recovery subscale (OFER-IR) comprising just 3 items, and the Acute Fatigue subscale (OFER-AF) comprises only 4 items. Although the Cronbach's alpha coefficient of internal reliability for the OFER-AF subscale is acceptable at 0.83, the figure for the OFER-IR is at the low end of acceptability at 0.73. These observations give rise to the question of whether the three items in the important Recovery subscale are adequate to capture the full dimension of this important construct. A similar, but lesser criticism might also be made about the four-item OFER-AF scale. In addition, the reported CFA model of the OFER scale, although demonstrating a satisfactory fit of the data to the model, required the specification of a number of covariances between the residual errors of items on the OFER-CF subscale to achieve this fit.[24] Consequently, the model could be criticized as being "overfitted" to the population sample from which the scale development data was drawn.

As indicated in the original research detailing the development of the OFER scale, these issues suggested the need not only for further validation studies of the OFER scale but for refinement of the scale to improve its psychometric properties and provide confidence in its construct validity.[24] The principle aim of this study was to achieve these purposes.

In addition, we intended to investigate the mediation effect of recovery on the transition of acute fatigue states to chronic fatigue traits as identified from revised OFER subscale scores. Consistent with the literature on the relationship between fatigue and recovery, it was anticipated that a mediation effect of recovery on acute fatigue/chronic fatigue interaction would be evident.

Materials and Methods

A sample of 1400 South Australian nurses in a large metropolitan hospital was provided with an anonymous self-report questionnaire that included the revised version of the OFER scale. After the initial delivery of the study pack to potential participants (by attachment to pay slips), where possible, reminders were posted on nurse's ward common-room after 1 week then 2 weeks, and circulated electronically via the hospital intranet.

Of the 1400 questionnaires distributed, a total of 510 participants returned completed questionnaires, representing a response rate of 36%. Given that the opportunity to promote the study within this large, dispersed, institution was restricted and not completely under the researcher's control, this response rate was viewed as satisfactory. The mean (SD) of participants was 41.09 (10.0) years, of whom: 463 (90%) were women; 262 (51%) had been nurses for longer than 15 years; 76% (388) worked full time (>25 hours per week), and 76% (388)

worked more than one shift type (morning, afternoon, or night) on an irregular rotating roster. Because a condition of ethics committee approval was the maintenance of participant anonymity, a nonresponse analysis was preclude.

The relatively modest response rate and absence of nonresponse analysis could give rise to concerns about the validity, particularly the generalizability, of the study findings. For example, were highly fatigued nurses disinclined to undertake the work of completing the survey or, conversely, were they *more* inclined to participate to "give voice" to their experience? Because each possibility is as likely as the other, these confounds could be considered as being self canceling. However, given that an analysis of the demographic distribution of the study population (reported above) indicated that it was broadly similar to the population of nurses within Australia,[26] and given that the principle aim of the study was to analyze and confirm the relationship between factors, rather than specifically determine the prevalence of those factors within the broad community of nurses, the study sample was considered suitable for the essential purposes of the study.

Occupational Fatigue Exhaustion Recovery Scale (Revised)

The principle aim of the current study was to test a modified form of the OFER scale[24] to address some perceived limitations of it and to confirm its construct validity. The modifications undertaken comprised the addition of a total of eight items to the item pool from which the (original) acute fatigue (OFER-AF) and intershift recovery (OFER-IR) subscales were formed. These additional items were derived as a result of consultation with learned colleagues in the stress research field and consideration of the stress literature.

The four original OFER-AF items were exclusively based on acute fatigue manifesting as a relative "incapacitation" within the Bartley concept of "psychologic fatigue"[27] and are an "indirect" assessment of fatigue, such as "I have plenty of reserve energy when I need it," "I have plenty of energy for my hobbies and other creative activities after I finish work." All of the items forming the OFER-AF subscale were negatively keyed; consequently, it was felt appropriate that other, positively keyed, items addressing the experience of acute fatigue more directly should be included in this subscale. Thus, added items included; "After a typical work shift I have little energy left," "I usually feel exhausted when I get home from work," "My work drains my energy completely every day," "I have lots of energy left at the end of a typical work shift." The amended OFER-AF subscale for testing in the study comprised a total of eight items, both positively and negatively keyed, thereby meeting the requirements suggested by Anastasi of including both types of item in measurement instruments.[28]

