Published in final edited form as:

J Behav Med. 2015 December ; 38(6): 944–955. doi:10.1007/s10865-015-9651-4.

The effects of daily mood and couple interactions on the sleep quality of older adults with chronic pain

Sunmi Song¹, Jennifer E. Graham-Engeland², Jacqueline Mogle³, and Lynn M. Martire⁴

¹Social and Behavioral Research Branch, National Human Genome Research Institute, National Institutes of Health, Room B1B36, Building 31, 31 Center Dr, MSC 2073, Bethesda, MD 20892-2073, USA

²Department of Biobehavioral Health, The Pennsylvania State University, University Park, PA, USA

³The College of Nursing, The Pennsylvania State University, University Park, PA, USA

⁴Department of Human Development and Family Studies, The Pennsylvania State University, University Park, PA, USA

Abstract

We examined the effect of daily negative and positive mood on the sleep quality of knee osteoarthritis (OA) patients ($N = 152$) and whether a partner's daily responses to a patient's pain behaviors moderated these associations. Patients and their partners completed a baseline interview and 22 daily diary assessments. After controlling for demographic characteristics, OA severity, comorbidities, medication use, relationship satisfaction, and depressed mood, multilevel modeling analyses demonstrated main effects of negative and positive mood on sleep quality indicators. Mood and partner responses interacted such that high solicitous and punishing responses strengthened the association between negative mood and worse sleep. Further, high solicitous responses increased the degree of association between low positive mood and poor sleep, and empathic responses combined with positive mood were associated with better sleep. Results demonstrate that daily negative and positive mood fluctuations can interact with partner responses to affect sleep quality among older adults with chronic pain.

Keywords

Daily diary; Mood; Couple interactions; Sleep quality; Chronic pain

In the United States, 27 million adults have osteoarthritis (OA), and nearly half of adults are likely to develop knee OA in their lifetime (Lawrence et al., 2008; Murphy et al., 2008). OA causes loss of function and disability and is the second leading cause of work disability

Correspondence to: Sunmi Song.

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights and Informed consent All procedures followed were in accordance with the ethical standards of the responsible committees on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent for inclusion in the study was obtained from all patients and their partners.

among adults over 50 years old in the US (Arden & Nevitt, 2006). Due to the pain and disruption in daily life by OA, individuals with OA often experience emotional distress and sleep disturbances and depend on the support of a partner to help them cope (Leonard et al., 2006). Sleep is a critical outcome for individuals with chronic pain because sleep disturbances increase pain sensitivity and risk for pain-related disability, depression, and overall health problems (Campbell et al., 2013; Naughton et al., 2007; Smith & Haythornthwaite, 2004). Although a few studies have shown an association between daily mood and sleep quality among adults with and without chronic pain (Hamilton et al., 2008; Totterdell et al., 1994), very little research has examined how mood and social interactions with a partner jointly affect daily sleep quality of chronic pain patients, despite growing evidence that interconnections between mood and social interactions with a partner may affect sleep. The aim of the present study is to examine the degree to which daily couple interactions moderate the association between daily mood and nightly sleep quality among older adults with OA.

A number of studies focused on the effects of mood on both pain and sleep suggest that daily negative and positive mood are likely to affect sleep in different ways. Greater anxiety and fear about pain is associated with greater pain and sleep disturbances among chronic pain patients (Morin et al., 1998). Short-term mood changes are also known to affect pain perception among those with chronic pain, and short-term changes in pain in turn appear to affect daily sleep (Alsaadi et al., 2014; Newth & Delongis, 2004; Zautra et al., 2001, 2005). Also, daily pain ratings and negative mood are associated with the night's poor sleep among adults with back pain, facial pain, and fibromyalgia syndrome (FMA) (Alsaadi et al., 2014; Hamilton et al., 2008; O'Brien et al., 2011). Taken as a whole, these studies suggest that daily negative mood may contribute to disturbed sleep, whereas daily positive affect may lead to improved sleep.

