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Daily Social Enjoyment Interrupts the Cycle of Same-day and Next-day Fatigue in Women with Fibromyalgia

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Abstract

Background—Fatigue is a debilitating symptom of fibromyalgia (FM) that has limited treatment options. Some evidence, however, has linked positive social engagement with reduced within-day fatigue.

Purpose—This study elaborated longitudinal within-day and across-day relations between FM fatigue and social enjoyment.

Methods—176 women with FM completed 21-day automated diaries assessing morning and end-of-day fatigue, and both afternoon social enjoyment and stress within two social domains: non-spousal and spousal.

Results—In the non-spousal domain, analysis supported a mediational path from lower morning fatigue to higher afternoon social enjoyment, which predicted lower end-of-day fatigue, and subsequently, lower next-morning fatigue. Enjoyment exerted a greater impact on within-day fatigue than did stress. Patterns in the spousal domain were similar, but the mediated path was nonsignificant.

Conclusions—Positive social engagement offers relief from FM fatigue that carries over across days and may provide an additional target to enhance the effectiveness of current interventions.

Keywords

Fibromyalgia; Diary study; Fatigue; Social relations; Enjoyment; Stress

Fibromyalgia (FM) is a condition characterized by chronic widespread musculoskeletal pain that affects 2% – 6% of the U.S. population, of whom the majority are women (1–4).

Beyond pain, FM cardinal symptoms can include fatigue, poor sleep, memory problems and mood disturbances (5–9). Empirical attention has been mainly focused on the study of pain

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Conflict of Interest

All the authors of the current study have no conflict of interest to disclose.

Adherence to Ethical Standards

All procedures were approved by the Institutional Review Board at Arizona State University and all the participants gave their informed consent prior to their inclusion in the study.

in FM even though over 80% of FM patients complain about fatigue and its physical and psychological effects (10–12). The societal and personal costs of fatigue can be substantial. Pain patients who report clinically significant levels of fatigue are six times more likely to report being unable to work (10), and fatigue is a greater impediment to FM patients' ability to accomplish daily tasks than is pain (13). Despite the clinical relevance of fatigue, relatively little is known about aspects of an individual and/or his/her environment that may play a role in exacerbating or alleviating daily FM fatigue. Elaborating the processes that fuel fluctuations in fatigue can inform intervention strategies that maximize functional health.

The limited available evidence indicates that fatigue fluctuates substantially from day to day among individuals with FM (12, 14). Not surprisingly, pain on one day predicts increased FM fatigue the next day, but pain only accounts for approximately 3% of the within-person variation in day-to-day fatigue (14). Beyond pain, what other factors may contribute to daily FM fatigue? In recent decades, accruing evidence has suggested that the ebb and flow of small daily positive interpersonal events are significantly associated with daily fatigue in chronic pain samples (15–17). For example, in a daily diary study among patients with chronic pain that included only end of day reports, within-person analyses across days showed that on days when the number of positive interpersonal events was elevated, levels of same-day fatigue were reduced (17). Moreover, the number of positive events showed a stronger association with same-day fatigue than did the number of negative events.

Some evidence suggests that positive interpersonal events may influence fatigue in patients with chronic pain via their impact on positive affect. A substantial body of work points to the quality of social interactions as central to positive affect and general well-being (18, 19), and the limited available evidence suggests that positive affect is linked to lowered levels of fatigue. For example, findings from a diary study that assessed daily fatigue and affect at the end of each day among women with FM, osteoarthritis (OA), or rheumatoid arthritis (RA) indicated that on days when women reported elevated positive affect, they also reported lower fatigue (12). Furthermore, positive affect played a much larger role in predicting same-day fatigue than did negative affect; 13% *versus* 5% of the within-person variance in fatigue was explained by positive and negative affect, respectively. Of particular relevance for the current study, the negative relationship between positive affect and same-day fatigue was more pronounced in FM patients compared to OA and RA patients. Thus, similar to the inverse relation between same-day positive interpersonal events and fatigue, elevations in positive affect are linked to diminished same-day fatigue. These findings highlight the potential for positive affect to restore energy, especially for individuals with FM fatigue.