The important OFER-IR subscale also was enlarged by the addition of four more items such that the seven-item pool for the expanded subscale to be tested addressed the issue of recovery both directly and indirectly with both positively and negatively keyed items. The additional items included "I rarely feel too tired to work at the start of a work shift," "I rarely recover my strength fully between work shifts," "Recovering from work fatigue between work shifts isn't a problem for me," and "I'm often still feeling fatigued from one shift by the time I have to start the next shift."

The chronic fatigue (OFER-CF) subscale of the original OFER scale already contained eight items. However, the item "I often feel exhausted at work" had the lowest item/factor correlation in the original scale, and its face validity was potentially ambiguous as a reference to acute or chronic fatigue experience. Consequently, we decided to drop this item from the OFER-CF subscale item pool.

The version of the refined OFER scale tested in this study thus comprised a total of 22 items. Confirmatory factor analysis of responses to this wider pool of items was undertaken to determine the model of an amended OFER scale, which constituted the best fit to the data. It was intended to identify three robust subscales of chronic fatigue, acute fatigue, and intershift recovery, comprising at least five/six items each, with high construct validity and Cronbach's alpha coefficients of at least 0.80.

We anticipated that the direction and strength of correlations between these amended OFER subscales would be similar to what had been observed with the original OFER scale.[24] Similarly, it was expected that the predictive capacity of the amended OFER-CF and AF subscales to identify chronic fatigue traits differentially from acute fatigue states, (which had been indicated in the original OFER scale development studies), would also be confirmed.

In addition, we intended to investigate the mediating role of recovery (measured on an amended OFER-IR subscale) in the transition from acute fatigue states (measured on an amended OFER-AF subscale) to chronic fatigue traits (measured by an amended OFER-CF subscale) using structural equation modeling analysis (SEM).

Nottingham Health Profile (NHP)

This is an extensively validated, item-weighted, "quality of life" scale[29] comprising several subscales. Three of these subscales, Emotional Health, Sleep Health, and Energy Health, were thought to be of particular value in confirming the construct (convergent) validity and predictive capacity of the amended OFER subscales. In particular, the NHP Emotional Health subscale was felt to be of value in confirming the capacity of the OFER-CF subscale to identify the depressive element of chronic fatigue traits. The NHP Energy Health subscale was also felt to be of value in confirming the amended OFER subscale's capacity to identify differences between chronic fatigue traits and acute fatigue states within the broad self reported perception of energy state.

Pre-Shift and Post-Shift Fatigue

In addition to providing demographic information, participants were asked to report the level of fatigue they had usually experienced during the previous month, both at the beginning and the end of the various shifts (morning, afternoon, or night) they worked. Responses were recorded on a closed seven-point Likert scale between Completely Refreshed and Completely Exhausted. Because a number of the nurse-participants were anticipated to work a regular predictable shift, whereas others could work two or three different shift in an unpredictable internal rotation pattern, participants were asked to report their pre- and post-shift fatigue after each shift type (ie, morning, afternoon, or night shift). For each participant, an average figure of their pre- and post-shift fatigue was then derived by manually processing their responses in relation to the type of shift(s) they worked, on a case-by-case basis.

Procedure

With the approval of the respective ethics committees of the University of South Australia and the hospital concerned, a study of fatigue, recovery, and its outcomes was conducted among nurses of all job categories in the hospital. No exclusion criteria were specified, and all participants were assured of anonymity. The anonymous study questionnaire pack, which included an explanatory letter and reply paid envelope for the voluntary return of the questionnaire, was delivered to all nurses attached to their pay slips in the same pay period. Approximately 2 months after the initial survey, a group of respondents who had indicated a willingness to do so in their returned questionnaire and who voluntarily supplied an E-mail contact address for the purpose were re-surveyed to assess the test/retest reliability of the amended OFER subscales.

