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**Daytime patterning of fatigue and its associations with the previous night’s discomfort and poor sleep among women with primary Sjögren’s syndrome or rheumatoid arthritis**

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ABSTRACT

Objectives. Fatigue is a prominent symptom in many rheumatic diseases and has substantial impact on many outcomes. In previous research, fatigue has been linked with poor sleep and discomfort, including joint pain and sicca symptoms. The aim of the present study was to investigate prospectively the daily variations in fatigue and the roles of discomfort and adequacy of sleep the previous night in that fatigue for people with primary Sjögren’s syndrome (pSS) or rheumatoid arthritis (RA).

Methods. Thirty-nine women with pSS or RA reported their discomfort and fatigue, for 35 days using the Profile of Fatigue and Discomfort. Sleep was monitored with wrist actigraphy and the quantity and quality of the night’s sleep was reported in a diary each morning.

Results. The pattern of fatigue did not differ significantly between women with pSS and women with RA. For participants with either condition, both somatic and mental fatigue increased steadily throughout the day. Multi-level regressions indicated that evenings of worse discomfort were followed by poorer reported quantity/quality of sleep and worse sleep efficiency (percentage of time asleep when in bed). In addition, a night of worse discomfort and poor sleep was followed by more severe fatigue compared to the individual’s average.

Conclusions. Fatigue management for people with rheumatic disease could include strategies for coping with discomfort at night and difficulties in sleeping. Further research into ameliorating fatigue should include assessments of persistent discomfort or periods of insomnia and identify disease-specific needs that require targeted intervention.
Introduction

Fatigue is a prominent symptom of both primary Sjögren’s syndrome (pSS) (Godaert et al., 2002) and rheumatoid arthritis (RA) (Belza et al., 1993; Kirwan & Hewlett, 2007; Pollard et al., 2006). People with pSS report fatigue to be the worst biopsychosocial stressor they associate with the disease (Anderson et al., 2001) and one of the most common reasons for seeking treatment (Melvin, 2005). People with RA have reported experiencing fatigue on a daily basis, although the duration and frequency is unpredictable, and they rate its impact and importance as similar to that of pain (Hewlett et al., 2005b; Hewlett et al., 2008; Wolfe et al., 2004). Improved management of fatigue is commonly regarded by people with RA as one of the most important outcomes of medical treatment (Hewlett et al., 2005a), although this symptom is commonly ignored in clinical encounters (Hewlett et al., 2005b).

Fatigue is emerging as an important priority for improvement of health status in RA (Minnock & Bresnihan, 2004). Inclusion of fatigue as an outcome measure in RA clinical trials is currently under debate at an international level (Kirwan et al., 2005; Kirwan et al., 2007). It has also been argued that fatigue is a better indicator of functioning in pSS than biological tests such as erythrocyte sedimentation rate or levels of haemoglobin or antinuclear antibodies (Barendregt et al., 1998). Therefore, detailed investigation of the experience and causes of fatigue is needed (Hewlett et al., 2008).

Daily variation in fatigue severity has been examined separately for pSS (Godaert et al., 2002) and RA (Stone et al., 1997). Single-item ratings of general fatigue, Somatic Fatigue and reduced activity provided by women with pSS (over a 2-day period) increased steadily as the day progressed, except for dips at 10am and 5pm (Godaert et al., 2002). Single-item ratings of fatigue given by participants with RA (at seven time
points each day for 7 days) also increased during the afternoon and evening after a decline mid morning (Stone et al., 1997). However, despite the evidence that fatigue is a complex state that needs careful assessment (Barendregt et al., 1998; Bowman et al., 2004; Goodchild et al., 2008; Repping-Wuts et al., 2009), multi-dimensional measurements of fatigue are not yet regularly administered among people with pSS or RA.

The most common self-management strategies for fatigue reported by patients with pSS or RA have been achieving good quality sleep at night and resting when needed (Goodchild et al., 2004). Nevertheless, disruption of sleep is common in both pSS and RA (Drewes et al., 1998; Gudbjörnsson et al., 1993) and, at least in part, is related to symptoms of fatigue, pain, discomfort and, in the case of pSS, dryness of the mouth and/or eyes.