A key limitation in the existing research is the cross-sectional nature of same-day assessments of positive affective experiences and fatigue. Although the negative relation between daily positive interpersonal engagement and fatigue is intriguing, determining the nature of the relation between positive social experiences and FM fatigue requires that investigators move beyond cross-sectional data to examine the temporal ordering of the affect-fatigue association. Positive social experiences may alleviate subsequent fatigue, and/or elevated fatigue may dampen subsequent experiences of positive social interactions. Some existing diary data collected within-day shed light on the temporal associations

between social engagement and fatigue in FM (20). On mornings on which FM patients reported that their morning fatigue was elevated above their average level, they also reported at the end of the day that they invested less effort and made less progress toward achieving their medium range social goals, such as “going to lunch or shop with friends” (p.44) (20). Thus, morning fatigue predicted lower end-of-day reports of interpersonal engagement. However, the influence of interpersonal engagement on subsequent fatigue within a day was not examined.

Identifying psychosocial factors that shape the experience of daily fatigue in FM represents an initial step in the development of potential intervention strategies to alleviate fatigue and thereby improve patients’ functional health. Existing evidence points to the reciprocal relation between FM fatigue and positive interpersonal engagement, but no study has examined these relations within a day. The primary goal of the current study was to assess the dynamic relations between fatigue and a relationship-bound facet of positive affect (i.e., enjoyment of social relations), as they unfold over time within a day among individuals with FM. A secondary goal was to test whether the within-day relation between FM fatigue and social enjoyment was stronger in magnitude than the within-day relations between FM fatigue and social stress, a negative appraisal of relationship engagement.

The current study drew on diary reports that measured FM participants’ fatigue levels in the morning and at the end of day, and the affective quality of their social relations (i.e., enjoyment and stress) in the afternoon for 21 days in 176 women. Five hypotheses regarding the within-day relations between fatigue and interpersonal relationship were tested (depicted in Figure 1): 1) days of low morning fatigue will predict higher levels of afternoon social enjoyment; 2) days of higher levels of afternoon social enjoyment will predict lower levels of fatigue at the end of that day; 3) afternoon social enjoyment will mediate the relation between morning and end-of-day fatigue; 4) the mediating role of afternoon social enjoyment will be sustained even when social stress is modeled as a second mediator; and 5) the magnitude of influence derived from enjoyment will be greater than that from stress in mediating morning and end-of-day fatigue. Beyond testing within-day relations, the current study also examined across-day relations among fatigue and social enjoyment. Specifically, the study explored whether afternoon social enjoyment on one day carried over to predict morning fatigue on the next day via end-of-day fatigue (depicted in Figure 2). The examination of the carry-over effects addresses a key question: are the effects of social enjoyment on fatigue sustained from one day to the next? Finally, previous literature has suggested that social relationships within different domains may play different roles in the well-being of patients with chronic mental or physical illnesses (e.g., 21, 22). Thus, the relations between fatigue and social enjoyment over time in the spousal domain, confined to marital partners or partners living as married, and non-spousal domain, including family, friends, and co-workers were tested separately.

METHOD

Participants

The sample for the present study was recruited to participate in a randomized trial comparing cognitive-behavioral treatment, mindful-awareness treatment, and arthritis

education for FM. Participants were recruited in the Phoenix, Arizona metropolitan area via newspaper and online advertisements, fliers posted at medical clinics, and referrals from physicians. Respondents who expressed an interest in participation were first screened *via* telephone, and then *via* an in-home assessment conducted by a registered nurse with respect to the following inclusion criteria: (1) 18 years of age or older; (2) English-speaker; (3) no involvement in litigation associated with their pain condition; (4) agreed to be randomized into one of the three treatment conditions; (5) without co-morbid psychological or medical conditions that might interfere with their participation in the study; and (6) fulfilled FM criteria specified by the American College of Rheumatology (ACR) (11) that included a tender point assessment (23).

The current study only included data collected prior to randomization to treatment. Thus, in the following sections, only those aspects of the method and data pertaining to the pre-intervention portion of this study are included. Of the 272 participants enrolled into the larger study, 220 participants continued on to the daily diary component of the study. The current study excluded males ($n=25$) to increase homogeneity, and excluded participants who completed fewer than 10 out of 21 end-of-day diaries (fewer than 50% of the end-of-day diaries, described below), consistent with the requirement to proceed to randomization to treatment condition in the larger project. As a result, 176 out of 198 females were retained in the analyses.