Statistical Analysis

Confirmatory factor analysis was undertaken to identify the most compelling model of an amended OFER scale. In addition, structural equation modeling techniques were used to determining the functional relationships and inter-reactions between the OFER subscales and to investigate the moderating/mediating role of recovery, measured on the OFER-IR subscale, in buffering the relationship between acute fatigue measured on the OFER-AF subscale and chronic fatigue, measured on the OFER-CF subscale. All analyses were undertaken with Amos 5 software.[30]

For confirmatory factor and structural equation modeling analyses, the model fit criteria were assessed with the χ^2 statistic, the Goodness of Fit Index (GFI) and the Root Mean Square Error of Approximation (RMSEA),[31] the Comparative Fit Index (CFI),[32] and the Tucker-Lewis (non-normed) index (TLI).[33] For each of these statistics, values of 0.90 or higher are acceptable,[34] except for the RMSEA for which values up to 0.08 indicate an acceptable fit to the data.[13]

Because the Likert response scale for the OFER scale items was structured such that lower values indicated lower levels of the construct being measured, appropriate recoding of items was performed to ensure directional consistency in the indicators (items) of the latent variables. This change was applied to items 3, 4, 5, and 6 on the acute fatigue subscale and items 1, 5, and 7 on the intershift recovery subscale.

Results

Confirmatory Factor Analysis

Before analysis, criteria for an acceptable model of the amended OFER scale were determined as subscales with a minimum of five items per latent variable providing the best overall model fit to the data, demonstrated high face/content validity.

Of the 22 items in the item pool, OFER items 1 to 7 were entered as indicators of the latent variable "chronic fatigue"; items 8 to 15 (recoded where necessary) were entered as indicators of the latent variable "acute fatigue"; and items 16 to 22 (recoded where necessary) entered as indicators of the latent variable of intershift recovery. The initial model fit was $\chi^2 = 958.83$, TLI = 0.87, GFI = 0.83, CFI = 0.88, and RMSEA = 0.09, which failed to meet minimally acceptable statistical criteria.

To improve the model fit, the modification indices (regression weights and covariances) and item/variable correlations were examined to determine appropriate changes to the model, including removal of indicators from the model. The final model (which best met both the statistical and pre-set criteria) had five items as indicators of each latent variable (subscale) with highly acceptable fit indices. This model is shown in Fig. 1.

The modification indices of covariances indicated that a significant model improvement could be achieved (χ^2 reduction from 242.53 to 216.63) by adding a covariance in the error variance terms between items 3 and 5 on the acute fatigue subscale. Examining the respective items suggested this covariance was most likely a function of similarity in error response to items with a similar theme, ie, "I usually have plenty of energy left for my hobbies and other creative activities after I finish work," and "I usually have lots of energy to give my family and friends." This single error covariance was included in the final model, as shown in Fig. 1, and was not considered to represent a significant model over fitting.

The final model fit was excellent and was significantly better than that reported for the original OFER scale model:[24]