The prevalence of sleep disturbance in pSS has been investigated in comparison to RA and healthy women using a retrospective standardized sleep questionnaire (Gudbjörnsson et al., 1993). More of the women with pSS reported sleeping difficulties than the women with RA and the healthy women (Gudbjörnsson et al., 1993). Moreover, the women with pSS also reported nocturnal discomfort more frequently as a reason for waking, and their disturbed sleep was associated with greater fatigue, although the strengths of these associations were not reported. In a week-long study of daily fatigue and pain in RA, both pain and fatigue were higher following nights when sleep quality was perceived to be worse (Stone et al., 1997), but the role of sleep in the relationship between pain and later fatigue was not tested.

The previous studies that have assessed the associations between discomfort, sleep and fatigue in rheumatic disease have either used retrospective measures or monitored
participants for a short period of time. The present research has a month-long prospective design and investigates the pattern of fatigue across the day as well as its relationship with night-time discomfort and poor sleep in both SS and RA. Frequent prospective measurement allows variables to be captured as closely as possible to the time of their occurrence, thus reducing the chance of errors from memory and retrospection bias (Affleck et al., 1994). Such “micro-longitudinal” measurement can also capture the interplay of rapidly changing processes such as pain and sleep (Affleck et al., 1996; Conner et al., 2009) and can establish temporal precedence in order to strengthen causal inference (Affleck et al., 1999).

In the present study, we hypothesized that an individual’s fatigue would be greater on the day following an evening of greater discomfort and a night of worse sleep, and tested sleep as a moderator of the relation between evening discomfort and the next day's fatigue. This study also aimed to assess prospectively if, as in previous studies, patients with pSS reported more discomfort, disturbed sleep and fatigue than individuals with RA.

METHODS

Participants

The participants for the present study consisted of a convenience sample of White-British women - the most prevalent ethnic background and gender seen among patients with pSS (Bowman et al., 2004) and RA (Symmons et al., 2002) at rheumatology clinics in the UK. The women were recruited from such clinics in Birmingham, serving a mainly urban and suburban population. Ethics approval was gained from West Midlands Research Ethics Committee, and all of the participants provided informed
consent in writing before participating in the study. Collection of data began in October 2005 and continued for 11 months; one researcher (CEG) recruited and followed-up all participants to ensure consistency.

Fourteen women with a diagnosis of pSS according to the American-European Consensus Group criteria (Vitali et al., 2002) completed the present study. Their ages ranged from 35 to 71 years [mean = 58.1, SD = 9.3] and their duration of pSS (years since medical diagnosis) ranged from 1 to 22 years (mean = 8.7, SD = 6.1).

Twenty-five women with a diagnosis of RA (and without secondary SS) also took part in the present study. These women’s ages ranged from 37 to 78 years (mean age = 61.9, SD = 10.6). Their duration of RA ranged from 4 to 40 years since diagnosis (mean duration = 13.2, SD = 8.7). There was no significant difference between participants with pSS or RA in either age (p = 0.27) or disease duration (p = 0.10).

**Measures**

Sleep diary. Participants were asked to recall sleep-onset latency, the frequency and total duration of their awakenings and their total time asleep. They then rated the quality of their sleep that night and how refreshed they felt upon waking; both items were rated between 0 defined as “not at all” and 7 meaning “totally”.

Actigraphy. The Actiwatch Score™ (Cambridge Neurotechnology Ltd., Cambridge, UK) provided a record of movement during the night. The instrument is similar in size and weight to a wristwatch and, when worn on the wrist, detects movement incompatible with sleep (Lavie et al., 1992). Movement with a force above 0.05 g and a frequency between 3-11 Hz was recorded in 30-second epochs. The activity data were downloaded into Actiwatch Activity and Sleep Analysis v.5.32 software (Cambridge Neurotechnology Ltd., 2003) to translate each night’s movement into scores for sleep-
onset latency, total wake time, total sleep time and sleep efficiency (percentage of time in bed spent asleep). Comparative studies of actigraphy with polysomnography (considered the gold standard of sleep measures; Lavie et al., 1992) have reported good agreement in distinguishing sleep from wake (Morin & Espie, 2004). Percent of agreement between epochs recorded by actigraphy and polysomnography has ranged from 78.8% to 99.7% for sleep and from 48.5% to 79.8% for wake (Kushida et al., 2001; Tang & Harvey, 2004; Tyron, 2004; Wilson et al., 1998).