Based on several lines of research, it seems likely that specific patterns of partner behavior also have substantial effects on the sleep quality of chronic pain patients as well as that of their partners (Leonard et al., 2006; Martire et al., 2013). First, individuals with pain who receive supportive and empathic responses from their partner when they express pain or exhibit pain behavior (such as grimacing or complaining) are likely to have reduced stress and better health behaviors (Cano et al., 2008; Goubert et al., 2005). Second, partners' solicitous responses to pain behaviors—characterized by helping behaviors, such as obtaining the patient's medication and taking over tasks—are associated with more observed pain behaviors and more severe pain intensity (Turk et al., 1992). Although often well intentioned, solicitous partner behaviors can also lead to mixed emotional responses on the part of the patient, who may feel cared for but also guilty for becoming a burden on the support provider (Newton-John & Williams, 2006). Finally, a partner might respond to a patient's pain behaviors with "punishing responses", which include ignoring and angry or irritated reactions. Punishing responses are likely to trigger psychological distress, pain, and less adaptive health behaviors (Leonard et al., 2006). Poorer sleep may thus result from either solicitous or punishing responses—the former because they can elicit increased pain behaviors and mixed emotional reactions and the latter because the individual experiencing pain does not have the opportunity to disclose their pain in a way that feels validated and supported.

Mood and social interactions may dynamically interact to affect sleep quality. Negative social interactions within intimate relationships between healthy adults are associated with negative mood and subsequent onset of depression, which, in turn, is linked with disturbed sleep (Joiner & Timmons, 2009; Morin et al., 1998; Schuster et al., 1990). Ongoing social interactions can either amplify or reduce the degree to which positive and negative moods influence the stress reactivity of the body, which can also affect sleep (Cohen, 2004). For example, individuals with rheumatoid arthritis (RA) reported greater emotional disturbances in response to daily stressful events if they perceived less social support (Affleck et al., 1994). Also, daily perceived social support predicted lower levels of negative mood the next day and weakened the association between daily pain and negative mood the next day (Feldman et al., 1999). Thus, previous studies suggest that mood and social relationship dynamics are likely to interact to affect sleep of those with chronic pain.

Purpose of the present research

The present study examines whether daily negative and positive mood at the end of day affects the nightly sleep (quality, and feeling refreshed) of older adults with knee OA and how this association is further influenced by three different types of daily partner responses to pain behaviors: solicitous, punishing, and empathic. We expected that daily negative mood at the end of day would predict worse reported sleep that night, whereas daily positive mood at the end of day would predict better sleep. We hypothesized that partner responses would moderate the association between daily mood and sleep such that daily solicitous and punishing responses from the partner would amplify the effect of daily negative mood on sleep whereas daily empathic responses from the partner would reduce the effect of daily negative mood on sleep. Interactions between daily positive mood and the partner's responses were examined on an exploratory basis due to a dearth of previous studies. We utilized partners' reports of their own behaviors in response to patients' pain rather than patients' reports of their partners' responses for several reasons. Although previous research has shown an association between chronic pain patients' perception of support from their partner and health outcomes (Leonard et al., 2006), there appears to be a discrepancy between the patient's perception of support from their partner and the support reported by partners themselves (Cano et al., 2004). A patient's daily reports on partner response are likely biased by the patient's mood that is assessed at the same moment. In addition, using partner's report enables us to capture the partner behavior that is helpful but not perceived by patients, which is known to be more effective in reducing emotional distress of a spouse (Bolger et al., 2000).

Method

Study design

The data used in the present study were derived from a larger study of older adults with knee OA and their partners (Martire et al., 2013). This larger study involved three in-person interviews and 22 days of daily diary measurements immediately after the first interview. The current research used the data from the first interview and the diary measurements.

Participants

To be eligible, patients had to have a diagnosis of knee OA by a physician, have experienced usual knee pain of moderate or greater intensity, be at least 50 years old age, and be married or in a long-term relationship in which they shared a residence with their partner. The exclusion criteria for patients included comorbidity with FMA or RA, use of a wheelchair, and a plan for hip or knee surgery within the next 6 months. Couples were also excluded from participation if their partner had a chronic pain condition, including arthritis, that resulted in moderate to severe pain (couples where the partner had mild chronic pain were included), used a wheelchair, or required assistance for personal care. Both members of the couples were cognitively functional and were free of any major hearing, speech or language problems. Participants were recruited via the research registries of rheumatology clinic patients and older adults interested in the research, flyers distributed to staff and faculty at a northeastern university in the United States, and word of mouth. Of 606 couples who were contacted, 221 couples declined to participate, and 233 couples were not eligible, primarily due to their less than moderate level of pain or no OA on their knee.