$$\chi^2\ (\text{CMIN}) = 216.63,\ \text{DF} = 86,$$

$$\text{CMIN/DF} = 2.51,$$

$$\text{TLI} = 0.96,\ \text{GFI} = 0.95,$$

$$\text{CFI} = 0.97,\ \text{RMSEA} = 0.05.$$

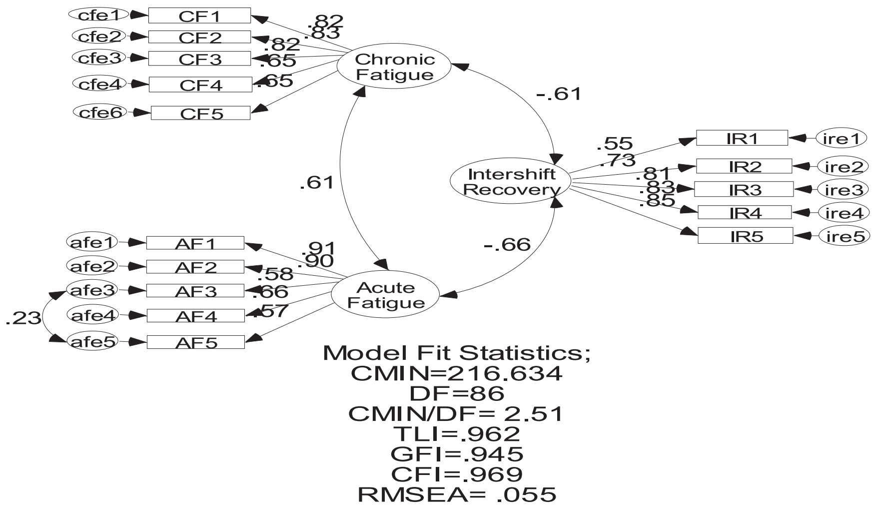

Fig. 1. Standardize estimates and model fit statistics of the final model of the OFER15 Scale.

The face validity of the subscale items is excellent and, in addition, the acute fatigue and recovery subscales both contain 2 of 5, and 3 of 5 negatively keyed items respectively, satisfying the suggestions of various researchers on the importance of incorporating both positive and negatively keyed items in self-report scales.[28,35]

The improvement in model fit characteristics and other comparisons between the original form and the revised form of the OFER15 scale are reported in Table 1. The final form of the scale was designated the OFER15 scale to distinguish it from the original OFER scale.

Internal Reliability

The subscales of the OFER15 scale were examined for internal reliability. Cronbach's alpha coefficient for the OFER15-CF chronic fatigue subscale was 0.86; for the OFER15-AF subscale, 0.84, and for the OFER15-IR subscale, 0.84. These values comfortably satisfy the requirements for adequate internal reliability in scale[36] and are generally superior to those in the original OFER scale.

Bivariate Correlations

Bivariate (Pearson) correlations between the OFER-15 subscales and other measures used in the study are reported in Table 2. A number of these correlations are notable. They include the close correspondence between the strength and direction of the inter-correlation of the OFER-15 subscales and those evident in the original OFER scale. In addition a negative correlation between OFER-IR (recovery) scores and fatigue scores measured on both the OFER-CF and -AF subscales, consistent with previous observations, suggesting as expected, that high levels of recovery between work shifts are incompatible with high levels of chronic fatigue.

An even higher negative correlation between acute fatigue score and recovery also is evident, which is intuitively consistent with the observation that the greater the level of work-related fatigue/stress, evident at the end of a work shift, the longer the time required for recovery from it; time which may or may not be actually available before the next work shift.

Also notable are the correlations between OFER-IR and both Pre- and Post-Shift Fatigue average, which suggest an expected relationship be-

TABLE 1

Comparisons: Subscale Item N., Cronbach's Alpha, Retest Correlations and Subscale Correlations Between Original (OFER) and Amended (OFER15) Subscales

OFER Scale Version/Subscale	N Items	Cronbach's Alpha	Test/Retest Pearson Correlation	Subscale Correlation			Confirmatory Factor Analysis Fit Indices				
				CF	AF	IR	χ^2	GFI	CFI	TLI	RMSEA
OFER							394.0	0.93	0.95	0.93	0.07
OFER-CF	8	0.84	0.84	1							
OFER-AF	4	0.83	0.64	0.55	1						
OFER-IR	3	0.73	0.62	−.54	−.44	1					
OFER15							210.9	0.95	0.97	0.96	0.05
OFER15-CF	5	0.89	0.62	1							
OFER15-AF	5	0.84	0.61	0.53	1						
OFER15-IR	5	0.84	0.62	−.53	−.61	1					

OFER-CF (CF) = Chronic Fatigue Subscale; OFER-AF (AF) = Acute Fatigue Subscale; OFER-IR (IR) = Intershift Recovery Subscale; N items = number of items in the version of the respective subscale.

CFA model fit indices: GFI = Goodness of Fit Index; CFI = Cumulative Fit Index; TLI = Tucker-Lewis (non-normed) Index; RMSEA = Root Mean Square Error of Approximation.