Procedure

All procedures were approved by the Institutional Review Board at Arizona State University and all the participants gave their informed consent prior to their inclusion in the study. All participants received an in-home nurse visit to obtain written informed consent, and to undergo a tender point examination to verify their current FM diagnosis utilizing the ACR criterion – pain and tenderness experienced on at least 11 of 18 tender points (11). The home visit also included an assessment of current health status. Then, a clinical phone interview was conducted to assess depressive and anxiety symptoms. In addition, the participants completed an initial and a pre-treatment questionnaire that assessed demographic information, personality, and physical and mental functioning. They also participated in a laboratory session that measured their physiological and emotional reactivity to experimental stressors. Finally, they completed daily diaries that assessed their physical and mental health in their daily lives. The current study included data drawn from the diary assessment

In the diary portion of the larger study, participants were provided with a mobile phone and were trained by a research assistant to use the phone to complete electronic diaries four times a day for 21 days. An automated phone system called each of the participants each morning 20 minutes following her specified usual wake up time for the first morning interview, at 11 a.m. for the second morning interview, at 4 p.m. for the afternoon interview, and at 7 p.m. for the end-of-day interview. If the participant missed the call, she could call the system within two and half hours to complete the interview. Participants were encouraged to call our laboratory staff immediately if a problem occurred with the phone system. Participants were monitored and contacted if they failed to complete diaries for two

days in a row. Participants were compensated \$3 each day for completing a 21-day diary. Data regarding fatigue, and social enjoyment and stress for the current study were extracted from the 11 a.m., 4 p.m., and 7 p.m. reports, which were assessed at the same time of day for all participants.

Measures

(1) Average Fatigue—Average fatigue was assessed in the morning and at the end of the day via a widely-used one item measure (24). The question stated, “What was your overall level of fatigue? Enter a number between 0 and 100 that best describes your fatigue level. A zero (0) would mean ‘no fatigue’ and a one hundred (100) would mean ‘fatigue as bad as it can be’.”

(2) Perceived Social Enjoyment and Stress—Perceived social enjoyment and stress were assessed in the afternoon. They were measured via items drawn from the Inventory of Small Life Events (25) to assess affective appraisals of the current social milieu in two interpersonal domains: spouse/partner (spousal domain), and family, friends, and co-workers combined (non-spousal domain). Participants first indicated whether they had contact with individuals within a domain during the previous 2–3 hours, and if they reported contact, they were queried regarding their affective appraisals of that relational domain. Interpersonal relations were assessed with two items per domain, “How enjoyable (stressful) were your relations with spouse/partner (friends, family, or co-workers)?” Partnered participants were instructed to exclude their spouse/partner as family when rating the non-spousal domain. Enjoyment and stressfulness were each rated on a five-point scale ranging from 1 (*not at all*) to 5 (*completely*). Assessment of the spousal domain always preceded assessment of the non-spousal domain, and assessment of stress always preceded assessment of enjoyment.

Covariates

Several potential covariates were measured in the diary, including sleep, pain, anxiety-related emotion (i.e., fear), and depressive symptoms. Sleep disturbance was assessed in the first morning interview (upon awakening) with the question “Did you have trouble staying asleep last night?” on a 4-point scale ranging from 1 (*not at all*) to 4 (*quite a bit*) (26). Pain was assessed with the question “What was your overall level of pain?” on a 101-point scale ranging from 0 (*no pain*) to 100 (*pain as bad as it can be*) at 11 AM and 7 PM (end-of-day) (24). Anxiety-related emotion was assessed with the question “How afraid did you feel?” on a 5-point scale ranging from 1 (*not at all*) to 5 (*completely*) at 7 PM (27). Finally, depressive symptoms were assessed by five items, among them, “Did you feel down on yourself?” on a 3-point scale ranging from 1 (*no*) to 3 (*yes very much*) at 7 PM (28).

Data Analytic Strategy

Modeling strategy—Multilevel Structural Equation Modeling (MSEM) (29) was employed to estimate the direct and mediated effects at the between- and within-person levels simultaneously by using *Mplus* version 7 (30). This approach partitions the total variance into two mutually exclusive components – a within-person component that models relations among daily measures of each individual (e.g., morning fatigue each day to afternoon enjoyment on that same day), and a between-person component that captures

global relations (e.g., average morning fatigue per person across the whole diary to average afternoon enjoyment per person across the whole diary). All hypotheses addressed within-person relations. For within-person analysis, *Mplus* removes the between-person variability in the predictor and mediators via “implicit, model-based group mean centering” (p. 210) (29). This centering prevents biases in the standard error estimates and inflation of type I error rates of the test statistics of the parameters caused by the clustering effect. MSEM provides estimations of the relations among variables at both the between- and within-person levels. Consistent with the hypotheses, all results reported are based on the within-person component of the multilevel models.