Factor analyses of the 10 measures of sleep obtained from actigraphy and participants’ sleep diaries were conducted in order to simplify the number of sleep variables entered into subsequent multi-level analyses. The sleep measures were forced to load across two factors, which explained 50.4% of the total variance in the measures of sleep. Three of the 10 items did not load adequately onto either factor (both measures of sleep latency and the recalled number of awakenings loaded < 0.5) and so were removed before repeating the analyses with the remaining seven sleep measures (Table 1). The two-factor rotation of the remaining seven variables explained more of the total variance in the sleep measures (66.2%).

Four items referring to total sleep time (recorded both by actigraphy and by sleep diary), sleep quality and feeling refreshed loaded together (>0.5) onto the second factor providing a composite variable representing sleep quantity/quality. The internal reliability of this variable was adequate (α = 0.72). The remaining three items loaded strongly (>0.8) onto the first factor; two referred to waking during the night and the third, which loaded negatively, referred to the efficiency of sleep. Because of its negative loading onto Factor 1 with positively loaded other measures of awakenings, sleep efficiency was recoded as sleep inefficiency (included in Table 1) and transformed
linearly (percentage of time in bed spent awake = 100 – sleep efficiency). However, the internal consistency of these three items was unacceptably low ($\alpha = 0.42$). The contribution of each measure of awakening to the internal consistency was assessed and sleep inefficiency was identified as contributing most to the internal consistency of the scale. Sleep inefficiency is a composite measure which incorporates total time spent awake. For these reasons, only sleep inefficiency was used in further analyses as a measure of wakefulness during the night.

Profile of Fatigue. Fatigue was measured using the Profile of Fatigue (ProF) (Bowman et al., 2004) which contains 16 items. Previous factor analyses of responses given by patients with pSS or RA (Goodchild et al., 2008) supported the two subscales of somatic fatigue (12 items) and mental fatigue (4 items) originally proposed by Bowman et al. (2004). The subscale of somatic fatigue includes items referring to the need for rest and difficulties with poor starting, low stamina and weak muscles. The mental fatigue subscale includes items concerning poor concentration and poor memory. Participants rate each item between 0 (anchored as ‘no problem at all’) and 7 (anchored ‘as bad as imaginable’). The score for each subscale is the mean of the responses to the 12 somatic fatigue items or the 4 mental fatigue items.

Profile of Discomfort. The brief version of the Profile of Discomfort (ProD) (Bowman et al., 2003) contains 13 items covering arthralgia, cutaneous dryness, vascular dysfunction, ocular sicca and oral sicca. Participants described the severity of their discomfort on the same 8-point numerical rating used in the ProF. Factor analyses of pSS and RA responses to the brief ProD have indicated three subscales (Goodchild, 2008), two separating oral from ocular dryness, and the third subscale involving discomfort of the joints (arthralgia).
Procedure

Participants’ sleep patterns, fatigue and discomfort ratings were monitored for 35 consecutive days and nights, with visits every 7 days in between to confirm if the participant wished to continue, to collect completed questionnaires and to download data from the Actiwatch.

At night, participants completed the ProF and ProD approximately 1 hour before going to bed (mean time of completion: 9.43pm) and strapped the Actiwatch onto their non-dominant wrist. When settling down to sleep, participants pressed the event marker on the Actiwatch. This marker was pressed a second time when participants woke in the morning. This procedure provided settings for parameters in the sleep analysis software (i.e. the period in bed).

After arising in the morning, participants completed the sleep diary and the ProF (mean completion time: 8.02am). The ProF was completed twice more during the day, in the late-morning (mean completion time: 11.43am) and mid-afternoon (mean completion time: 4.23pm). Participants were asked to write the time and date at the beginning of the questionnaire; this information was reported on all completed questionnaires.

Statistical analyses

Symptom severity of fatigue and its variation across the day were examined by first aggregating the 35 days’ severity scores for each person’s early morning, late morning, late afternoon and late evening reports of somatic fatigue and mental fatigue from the ProF. Repeated measures analyses of variance (RMANOVA) were then conducted on these aggregated fatigue ratings of each participant investigating variation across the four daily ratings. Following the procedure of Stone et al. (1997), the Greenhouse-
Geisser correction was applied to the within-person analyses of variance where Mauchly’s test of sphericity indicated that the assumption of the homogeneity of variance was violated. In these cases, the degrees of freedom are adjusted and are thus sometimes not whole numbers.