TABLE 2
Pearson Correlations Between Scales/Subscales and Variables

	OFER15 Chronic Fatigue	OFER15 Acute Fatigue	OFER15 Recovery	Average Pre Shift Fatigue	Average Post Shift Fatigue	NHP Energy Health	NHP Emotional Health	NHP Sleep Health
OFER15 chronic fatigue	1.00							
OFER15 acute fatigue	0.53**	1.00						
OFER15 recovery	−.53**	−.61**	1.00					
Average pre-shift fatigue	0.30**	0.26**	−.43**	1.00				
Average post-shift fatigue	0.29**	0.30**	−.42**	0.75**	1.00			
NHP energy health	−.52**	−.57**	0.50**	−.29**	−.25**	1.00		
NHP emotional health	−.58**	−.42**	0.40**	−.22**	−.21**	0.56**	1.00	
NHP sleep health	−.31**	−.25**	0.29**	−.19**	−.17**	0.29**	0.44**	1.00

** = Correlation is significant at the 0.01 level.
NHP = Nottingham Health Profile (quality of life measure); OFER = Occupational Fatigue Exhaustion Recovery scale.

tween recovery from the previous shift to perception of fatigue at the start of the next shift and the resulting greater fatigue by the end of that shift if it is commenced in a fatigued state.

The significant negative correlations between the OFER15-CF subscale and the NHP Emotional Health subscale (−0.58) and NHP Energy Health (−0.52) suggest the perspective of chronic fatigue as a trait associated with depressed mood as well as depleted physical and psychic energy. In addition, the greater negative correlation between NHP Sleep Health and OFER-CF (−31) than OFER-AF (−0.25) is consistent with the sleep disturbance reported in chronic fatigue traits compared with uncomplicated acute fatigue.[37] By comparison, the negative correlations of OFER-CF and OFER-AF with NHP Energy Health (−0.52 and −0.57, respectively) were very similar. Because fatigue of any duration would be expected to result in reduced energy availability, this association was as expected.

The strongly positive correlation between NHP Energy, and Emotional Health scores and the OFER15-IR (recovery) subscale also were as expected and suggest the reciprocal nature of fatigue and recovery, and as measured on the OFER15 scale. Broadly, these results support the content validity of the OFER subscales.[38]

Regression Analysis of OFER15 Subscales

Given the strength and direction of Pearson correlations between study variables evident in Table 2, the predictive power of the OFER15 subscales was investigated by regression analysis as follows. The variable of NHP Emotional Health was entered as the dependent variable and the three OFER15 subscales as independent variables were entered into a regression equation using the Stepwise method of entry. A total of 36% of variance of Emotional Health was explained, with the OFER15-CF (chronic fatigue) predictor explaining 34% uniquely, followed by OFER15-AF (acute fatigue) explaining a further 2% of variance.

The variable NHP Energy Health was then entered into a similar regression equation with the OFER15 subscales as predictors. A total of 40% of variance of NHP Energy Health was explained, with OFER15-AF explaining 32% of variance uniquely, followed by OFER15-CF, 6% and OFER15-IR, 2% uniquely.

As expected, in the regression analysis of NHP Sleep Health, OFER15-CF was the major predictor, explaining 10% of the total 12% of variance explained, uniquely. OFER-IR explained 2% of variance uniquely and OFER-AF did not find significance in the equation. This observation is consistent with reports that sleep disturbance is a more consistent feature of chronic fatigue traits than acute (adaptive) fatigue states.[39–43]

When average Pre-Shift Fatigue was entered as the dependent variable in a regression equation a total of 19% of this variable was explained. OFER15-IR (recovery) explaining 18.5% uniquely, as expected, with an insignificant contribution of 0.5% from OFER15-CF. However, a similar analysis of average Post-Shift Fatigue produced a similar result. OFER15-IR explained 18% of this variable uniquely, with a minor (0.5% contribution from OFER15-CF). This result was unexpected, since the OFER15-AF (acute fatigue) subscale failed to reach significance in this analysis. However, intuitively and logically, the level of fatigue experienced *before* commencing a shift could well be expected to be a major determinant of the extent of fatigue experienced *after* a shift. Consequently, when the regression analysis was repeated without the inclusion of the OFER15-IR subscale as a predictor, as expected, the OFER15-AF subscale explained 11% of total the total 12% variance of average Post-Shift Fatigue that was explained. OFER15-CF contributed only a further 1% of variance uniquely.