Of the 152 couples, 143 completed the diary assessment of the study. The sample included three same-sex couples. Table 1 provides background information for patients and their partners. Patients reported a mean osteoarthritis severity of 36.54 ($SD = 15.42$) on Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC; Bellamy et al., 1988), which is scaled 0–100 with higher numbers signifying greater severity; The mean 36.54 is close to a cutoff score of 39 that indicates potential for arthroplasty (Hawker et al., 2000). Consistent with previous research on sleep quality in hip or knee OA patients (Hawker et al., 2010), baseline sleep quality of patients was 7.1 ($SD = 4.2$; range 0–18) on the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989): 70 % met criteria for poor sleep (i.e., PSQI global score of >5), and 10.5 % reported using medication for sleep, such as benzodiazepines and non-benzodiazepine sleep aids (e.g., Ambien). For pain medication use, 65.5 % of patients reported using nonsteroidal anti-inflammatory drugs (NSAIDs), and 11.8 % using opioids. Baseline depressed mood of patients was 6.59 ($SD = 5.28$; range 0–23) on the brief version of the Center for Epidemiological Studies Depression Scale (brief CES-D; Andresen et al., 1994), with 21.7 % meeting criteria for depressed symptoms based on the recommended cutoff score of 10. Couples reported high levels of marital satisfaction on average ($M_{Patient} = 39.61$, $SD = 6.26$; $M_{Spouse} = 38.94$, $SD = 6.47$) using the 10-item dyadic satisfaction subscale (range 0–50) of the Dyadic Adjustment Scale (Spanier, 1976).

Procedures

A trained research assistant visited the participating couples in their homes and conducted separate interviews of the patient and the partner. During the interviews, couples were asked to respond to a set of questionnaires to measure health status, physical comorbidity, and arthritis symptoms. Couples were also trained to use a hand-held computer (a Palm TX with Satellite Forms software, Thacker Network Technologies Inc., Canada), clearly labeled with each participant's name for daily diary measurements. Participants were asked to respond to the diary questionnaires three times each day: (1) within 60 min of rising in the morning (the beginning of day, BOD); (2) between 2:00 and 4:00 p.m., and (3) upon retiring at night (the end-of-day, EOD). Current mood and level of pain were assessed three times each day, but

only the EOD reports were used in the current research. Social interactions with the partner were measured at the EOD survey. Participants reported on the previous night's sleep at the BOD survey. Couples were instructed to provide responses independent of their partners.

Completion and compliance rates were examined for the diary data. Of a potential 3146 EOD observations (143 individuals $\times$ 22 days), a total of 2297 were completed (73.01 %). Compliance with the requested timing of the EOD assessment was evaluated by comparing the time of the handheld computer entries with participants' written log of daily bedtimes. EOD assessments of patients and partners that were completed more than 120 min before bedtime and BOD assessments that were completed more than 120 min after waking were excluded from analysis. We also excluded observations with missing data from the partner (when examining partner response variables) or missing data that caused a gap between the EOD assessment and the subsequent BOD assessment of patients. For example, if participants had the EOD on day 1 but no BOD assessment on day 2 we had to exclude them due to the lagged nature of the sleep analyses. Using these criteria, 1607 ($N = 134$) of the 2297 completed observations were included in analyses of patient reports (i.e., 69.7 % of the completed observations or 51.08 % of the total possible observations) and 1548 ($N = 134$) in analyses of both patient and partner reports.

Measures

Positive and negative mood—Daily positive and negative mood was measured at the end of the day with 9 item-adjective mood ratings (Thomas & Diener, 1990). Patients were asked to what extent they had each of four positive (e.g., felt happy, joyful, pleased, and enjoyment) and five negative moods (e.g., felt depressed or blue, frustrated, angry, unhappy, and worried or anxious) over the past 30 min on a 6-point scale from not at all to extremely. The sum of four items assessing positive mood and five items assessing negative mood was calculated.

Partner's responses to pain behaviors—At the end of the day, partners were asked to report their use of three different types of responses to the patient's pain behaviors (i.e., solicitous, punishing, and empathic) using a three-point scale with 1 = not at all, 2 = somewhat, and 3 = very much. The six items for solicitous (e.g., today, you took over your partner's jobs or duties to help him/her avoid pain) and punishing (e.g., today, you got frustrated with your partner when he/she seemed to be in pain) responses were modified from the subscales of the West Haven-Yale Multidimensional Pain Inventory (Kerns et al., 1985), and the three items for empathic responses (e.g., today you showed your partner that you knew how the pain made him/her feel) were modified from a questionnaire developed by Stephens and colleagues (Stephens et al., 2006).