Severities of evening discomfort and sleep disturbance were also aggregated across the 35 days for each participant. The pSS and RA groups’ mean scores were contrasted by independent t-tests, applying the Hochberg procedure to control for multiple comparisons.

Associations between discomfort, sleep and fatigue across patients were examined using product-moment correlations on the aggregate ratings (mean of the 35 observed days) of each person. Then multi-level models of predictors of daily fatigue (discomfort, sleep and previous fatigue) were then computed using MLwiN (version 2.02) software (Rasbash et al., 2005). Multi-level modelling accounts for the variance both between and within individuals and allows for unbalanced measurement intervals and missing responses, which are common within diary data (Baker, 2006; 2007; Blackwell et al., 2006).

The first step of the multi-level analyses involved fitting a baseline variance components model, to provide baseline estimates of how much of the variance in somatic fatigue and mental fatigue was partitioned between participants and days. These baseline estimates were then used to evaluate subsequent models.

The between-days variation in fatigue for each individual was modelled as a function of discomfort in the first model (after accounting for fatigue the previous day):

\[
\text{Fatigue}_{ij} = \beta_{0j} + \beta_{01}(\text{fatigue}_{i-1,ij}) + \beta_{02}(\text{discomfort}_{i-1,ij}) + e_{ij}
\]
The between-days variance in fatigue was then modelled as a function of discomfort and sleep:

\[ \text{Fatigue}_{ij} = \beta_{0j} + \beta_{01}(\text{fatigue}_{i-1j}) + \beta_{02}(\text{discomfort}_{i-1j}) + \beta_{03}(\text{sleep}_{i-1j}) + e_{ij} \]

\( \text{Fatigue}_{ij} \) represents the severity of fatigue on day \( i \) for person \( j \); \( \beta_{0j} \) represents the mean fatigue rating for person \( j \) across all 35 days; \( \beta_{01}(\text{fatigue}_{i-1j}) \) is the severity of fatigue rated by person \( j \) on the day previous to \( i \); \( \beta_{02}(\text{discomfort}_{i-1j}) \) is the rated severity of discomfort rated by person \( j \) on the evening previous to day \( i \); \( \beta_{03}(\text{sleep}_{i-1j}) \) is the sleep of person \( j \) for the night previous to day \( i \). The variance of \( e_{ij} \) represents the residual variance associated with each within-person observation of daily fatigue.

For easier interpretation of the data, discomfort and fatigue ratings (reported the day before the outcome variable of fatigue) were dichotomized around each individual’s mean, an analytical technique commonly employed with multi-level data (Baker, 2006; 2007). Discomfort and fatigue were coded as 1 for days when the scores were greater than each individual’s mean rating and as 0 for days that were below their mean (or, in rare cases, equal to it).

The between-person variance in fatigue was modelled as a function of disease type:

\[ \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{diagnosis}) + u_{0j} \]

\( \beta_{0j} \) represents the mean physical or mental fatigue ratings for person \( j \) from the level 1 model, \( \gamma_{00} \) is the grand central mean rating of physical or mental fatigue across all participants, \( \gamma_{01}(\text{diagnosis}) \) assesses if person \( j \)’s disease predicts their mean fatigue rating and the variance of \( u_{0j} \) is the unexplained amount that person \( j \)’s mean fatigue rating deviates from the grand central mean.
In order to compare models, we report the deviance index (-2 × log likelihood, denoted by $\Delta \chi^2$), which assesses the improvement in goodness of fit of the model to the data.

**RESULTS**

**Severity and diurnal variation of fatigue in SS and RA**

The pSS and RA groups did not differ in participants’ ratings of either somatic fatigue, $F(1,37) = 0.59, p = 0.45$, or mental fatigue, $F(1,37) = 0.69, p = 0.41$ (Figure 1). In both pSS and RA there was an increase as the day progressed in severity of both somatic fatigue, $F(1.7, 64.4) = 25.4, p < 0.001$, and mental fatigue, $F(2.1, 78.9) = 12.1, p < 0.001$. The time course of fatigue across the day did not differ between pSS and RA (the interaction of time of day with disease was not significant for either somatic or mental fatigue).