Taken together, these regression analyses are supportive of the construct and discriminant validity of the OFER15 subscales. Specifically, they support the capacity of the OFER15-CF and AF subscales to discriminate between the more complex construct of chronic fatigue (trait) experience, (with its elements of a depressive trait), from acute fatigue as a simpler depletion of energy state.

Test–Retest of the OFER15 Scale

A group of 132 of the original study participants completed and returned an electronic version of the OFER15 scale per E-mail approximately 2 months after the original study. Examination of original and subsequent responses indicated test-retest correlations of: OFER15-CF subscale = 0.64; OFER15-AF subscale = 0.61, and the OFER15-IR subscale = 0.62.

Paired-items t-tests of pre- and post-test scores indicated no significant differences between responses at time 1 and time 2. These results indicate consistency in responding to the OFER15 subscales over the time frame that the OFER15 measure is intended, ie, instructions to respondents completing the OFER15 scale ask for responses to questions about fatigue and recovery experience "over the last couple of months."

Structural Equation Modeling: (Test of Mediation Effect of Recovery on the Relationship Between Acute and Chronic Fatigue)

Before proceeding with these tests, we first assessed a Direct Effects model (M1). Specifically, we tested the fit and significance of path coefficients of the direct effect: acute fatigue → chronic fatigue. Table 3 shows that M1 fitted well to the data with all fit indices satisfying their criteria and with the path from acute fatigue to chronic fatigue (0.50, $P < 0.001$) being statistically significant and in the expected positive direction. The significance of the direct paths allows proceeding with the specific steps for testing our hypothesis.[44]

We compared a Full Mediation model (acute fatigue → recovery → chronic fatigue) with a Partial Mediation model (acute fatigue → recovery → chronic fatigue with an extra direct path from acute fatigue to chronic fatigue). If the Partial Mediation model fits significantly better than the Full Mediation model and the relation between the predictor and the outcome is smaller when the mediator is present (but greater than zero), there is a significant partial mediation effect.[45]

Table 3 indicates that the Full Mediation model (M2) has a satisfactory fit to the data. However, results of the χ^2 difference test show that the addition of the direct effect path in the Partial Mediation model (M3) *does* improve its fit significantly ($\Delta\chi^2$ (1) = 25.3, $P < 0.001$; Table 2). Furthermore, path coefficients from acute fatigue to recovery (−0.40, $P < 0.001$), from recovery to chronic (−0.25, $P < 0.01$) and from acute fatigue to chronic fatigue (0.40, $P < 0.001$) are statistically significant and in the expected direction. Inspection of the path coefficients also shows that the addition of the mediational effect reduced the magnitude (from 0.60 to 0.40) of the path coefficient between acute and chronic fatigue. Taken together, these findings support the partial mediation effect of recovery in the transition of acute to chronic fatigue that had been anticipated.

To test this result further, we performed a multigroup analysis across two random subsamples (N_1 = 260 and N_2 = 250) out of our total sample. Multigroup analyses again showed an acceptable fit of data to the proposed structure of the modified OFER scale (Table 3). All path coefficients were statistically significant and in the expected direction. Furthermore in both analyses of the model (Total Sample and Multigroup) there was a reduction in the magnitude of the direct effect after inclusion of the mediational effect of recovery. The fact that a full mediation model was not supported suggests that although 'recovery' plays an important role in the relationship between acute to chronic fatigue, it is not sufficient to offset the direct effects of acute fatigue.

Discussion

Taken together, the results of the study indicate that our intention to revise the original OFER such as to improve its fundamental structure, as indicated by CFA analysis, and to improve the overall psychometric robustness of its subscales, were successful.