Estimating mediated effects—In the same-day models (Figure 1), the specifications followed the recommendations stated in Preacher et al. (29)—all the paths in the MSEM were specified to have random intercepts but fixed slopes, except the association between morning and end-of-day fatigue, which was specified to have a random intercept and slope. At both the within-person and the between-person levels, the path from morning fatigue to afternoon enjoyment (the a_1 path in the mediational chain) and the path from afternoon enjoyment to end-of-day fatigue (the b_1 path in the mediational chain) were estimated (i.e., the a_1b_1 path in Figure 1). The distribution of the mediated or indirect effect (i.e., the product ab of the a and b paths) is asymmetrical and varies as a function of the correlation between the a and b paths; this correlation must be taken into account for unbiased test statistics of the mediational path (31). Therefore, the significance of the mediated effect (i.e., the ab product) was tested *via* RMediation, which produces asymmetric confidence intervals for the mediated effect, taking into account the ab correlation (32). Because the models testing mediation were fully saturated, no fit indices were available. The next-day models were similar to the same-day models with two exceptions: (1) afternoon social enjoyment and end-of-day fatigue were proposed as two sequential mediators of the relation between the same-day and next-day morning fatigue (i.e., the abc path in Figure 2); and (2) stress was not included in these models because the focus was on examining the carry-over effect from today’s enjoyment to fatigue experienced on the next morning.

Finally, we evaluated whether mediation effects were retained when other common comorbid symptoms in FM were controlled. To this end, analyses were repeated, including covariates as predictors of outcomes. In same-day analyses, covariates included reports of sleep disturbance (upon awakening), pain (7 PM), anxiety-related emotion (7 PM), and depressive symptoms (7 PM). In next-day analyses, covariates included next-day sleep disturbance (upon awakening) and pain (11 AM).

Handling missing data—Participants differed in the number of days of diary data they completed; this is comparable to having differing cluster sizes in a design with individuals clustered within groups. Furthermore, on any day on which a participant responded to the diary, she might have failed to respond at all time points. Full information maximum likelihood (FIML) was employed to estimate models with missing data. The full information maximum likelihood estimation via an accelerated EM algorithm routine used in *Mplus* version 7 is robust to nonnormality, missing data, and unbalanced cluster size of data (29, 33).

RESULTS

Sample Characteristics

The 176 women included in the current study were on average 52.44 years of age ($SD = 9.84$; range from 28 to 72). The majority of the participants were married or partnered (58%), Caucasian (80%), attended at least 1–3 years of college (74%), and had an annual household income greater than \$30,000 (60%). Half the participants were employed (50%).

Data Completion Rate

Across the 21 days of the protocol, partnered participants provided 92.1% of morning fatigue reports and 90.1% of end-of-day fatigue reports of a possible 2142 reports. Partnered participants reported that they had contact with their spouses on 50% out of the possible 2142 afternoon assessments of spouse contact, and in these instances, reported on social enjoyment and stress 99.8% of the time. Partnered participants reported that they had contact with family, friends, or co-workers on 47% of the possible 2142 afternoon assessments, and in these instances, reported on social enjoyment and stress 100% and 99.6% of the time, respectively. Across the 21 days of diaries, unpartnered participants provided 89.5% of the morning fatigue reports and 85.1% of the end-of-day fatigue reports of a possible 1554 reports. Unpartnered participants reported that they had contact with family, friends, or coworkers on 54% of the possible 1554 afternoon assessments, and in these instances, reported on social enjoyment and stress 99.9% and 99.8% of the time, respectively. The percentages of reports received regarding morning and end-of-day fatigue, contact, and enjoyment and stress were comparable across spousal and non-spousal domains for the partnered and non-partnered subsamples. The range of days on which participants provided at least one report was 10 to 21 days.