**Severity of discomfort and poor sleep in SS and RA**

Arthralgia was the most severe symptom of discomfort reported by participants with RA (Table 2), and was more severe among participants with RA than among those with pSS, $t(37) = -3.33, p < 0.05$. In contrast, as to be expected, discomfort was more severe in pSS than in RA for oral sicca, $t(37) = 2.98, p < 0.05$. The difference between pSS and RA for ocular sicca did not reach statistical significance, $t(37) = 1.81, p = 0.08$.

The two groups’ means did not differ significantly in ratings of sleep quality, $t(37) = -0.81, p = 0.42$, feeling refreshed, $t(34.3) = -1.2, p = 0.24$, recalled time asleep, $t(37) = 0.25, p = 0.80$, or the actigraphic measure of total sleep time, $t(37) = -0.98, p = 0.33$. However, actigraphy indicated that the sleep of women with pSS was less efficient than that of women with RA, $t(37) = -2.91, p < 0.05$ (see Table 2 for means).
Associations between discomfort, sleep and fatigue

Several significant correlation coefficients were observed between the aggregate ratings (participants’ mean ratings across the 35 observed days) of discomfort, sleep and fatigue (Table 3). In particular, individuals who had greater discomfort during the 35 days also rated their fatigue as more severe on average. These correlations were strongest for mental fatigue with ocular sicca and for somatic fatigue with arthralgia and with ocular sicca. There was a moderate association between sleep inefficiency and mental fatigue, indicating that individuals who slept less tended to report more problems with impaired concentration and memory.

Multi-level models exploring predictors of fatigue

Fatigue ratings given during the late afternoon were chosen as the outcome variable because fatigue at this time was rated as more severe than fatigue during the morning and because the afternoon is a time when individuals are likely to be attempting to continue activities such as paid work or household chores. Somatic and mental fatigue were kept as separate outcomes given that they showed some unique variance in correlations and may have different specific predictors.

When the previous day’s afternoon fatigue was entered into the baseline variance components model for either somatic fatigue or mental fatigue, the fit improved (Table 4). Participants’ fatigue was more severe on days that were preceded by greater than average severity of fatigue ($\beta_{01}$; Table 4), explaining 4% of the variance in somatic fatigue and 3% of the variance in mental fatigue.

The hypothesis that fatigue is more severe following evenings of greater discomfort was tested by entering arthralgia, oral sicca and ocular sicca into the models of somatic fatigue and mental fatigue. The addition of the three discomfort variables significantly
improved the goodness of fit for both the models of fatigue, with afternoon fatigue being greater following nights with more severe discomfort ($\beta_{01}$; Table 4). The greatest increase in somatic fatigue followed worse than average arthralgia, whereas worse oral sicca was followed by the greatest increase in mental fatigue. This addition of evening discomfort to the models explained a further 1% of the variance in somatic fatigue and mental fatigue.

The hypothesis that worse sleep disturbance statistically moderates the relationship between pain and fatigue was assessed by adding sleep quantity/quality and sleep inefficiency the previous night into the models of fatigue. This further improved the fit for both somatic and mental fatigue, with worse sleep predicting greater fatigue the subsequent afternoon ($\beta_{01}$; Table 4). However, sleep inefficiency appeared to have less impact than poor sleep quantity/quality for both somatic and mental fatigue (Table 4). This addition of sleep to the models explained a further 1% of the variance in somatic fatigue but the unexplained variance in mental fatigue was not further reduced.

Finally, type of disease was added to the between-persons models of somatic or mental fatigue to test the hypothesis that effects of discomfort, sleep disturbance previous fatigue severity differed between pSS and RA. The deviance indices indicated that such differences did not improve the fit of each model; somatic fatigue, $\Delta \chi^2(7) = 0.05$, n.s., and mental fatigue, $\Delta \chi^2(7) = 0.40$, n.s. The relationships between discomfort, sleep and fatigue did not differ reliably between pSS and RA in this sample.

**DISCUSSION**

In the present study we prospectively examined within-day variation in somatic and mental fatigue in both pSS and RA using a multi-dimensional instrument. Fatigue is
reported to be one of the most stressful and important symptoms of both pSS and RA and so it is perhaps not surprising that the two groups reported similar levels of fatigue throughout the day.