Sleep quality—Daily sleep quality was measured upon awakening with two items. The first item was adapted from the validated sleep quality item in the PSQI (Buysse et al., 1989), which asks, "How would you rate the quality of your sleep last night?" on a scale from 0 = very good to 3 = very bad. The second item rated "how refreshing sleep was the night before?" on a scale of 0 = not at all to 6 = extremely. The second item has been

validated as a global assessment measure of good sleep related to sleep continuity and efficiency (Åkerstedt et al., 1994).

Covariates—The control variables for the present study include age, gender, body mass index (BMI), years of education, number of comorbid conditions, use of pain medication and sleep medication, duration of knee OA, OA severity (WOMAC), marital satisfaction, duration of the relationship, baseline depressed mood (brief CES-D), and daily pain. All covariates except daily pain were assessed at the baseline interview. Comorbid conditions were measured by 24 questions asking participants if they had ever been told that they had chronic conditions, such as cardiovascular, respiratory, and digestive diseases. The number of existing conditions was summed. Using patients' medication log at the baseline, the use of pain medication was coded with two variables: use of NSAIDs and use of opioids, both coded as usage = 1 or no usage = 0, and sleep medication use was also coded as usage = 1 or no usage = 0. Daily levels of pain were assessed at the end of the day by asking patients how they would describe the pain/tenderness in 10 joints in the past 30 min on a 4-point scale from 0 = none to 3 = severe based on the Rapid Assessment of Disease Activity in Rheumatology (Mason et al., 1992).

Data analysis

Following the descriptive analyses and within-dyad correlations of key variables, multilevel modeling analysis (MLM) was used to examine daily fluctuations in mood, the partner's responses to pain behaviors, and sleep quality over time using SAS PROC MIXED (SAS Institute, Cary, NC). The application of MLM analysis of diary data enables the determination of the antecedents and correlates of daily health status and the use of participants as their own controls (Raudenbush & Bryk, 2002).

In the multilevel models, the Level 1 equation examined whether daily negative or positive mood predicts daily sleep quality and refreshing sleep and whether each of the three daily levels of partner responses moderate the association between mood and sleep. To examine the main effect of mood on two sleep measures, the main effect models for mood included daily negative or positive mood as a Level 1 predictor and daily sleep quality or feeling refreshed after sleep as a dependent variable. The interaction between mood and partner responses was examined by adding the interaction term between negative or positive mood and one of the three partner responses to the equation of the Level 1 of the main effect models. If there was a significant interaction effect, the pattern of the interaction was further examined by comparing the slope estimate and the standard error of negative or positive mood while fixing the partner response at 1 standard deviation (SD) above and below the mean of each individual. In all MLM analyses in this study, the Level 2 equations included the between-person control variables such as demographic variables and OA severity. Daily pain was also controlled in the analyses and was entered at Level 1. The control variables were retained in the final model only if they were significantly associated with sleep outcomes. Daily measures were within-person centered and Level 2 covariates were grand mean centered. The responses of each dyad of a couple were linked in the analyses of partner responses.

To demonstrate the magnitude of the significant effects of mood and partner responses to daily sleep, we conducted supplementary analyses using multilevel ordinal logistic regression (Hedeker et al., 2009). These analyses treated sleep outcomes as a set of ordered categories to demonstrate how one SD increase in patient negative or positive mood and/or one SD increase in one of the three partner responses to pain are related to the odds ratio decrements or increments in patients' sleep quality.

Results

Preliminary analysis

Descriptive statistics for daily diary variables indicated that knee OA patients reported fairly good sleep quality ($M = 0.97$, $SD = 0.43$ on a scale 0 = very good to 3 = very bad) and feeling moderately refreshed after sleep ($M = 3.57$, $SD = 1.01$) across days. Levels of average daily positive mood were higher than levels of average negative mood ($M = 10.81$, $SD = 5.69$; $M = 2.50$, $SD = 3.62$, respectively). Partners reported using daily empathic responses most frequently ($M = 5.24$, $SD = 3.62$), followed by solicitous and punishing responses ($M = 4.41$, $SD = 1.15$; $M = 3.26$, $SD = 0.62$, respectively). Patients reported daily experiences of pain and tenderness with mean levels of 5.88 ($SD = 4.73$, range 0–30).