Descriptives, Intraclass Correlations (ICCs), and Within-person Correlations

The partnered and unpartnered sub-samples of women were comparable on multiple aspects of model constructs in the non-spousal domain—morning and end-of-day fatigue and average afternoon social enjoyment and stress. These aspects included comparable variable distributions, ICCs (i.e., assessment of extent of between-person differences), and pooled within-person correlations on model constructs. Hence, the non-spousal domain enjoyment and stressfulness ratings of the 102 partnered women and 74 non-partnered women were combined in subsequent analyses. In the sample as a whole, fatigue ratings were similar in the morning ($M = 51.64$, $SD = 25.73$, $ICC = .51$) and at end-of-day ($M = 54.52$, $SD = 24.58$, $ICC = .56$). With regard to non-spousal domain ratings, enjoyment ($M = 3.40$, $SD = 1.15$, $ICC = .37$) was higher and less variable than stress ($M = 1.89$, $SD = 1.14$, $ICC = .27$). Likewise, for the 102 partnered women, spousal domain ratings of enjoyment ($M = 3.46$, $SD = 1.24$, $ICC = .39$) also were also higher and less variable than stress ($M = 1.68$, $SD = 1.15$, $ICC = .22$). Table 1 shows the pooled within-person correlations for the entire sample for the non-spousal domain, and the partnered subsample for the spousal domain. Corresponding correlations were comparable across domains, with slightly stronger correlation between social enjoyment and end-of-day fatigue in the non-spousal than spousal domains ($-.159$ versus $-.102$, respectively).

Same-day Analyses of Relation from Morning Fatigue to Afternoon Social Enjoyment and Stress to End-of-day Fatigue

A series of MSEMs were conducted to examine the relations among morning fatigue, afternoon social enjoyment and stress, and end-of-day fatigue of the spousal and non-spousal domains for the partnered subsample and the combined sample (see Figure 1). Figure 3 presents the within-person results in the non-spousal domain for the combined sample, which were consistent with our five predictions. 1) Days of lower morning fatigue predicted higher levels of afternoon social enjoyment, a_1 path ($p < .001$), which, in turn, 2) predicted lower levels of end-of-day fatigue, b_1 path ($p < .001$). 3) The relation between morning and end-of-day fatigue was significantly mediated by afternoon social enjoyment ($ab = .011$, $SE = .004$, $p < .01$), reflected in the asymmetric confidence intervals of the mediated path of enjoyment [.006, .018], taking into account the correlation between the a and b paths of .040. Of note, this mediated effect remained significant after incorporating same-day reports of sleep disturbance, pain, anxiety-related emotion, and depressive symptoms as covariates ($ab = .006$, $SE = .003$, $p < .05$). 4) In contrast, social stress did not serve as a mediator between morning and end-of-day fatigue, as neither the a_2 nor b_2 path achieved significance (see Figure 3). Of note, the significant mediated effect of afternoon social enjoyment was obtained even with afternoon social stress modeled as a second mediator. 5) Moreover, a contrast between the mediated paths through enjoyment versus stress showed that enjoyment was a significantly stronger mediator than stress (Est. = .010, $SE = .004$, $p = .006$).

Figure 4 presents the within-person results in the spousal domain for the partnered sample. Data were consistent only with hypothesis 1; lower morning fatigue was significantly associated with higher levels of afternoon social enjoyment, a_1 path ($p < .05$). The path from afternoon social enjoyment to end-of-day fatigue (i.e., b_1 path) was negative, as hypothesized, but nonsignificant. Consequently, the morning fatigue—afternoon enjoyment—end-of-day fatigue mediational chain was not significant within the spousal domain for partnered women.

Next-day Analysis of Relation from Morning Fatigue to Afternoon Social Enjoyment to End-of-day Fatigue on the Same Day to Morning Fatigue on the Next Day

The same-day within-person analyses revealed that afternoon social enjoyment in the non-spousal domain was a mediator between morning and end-of-day fatigue in the combined sample. We next examined whether the mediational chain from morning fatigue to afternoon social enjoyment in non-spousal domain to end-of-day fatigue on the same day predicted next-morning fatigue (Figure 2).

The findings were consistent with our predictions. Days of lower morning fatigue predicted higher levels of afternoon social enjoyment ($a = -.006$, $SE = .001$, $p < .001$), which, in turn, predicted lower levels of end-of-day fatigue ($b = -1.894$, $SE = .426$, $p < .001$). Importantly, days of lower levels of end-of-day fatigue, in turn, predicted lower levels of next-morning fatigue ($c = .142$, $SE = .028$, $p < .001$). The mediational chain from morning fatigue to afternoon social enjoyment to end-of-day fatigue on the same day to next-morning fatigue was significant ($abc = .001$, $SE = .001$, $p < .05$). This mediational chain remained significant

after including next morning report of sleep disturbance on the previous night and next morning experience of pain as covariates ($abc = .001$, $SE = .001$, $p < .05$).