Women with either pSS or RA also showed gradual increases in both bodily and mental fatigue as the day progressed. These increases in scores for fatigue across the day were, however, quite small. This may partly be because more extreme variations in severity with time of day were averaged out when the data were combined across days. The moderate increase over the day is not likely to have resulted from the method of judging severity. The scores we obtained (between 1.38 and 3.52) are in ranges similar to those previously reported for momentary assessments of fatigue that have used similar rating formats. Stone et al. (1997) reported fatigue ratings in the range of 1 to 2.25 on a scale from 0, anchored as ‘not at all,’ to 6, anchored as ‘extremely,’ among people with RA while Godaert et al. (2002) reported ratings of general fatigue that varied from 2 to 2.5 on a scale from 0, anchored as ‘not at all,’ to 4, anchored as ‘very much’.

The change in severity of fatigue observed in this study is consistent with the variation reported in previous studies (Godaert et al., 2002; Stone et al., 1997) in that fatigue was greater in the evening than in the morning. However, the fatigue ratings provided in the present study did not replicate the mid-morning reprieve previously observed in both pSS (Godaert et al., 2002) and RA (Stone et al., 1997). This disparity may have arisen from any of a number of differences between the studies, but one possibility is that the detailed profile monitored in the present study masked the personal selection of salient aspects of fatigue.
In both pSS and RA, the women who reported (on average) more severe discomfort and poorer sleep also reported more severe fatigue, as would be expected from previous research. The specific evidence that discomfort in the evening predicted fatigue the following afternoon for both somatic and mental aspects of fatigue is a novel finding. Furthermore, this evidence came from both correlations of 35-day averages and also multi-level analyses of daily values. In particular, the multi-level analyses identified a lagged relationship, with worse fatigue following a night that started with more severe discomfort. This evidence is similar to that of Zautra et al. (2007) who found that greater pain predicted greater fatigue the next day among women with RA, osteoarthritis or fibromyalgia. Our approach using a diary separating somatic from mental fatigue considerably extended previous evidence of an association between pain and fatigue among people with pSS (Godaert et al., 2002) or RA (Belza et al., 1993; Hewlett et al., 2005a; Pollard et al., 2006).

In addition, this study showed that the relationship between discomfort before bed and fatigue the following day depended on sleep that night. On nights when sleep was more disturbed, the association between discomfort in the evening and greater fatigue the next afternoon was stronger. Gudbjörnsson et al. (1993) reported that dryness-related discomfort caused waking in pSS and that women with pSS associated poor sleep with their fatigue. The current prospective study supports these previous observations in pSS and extends them to RA as well. The new findings concur also with the report by Stone et al. (1997) that perceived quality of sleep was more predictive of daily fatigue than was duration of sleep in people with RA.

It should be noted that the amount of variance in fatigue explained by discomfort and sleep combined was less than the amount explained by the previous day’s fatigue and
both together leave a large amount unexplained. People with RA have noted that their bouts of daily fatigue often have no obvious precipitating event, appearing as unannounced ‘wipeout’ (Hewlett et al., 2005b). The severity of discomfort and the disturbance of sleep for one night may have relatively little effect on fatigue the next day when that symptom is chronic. Discomfort, pain and insomnia may have to recur for several nights in succession for substantial effect on fatigue to accumulate. That is, any dependence of severe fatigue on discomfort and poor sleep may require chronic pain and/or insomnia.

Only one previous study compared discomfort, sleep and fatigue between women with pSS and women with RA: nocturnal discomfort and sleeping difficulties were reported more frequently by women with pSS and they also reported greater fatigue than women with RA (Gudbjörnsson et al., 1993). In the present study pSS and RA did not differ reliably in fatigue or in severity of discomfort, although the expected differences in the locations and types of discomfort were discriminated by our measures. The absence of reliable differences could arise from differences between our and the earlier samples of either disease or the modest sizes of our groups. Affleck et al. (1999) suggested that intensive self-monitoring can change the behavior of focus and so cross-sectional studies like that of Gudbjörnsson et al. (1993) and longitudinal studies might give different results. Indeed, increased monitoring is a core component of cognitive-behavioral treatments that are successful among people with rheumatic disease (Hale et al., 2007). Future research should be targeted at testing if fatigue, discomfort or disturbances of sleep among people with rheumatic disease are improved or aggravated by intensive prospective designs.
The present study followed the participant inclusion criteria of Bowman et al. (2004) and so the data were only collected from White-British women above the age of 35. Consequently, further studies would be required before these results could be generalized to a wider population of pSS and RA patients. In particular, research is needed to assess the relationship between discomfort, sleep and fatigue in men with rheumatic disease and in people in other locations and of other cultural origins.