The within-dyad correlations were estimated among the key daily measures to determine the extent to which daily variables covaried within the same individual or couple across days. As shown in Table 2, significant correlations were observed between daily negative and positive mood ($r = -0.42$, $p < 0.01$), between partner's solicitous and empathic responses ($r = 0.40$, $p < 0.01$), and between sleep quality and feeling refreshed after sleep ($r = -0.65$, $p < 0.01$). In addition to correlations on Table 2, correlations between patient's perceived levels of the three partner responses and the key daily measures were examined. The correlations between patients' perceived and partner's self-report on partner responses were $r = 0.29$ for solicitous, $r = 0.06$ for punishing, and $r = 0.22$ for empathic response (p values < 0.01). Patient's perception of solicitous responses was associated with daily pain ($r = 0.12$, $p < 0.01$). Patients' perception of punishing responses was also associated with positive ($r = -0.11$, $p < 0.01$) and negative mood ($r = 0.17$, $p < 0.01$) and perception of empathic responses was associated with positive mood ($r = 0.12$, $p < 0.01$) and daily pain ($r = 0.12$, $p < 0.01$).

Main effects of daily negative and positive mood on sleep

There were significant main effects of negative mood on both sleep measures and of positive mood on feeling refreshed after sleep. Daily negative mood was associated with poorer daily sleep quality (estimate = 0.02, $p < 0.05$) and refreshing sleep (estimate = -0.02 , $p < 0.05$) after controlling for covariates. The supplementary logistic regression showed that on days when patients experienced one SD higher level of negative mood than usual, the odds of having poor sleep and less refreshing sleep increased by 11.7 and 9.8 % respectively. Daily positive mood was associated with feeling more refreshed after sleep (estimate = 0.03, $p < 0.001$), such that on days when patients experienced one SD higher level of positive mood than usual, the odds of having more refreshing sleep increased by 19.9 %. Among the covariates, the baseline depressed mood was associated with poorer sleep quality (estimate =

0.02, $p < 0.01$) and more refreshing sleep (estimate = -0.08 , $p < 0.01$), and the use of pain medication (NSAIDs) was associated with less refreshing sleep (estimate = -0.34 , $p < 0.05$).

Interaction between daily mood and partners' responses to pain

Interaction between daily mood and solicitous responses to pain—Table 3 presents the estimates and standard errors of all the tested interaction models for sleep outcomes. As expected, interactions were found between daily negative mood and solicitous responses in predicting sleep quality (estimate = 0.01 , $p < 0.05$) and feeling refreshed after sleep (estimate = -0.03 , $p < 0.05$). Figure 1a, b shows that patients' daily negative mood was more strongly associated with daily sleep quality or refreshing sleep when they received more solicitous responses than when received less solicitous responses. The odds of patients having poor sleep quality and less refreshing sleep further increased by 10 and 9.6 % with one SD increase in both daily negative mood and partner solicitous responses.

In addition, there were interactions between daily positive mood and daily solicitous responses for predicting sleep quality (estimate = -0.01 , $p < 0.05$) and marginally predicting feeling refreshed after sleep (estimate = 0.02 , $p = 0.06$). As shown in Fig. 1c, d, daily solicitous responses appear to amplify the negative effects of low positive mood on two sleep indicators. When patients experienced less positive mood and received more solicitous responses than usual, they reported worse sleep quality and feeling less refreshed after sleep. With one SD decrease in daily positive mood and one SD increase in solicitous response, the odds having poor sleep quality and less refreshing sleep were decreased by 10.9 and 18.1 %, respectively.

Interaction between daily mood and punishing responses to pain—There was a marginally significant interaction between daily negative mood and punishing responses on feeling refreshed after sleep (estimate = -0.04 , $p = 0.06$). Figure 2 shows that, as predicted, daily negative mood was more strongly associated with a less refreshed feeling after sleep on the days when patients received more than the average punishing responses from their partners. With one SD increase in both daily negative mood and punishing response, the odds of having refreshing sleep were decreased by 9.3 %. The interaction was not significant for sleep quality. Punishing responses did not moderate the associations between daily positive mood and the two sleep indicators.

Interaction between daily mood and empathic responses to pain—Empathic responses significantly interacted with positive mood to affect sleep quality (estimate = 0.01 , $p < 0.05$). As shown in Fig. 3, there was a significant association between positive mood and sleep quality only when patients received more empathic responses than usual. Patients showed an 11.1 % decrease in the odds of having poor sleep quality with one SD increase in both daily positive mood and daily empathic responses from their partners. The interaction between positive mood and empathic responses did not significantly predict feeling refreshed after sleep, and empathic responses did not moderate the associations between daily negative mood and sleep indicators.