DISCUSSION

This study investigated the dynamic relation between fatigue and social enjoyment both within-day and across days in women with FM. Three aspects of this examination were especially novel: (1) the focus on the influence of positive social engagement in mitigating fatigue above and beyond the detrimental effect of negative social engagement in FM women; (2) a temporal ordering of the assessments within a day that allowed for evaluation of a potential psychosocial mechanism associated with the cycle of FM fatigue; and (3) an evaluation of the carry-over effect of enjoyment on fatigue from one day to the next.

The current findings revealed that positive social engagement, at least with friends, family, and co-workers, interrupts the cycle of fatigue from morning to the end-of-day. These findings are consistent with existing evidence indicating that lower levels of morning fatigue are associated with a greater likelihood of achieving of social goals reported in the evening among individuals with FM (20). They further suggest that enjoyment may be a key affective mechanism linking social engagement with lower fatigue reported several hours later. Importantly, daily social enjoyment remained a significant mediator after including daily social stress as a second mediator in the model. Moreover, enjoyment showed a stronger relation than did stress with subsequent fatigue within a day in individuals with FM, indicating that boosting positive social engagement may have a more potent impact than does diminishing negative social engagement on later fatigue.

One unexpected finding in the current study is that the mediating effect of spousal enjoyment on the relation between morning and end-of-day fatigue did not reach statistical significance. What can account for the discrepant findings between the spousal and nonspousal domains? Inspection of the patterns of the relations between fatigue and spousal enjoyment (i.e. the a and b paths) indicate that they generally were similar to those obtained from the non-spousal domain. However, the lack of significance in the relations both between morning fatigue and afternoon social enjoyment (a path), and between afternoon social enjoyment and end-of-day fatigue (b path) in the spousal domain may indicate that these relations are more heterogeneous in the spousal than non-spousal domain. A significant body of evidence points to the importance of the quality of spousal relations as a key determinant of their health-related effects; unsatisfying relations have deleterious effects whereas satisfying relations have beneficial effects (34, 35). Thus, future work elaborating the effects of spousal relations on within-day changes in fatigue may benefit from testing relationship satisfaction as a time-invariant moderator of the a and b paths in mediation models. Because such tests of moderated mediation require large sample sizes, we were unable to determine whether relationship quality could account for the less robust role of spousal versus nonspousal enjoyment as a factor influencing within-day fatigue.

A question that often arises when evaluating intensive covariation in diary data is to what extent relations are sustained over time. In the current study, consistent with our predictions, the alleviation of end-of-day fatigue brought about by afternoon social enjoyment was

sustained to the next morning. The broaden-and-build theory of positive emotion of Fredrickson (36) provides some clues regarding how social enjoyment helps limit the cycle of fatigue both within-day and from one day to the next in FM. This theory suggests that social enjoyment facilitates cognitive processing and adaptive coping, such as benefit finding, which, in turn, builds resources that subsequently replenish energy (36, 37). To continue to advance our understanding of the links between fatigue and social enjoyment over time, it is important to incorporate measures of theoretically-derived intervening cognitive and affective processes in future work.

It is noteworthy that the carry-over effect of today's social enjoyment to lower feelings of fatigue on the next day stands in contrast to findings reported in a prior study linking positive social events with greater next-day fatigue in FM (17). What may account for these contradictory findings? The most likely explanation is the difference in the time frame of assessment between the studies. In Parrish et al. (17), both positive events and next-day fatigue were measured at bedtime. Thus, an intervening period of 24 hours separated each assessment of today's positive events and next-day fatigue. Variations in fatigue among individuals with chronic pain occur within a day, with some circadian influences that cannot be captured by assessments every 24 hours (38). In the present study, social enjoyment was measured in the afternoon of one day and fatigue was measured in the morning on the next day. The intensive temporal spacing of the assessments of the constructs in the current study provides a more fine-grained approach to capturing the variability in fatigue and discerning the dynamic relations between today's enjoyment and next-morning fatigue.

Several limitations in the current study deserve comment. First, the morning and afternoon diary measures assessed the participants' experiences during the three-hour period prior to the automated calls. Hence, morning measures had no temporal overlap with afternoon measures, but the end-of-day measures assessed the participants' overall experiences during the entire day. Thus, end-of-day measures had temporal overlap with morning and afternoon measures. To adjust for potential bias, we adopted an ANCOVA approach allowing a direct path from morning to end-of-day fatigue to be estimated. This path controlled for the variance in end-of-day fatigue accounted for by morning fatigue (39). Nevertheless, future studies may consider limiting the end-of-day measures to the participants' experience during the three hours prior to bedtime.