In conclusion, the present study highlights fatigue as a persistent problem that is present throughout the day in both pSS and RA. Greater discomfort in the evening is associated with more fatigue the following day for women with pSS or RA and this relationship was statistically moderated by poor sleep, such that an evening’s discomfort and disrupted sleep exacerbated fatigue the following day. The present findings support and extend the previous evidence that both discomfort and poor sleep have substantial impact on fatigue for people with pSS or RA. Future research should focus on effects of recurrent discomfort and disrupted sleep on persistent fatigue. As far as they go, however, the present results indicate that interventions targeted at reducing discomfort at night and improving quality of sleep may be helpful in reducing fatigue in pSS and RA.


Hale, ED, Treharne, GJ, & Kitas GD (2007). The Common-Sense Model of self-regulation of health and illness: how can we use it to understand and respond to our patients' needs? Rheumatology 46: 904-906. DOI: 10.1093/rheumatology/kem060


Table 1: Loadings of questionnaire and actigraph sleep measures onto principal components in a two-factor rotation of records from 35 nights of sleep monitoring

<table>
<thead>
<tr>
<th>Sleep Measure</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Hours asleep (Q)</td>
<td>0.04</td>
</tr>
<tr>
<td>Actual sleep in hours (A)</td>
<td>0.09</td>
</tr>
<tr>
<td>Sleep quality rating (Q)</td>
<td>-0.18</td>
</tr>
<tr>
<td>Refreshment rating (Q)</td>
<td>-0.15</td>
</tr>
<tr>
<td>Actual time awake in hours (A)</td>
<td><strong>0.94</strong></td>
</tr>
<tr>
<td>Number of wake bouts (A)</td>
<td><strong>0.87</strong></td>
</tr>
<tr>
<td>Sleep inefficiency % (A)</td>
<td><strong>0.80</strong></td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>2.35</td>
</tr>
<tr>
<td>Variance accounted for ($R^2$)</td>
<td>33.57</td>
</tr>
<tr>
<td>Cronbach’s $\alpha$ (of bolded items)</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Q = questionnaire measure; A = actigraph record; items in bold load > 0.5.
Figure 1: Mean ratings of fatigue severity reported by women with SS or RA across the day
Table 2: Average discomfort and sleep scores across 35 nights for the 39 participants with SS or RA

<table>
<thead>
<tr>
<th>Measures</th>
<th>Range</th>
<th>Mean (SD) SS</th>
<th>Mean (SD) RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthralgia (Profile of Discomfort)</td>
<td>0.00 – 7.00</td>
<td>1.67 (1.55)</td>
<td>3.50 (1.94)</td>
</tr>
<tr>
<td>Oral sicca (Profile of Discomfort)</td>
<td>0.00 – 6.50</td>
<td>2.92 (1.49)</td>
<td>1.31 (1.63)</td>
</tr>
<tr>
<td>Ocular sicca (Profile of Discomfort)</td>
<td>0.00 – 6.60</td>
<td>2.36 (1.37)</td>
<td>1.32 (1.68)</td>
</tr>
<tr>
<td>Hours of sleep (Diary)</td>
<td>1.40 – 11.00</td>
<td>6.94 (1.31)</td>
<td>6.85 (1.32)</td>
</tr>
<tr>
<td>Sleep quality rating (Diary)</td>
<td>0.00 – 7.00</td>
<td>4.10 (1.30)</td>
<td>4.37 (1.50)</td>
</tr>
<tr>
<td>Refresh rating (Diary)</td>
<td>0.00 – 7.00</td>
<td>3.50 (1.41)</td>
<td>3.93 (1.61)</td>
</tr>
<tr>
<td>Hours of sleep (Actigraph)</td>
<td>3.48 – 10.42</td>
<td>7.01 (1.04)</td>
<td>7.23 (1.08)</td>
</tr>
<tr>
<td>Sleep inefficiency (%: Actigraph)</td>
<td>0.50 – 39.80</td>
<td>14.00 (6.25)</td>
<td>10.30 (4.70)</td>
</tr>
</tbody>
</table>

n.b. the average discomfort scores are those rated in the evening prior to sleep
Table 3: Correlations between person-specific variables, with mean evening ratings of discomfort, sleep and afternoon ratings of fatigue aggregated across all days of reporting (n = 39)