Confirmatory factor analysis of the enlarged pool of items for the OFER

TABLE 3
Results of Structural Equation Modeling (Maximum Likelihood Estimates) for the Total Sample (N = 510) and Iterative Multigroup Analyses in Two Random Samples (N_1 = 250 and N_2 = 260)

Model	χ^2	Df	GFI	RMSEA	CFI	TLI
M1 Direct effects	151.85	66	0.94	0.05	0.96	0.94
Recovery process						
M2 Full mediation	251.83	87	0.94	0.08	0.96	0.95
M3 Partial mediation	210.92	86	0.95	0.05	0.97	0.96
Additional analysis						
M4 Multigroup (N_1 = 260 and N_2 = 250)	331.4	206	0.93	0.04	0.97	0.97

Notes: χ^2 = Chi-Square Statistic; Df = degrees of freedom; GFI = goodness-of-fit index; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis (non-normed) fit index.

scale resulted in a 15-item measure with subscales of equal numbers, demonstrating a highly satisfactory fit of data to the model and that is superior to that evident with the original OFER scale. The internal reliability of the resulting three OFER subscales is high having Cronbach's alpha coefficients, which are at least 0.84 for each subscale. This amended measure has been provisionally designated as the OFER15 scale.

The overall study results are strongly supportive of the construct validity of the OFER15-CF (chronic fatigue) and OFER15-AF (acute fatigue) subscales and the intention that they distinguish well between chronic and acute fatigue. These supportive results include the extent and direction of the correlations between the OFER15 subscales and other scales and variables used in the study, which when further investigated using regression analyses, confirmed the differential predictive capacity of the OFER15 subscales. This discriminant capacity is supported by: the capacity of the OFER15-IR subscale to identify preshift fatigue among participants; the observation that OFER15-CF subscale scores were most strongly predictive of emotional and sleep health measured on the NHP scale compared with the OFER15-AF subscale. This observation is consistent with our understanding of the different characteristics of acute and chronic fatigue and that which has been reported in the literature.[46–50] So too is the observation that NHP Energy Health scores were more strongly predicted by the OFER15-AF subscale than the OFER15-CF subscale. Overall, the results of this study are supportive of the construct and discriminant validity of the OFER15 subscales.

SEM analysis of results obtained using the OFER15 scale confirmed a significant mediating role of recovery in the relationship between acute and chronic fatigue, which had been hypothesized. This role suggests that in the absence of adequate recovery between shifts, a transition of persistent high acute (end of shift) fatigue to maladaptive chronic fatigue traits is facilitated, as was predicted. Overall, the results of these SEM analyses offer additional support to the construct validity of the OFER15 subscales.

Conclusions

The results of the study indicate that a very useful revision of the original OFER scale has been achieved. The revised version (OFER15) of the OFER scale has been demonstrated to possess high construct, discriminate validity and internal reliability. Test/retest indicates a high degree of consistency in responding over the time frame of measurement upon which the scale is based.

Taken together, this suggests that the OFER15 scale can be recommended to workers in the field of work-related stress and fatigue with increased confidence. Its capacity to quantify and distinguish between acute and chronic fatigue states and measure recovery from acute fatigue between work shifts are not provided by other published scales. Given the indications that concerns about work-related fatigue are becoming greater in the 21st century, rather than fewer,[51] interest in this area of research may be anticipated to be intensified. The OFER15 scale is suggested as a useful adjunct to other tools available to researchers in progressing increased understanding in this important area of study. Researchers interested in evaluating or incorporating the OFER scale in their studies should contact the corresponding author.

Limitations of the Study

Thus far, practical opportunities for the testing and validation of the OFER scale have been largely limited to workers in the health care sector (nurses), of whom the majority of participants have been women. The original development studies[24] indicated the OFER scale was gender-bias free; however, it must be acknowledged that other studies comprising different industry groups and/or more heterogeneous populations are needed to confirm the consistency and value of results using the OFER15 scale. In addition, comparative studies are required that use objective, rather than self-report, measures of fatigue. Ideally, measures such as sickness and absenteeism records and/or stress hormonal levels are needed to support and confirm the accuracy of results provided by the OFER scale. Finally, we acknowledge that the testing of the OFER15 scale in longitudinal studies, permitting variability of responses over time to identify alterations in the balance between mean levels of acute fatigue and recovery, and the relationship between this dynamic and chronic fatigue trait evolution are desirable.

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