Second, the current study focused exclusively on women because we only had a small number of male participants, consistent with much lower prevalence of FM among men relative to women (3). Previous studies have found a few gender differences in the links between psychosocial factors and fatigue among individuals with chronic pain. For example, women vs. men with RA show a stronger within-person relation between positive interpersonal engagement and lower same-day fatigue (15). Additional work explicitly designed and powered to test for the moderating effect of gender on the links between positive social engagement and fatigue would provide important evidence regarding the generalizability of the current findings to men with FM and other chronic pain conditions.

Last but not least, because this study was observational, we cannot comment on the causal links between positive social engagement and fatigue. Temporal precedence is established

by the sequence of within-day measures. Yet experimental manipulation of positive interpersonal experiences is a necessary condition to establish a causal relation between fatigue and enjoyment. Exciting advances in technology make it possible to both test that causal association in a within-day time frame, and provide some evidence of the potential clinical utility of such a manipulation. One manipulation, for example, might involve randomly assigning individuals to a daily intervention that focuses exclusively on boosting afternoon social enjoyment *vs.* a neutral control condition and assessing subsequent fatigue among individuals with FM.

Fatigue is a clinically meaningful and often frustrating symptom of FM with relatively few treatment options. Findings from a recent meta-analysis showed that cognitive-behavioral therapy, the most promising approach to date, showed no significant effects on fatigue in FM (40). The current findings point to the possibility that positive social engagement offers some relief from FM fatigue that carries over from one day to the next. In addition, this study points to the importance of positive cognitive-affective experiences of interpersonal relations. These experiences are more readily accessible than are actual interpersonal events (e.g., going to lunch with friends), particularly when individuals are fatigued. Thus, including a focus on fostering individuals' ability to seek and savor enjoyment in social relations in current treatment approaches has the potential to add to the current clinical armamentarium. Of course, establishing the causal relation between enjoyment and fatigue is a critical step going forward. Nevertheless, the accruing evidence points to the value of attending to positive social engagement in the management of daily FM fatigue.

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards: Authors Wan, Davis, Aiken, and Tennen declare that they have no conflict of interest. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

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Figure 1. Model depicting the hypothesized relations among morning fatigue, afternoon social enjoyment and stress, and end-of-day fatigue on the same day.

Figure 2.

Model depicting the hypothesized relations among morning fatigue, afternoon social enjoyment and end-of-day fatigue on the same day, and morning fatigue on the next day.

Figure 3.

The parameter estimates and standard errors (in parentheses) of the direct effects of within-person mediation model of afternoon social enjoyment and stress in the non-spousal domain as the mediators between morning and end-of-day fatigue for 176 partnered and unpartnered FM patients are reported in the figure.

The indirect effects were as following:

$a_1b_1 = .011$, $SE = .004$, $p < .01$, Asymmetric CI = [.006, .018];

$a_2b_2 = .000$, $SE = .001$, $p > .05$, Asymmetric CI = [-.001, .002];

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 4.

The parameter estimates and standard errors (in parentheses) of the direct effects of within-person mediation model of afternoon social enjoyment and stress in the spousal domain as the mediators between morning and end-of-day fatigue for 102 partnered FM patients are reported in the figure.

The indirect effects were as following:

$a_1b_1 = .003$, $SE = .002$, $p > .05$, Asymmetric CI = $[-.001, .009]$;

$a_2b_2 = .000$, $SE = .001$, $p > .05$, Asymmetric CI = $[-.001, .002]$;

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 1

Within-person correlations among morning and end-of-day fatigue, and afternoon social enjoyment and stress in the spousal domain for the partnered subsample (below the diagonal) and the non-spousal domain for the partnered and non-partnered subsamples, i.e. combined sample (above the diagonal)

Variables	1	2	3	4
1. Morning Fatigue (Predictor)	-	-.108	-.017	.459
2. Afternoon Social Enjoyment (1 st Mediator)	-.086	-	-.297	-.159
3. Afternoon Social Stress (2 nd Mediator)	.023	-.291	-	.012
4. End-of-day Fatigue (Outcome)	.471	-.102	.031	-

Note. Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in *Mplus*.