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Age</th>
<th>Disease duration</th>
<th>Arthralgia</th>
<th>Oral sicca</th>
<th>Ocular sicca</th>
<th>Sleep inefficiency</th>
<th>Sleep quantity/quality</th>
<th>Mental fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease duration</td>
<td>12.32 (7.92)</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthralgia</td>
<td>2.84 (1.87)</td>
<td>0.09</td>
<td>0.33*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral sicca</td>
<td>1.88 (1.74)</td>
<td>-0.11</td>
<td>0.08</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ocular sicca</td>
<td>1.69 (1.59)</td>
<td>-0.03</td>
<td>-0.10</td>
<td>0.45**</td>
<td>0.72***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep inefficiency</td>
<td>11.63 (4.17)</td>
<td>-0.16</td>
<td>-0.17</td>
<td>-0.05</td>
<td>0.22</td>
<td>0.30†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep quantity/quality</td>
<td></td>
<td>0.08</td>
<td>0.35*</td>
<td>0.01</td>
<td>0.11</td>
<td>-0.01</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental fatigue</td>
<td>1.74 (1.60)</td>
<td>0.05</td>
<td>0.00</td>
<td>0.33*</td>
<td>0.46**</td>
<td>0.72***</td>
<td>0.38*</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Somatic fatigue</td>
<td>2.83 (1.60)</td>
<td>0.18</td>
<td>0.21</td>
<td>0.67***</td>
<td>0.34*</td>
<td>0.65***</td>
<td>0.23</td>
<td>0.14</td>
<td>0.62***</td>
</tr>
</tbody>
</table>

* p < 0.05; ** p < 0.01; *** p < 0.001; † p = 0.06
Table 4: Deviance indices ($\Delta \chi^2$) and changes in afternoon fatigue ($\beta_{0j}$ and $\beta_{01}$) for each predictive model of Somatic Fatigue and Mental Fatigue

<table>
<thead>
<tr>
<th></th>
<th>$\Delta \chi^2$</th>
<th>df</th>
<th>$\beta_{0j}$ (SE)</th>
<th>$\beta_{01}$ (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Somatic Fatigue (SF)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous day’s SF</td>
<td>245*</td>
<td>1</td>
<td>-0.13 (0.03)</td>
<td>0.26 (0.04)</td>
</tr>
<tr>
<td>Previous evening’s discomfort</td>
<td>42*</td>
<td>4</td>
<td>-0.24 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Arthralgia</td>
<td></td>
<td></td>
<td>0.13 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Oral sicca</td>
<td></td>
<td></td>
<td>0.05 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Ocular sicca</td>
<td></td>
<td></td>
<td>0.06 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td>71*</td>
<td>6</td>
<td>-0.33 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Sleep quantity/quality</td>
<td></td>
<td></td>
<td>0.13 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Sleep inefficiency</td>
<td></td>
<td></td>
<td>0.06 (0.04)</td>
<td></td>
</tr>
<tr>
<td><strong>Mental Fatigue (MF)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous day’s MF</td>
<td>171*</td>
<td>1</td>
<td>-0.12 (0.02)</td>
<td>0.29 (0.03)</td>
</tr>
<tr>
<td>Previous evening’s discomfort</td>
<td>41*</td>
<td>4</td>
<td>-0.19 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Arthralgia</td>
<td></td>
<td></td>
<td>0.02 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Oral sicca</td>
<td></td>
<td></td>
<td>0.16 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Ocular sicca</td>
<td></td>
<td></td>
<td>0.06 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td>44.53*</td>
<td>6</td>
<td>-0.21 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Sleep quantity/quality</td>
<td></td>
<td></td>
<td>0.06 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Sleep inefficiency</td>
<td></td>
<td></td>
<td>0.02 (0.03)</td>
<td></td>
</tr>
</tbody>
</table>

* $p < 0.005$