Discussion

Based on daily diary surveys of chronic pain patients and their partners over a 22-day period, the current research examined how the daily negative and positive mood of chronic pain patients and three different partner responses to pain (solicitous, punishing, and empathic responses) predicted two indicators of sleep (self-reported sleep quality and feeling refreshed after sleep) among patients. Higher than average daily negative mood was associated with poorer sleep quality and less refreshing sleep, whereas higher than average daily positive mood was associated with more refreshing sleep. All of these effects were amplified on days when the patient's partner reported providing a greater than usual amount of solicitous behavior in response to pain expression. Further, daily negative mood was more strongly associated with feeling less refreshed when patients received more punishing responses from the partner, (although this effect became marginal after adjusting for covariates), whereas daily positive mood was more strongly associated with better sleep quality on days when patients received more empathic responses. Overall, the results demonstrate that the daily mood of chronic pain patients and the manner in which their romantic partners respond to their pain behavior can interact to influence fluctuations in patients' sleep across days. Although the magnitude of effects is small, these effects are specific to the timeframe of on any given day and the subsequent day. That is, on any given day mood combined with partner response predicted the likelihood of poorer sleep. Over time, poor sleep can accumulate to have a significant impact on daily functioning (Smith & Haythornthwaite, 2004). Given that the majority of the present sample (70 %) met criteria for poor sleep at baseline, the small but repeated daily sleep disturbances shown here may have a clinically meaningful impact on pain symptoms and daily functioning among older adults with chronic pain. Additionally the inclusion of a number of potential person-level covariates suggests these effects are not explained by any between patients' factors such as differences in age, gender, BMI, years of education, depressed mood, marital relationship quality, medication use, or disease severity.

Our finding that negative mood predicts worse sleep quality the same night is an important extension of the literature, which has demonstrated adverse effects of frequent experiences of negative mood on pain and the quality and duration of sleep among people with chronic pain (Naughton et al., 2007; Waters et al., 1993). Further, this study reveals an intra-individual association between daily mood and sleep among older adults with moderate to severe chronic pain and therefore provides more stringent evidence to suggest that experiences of daytime negative mood can carry over to the night and affect sleep quality.

Our findings for positive mood complement a smaller but growing body of literature on the impact of positive mood on pain among individuals with chronic pain conditions (Davis et al., 2014; Kothari et al., 2015). Interestingly, daily positive mood predicted feeling refreshed after sleep but did not predict sleep quality after controlling for concurrent pain symptoms and other covariates. Studies examining the concordance of subjective and objective sleep measures suggest that the subjective feeling of refreshment after sleep may indicate different patterns of sleep disturbances than evaluations of the overall quality of sleep. Feeling refreshed after sleep has been linked to sleep fragmentation, whereas subjective sleep quality is associated with total hours of sleep (Åkerstedt et al., 1997). Thus, daily experiences of

positive mood are likely to be associated with better and less fragmented sleep among chronic pain patients.

Our finding that solicitous responses can amplify the impact of state mood on disturbed sleep may help to advance understanding of how solicitous responses affect individuals with chronic pain. Solicitous responses are associated with pain severity and physical disability among chronic pain patients (Kerns et al., 1990; Romano et al., 1995). Receiving solicitous responses may aggravate pain by providing positive reinforcement for pain behaviors (for a review, see Leonard et al., 2006), and increased pain, in turn, may disturb sleep. Although they often are well intentioned, partner's solicitous behaviors seem to generate negative or mixed feelings in those with chronic pain. People with chronic pain would prefer to be encouraged to persist with tasks despite pain (Newton-John & Williams, 2006).

Solicitousness is also sometimes accompanied by a negative partner attitude (Newton-John & Williams, 2006), potentially sending a mixed message to the individual with chronic pain. Such behaviors might cause the patient to ruminate or experience increased anxiety, behavioral tendencies which are known to disrupt sleep among those with and without chronic pain (Smith et al., 2000; Zawadzki et al., 2013).

Interestingly, positive mood also interacted with the partner's solicitous responses such that the experience of solicitous responses strengthened the association between low positive mood and poor sleep quality. Solicitous partners' responses to chronic pain patients appear to have adverse effects on pain symptoms in the majority of research (Leonard et al., 2006). It is possible that the patients' lower than usual positive mood may have lead them to respond to partners' solicitous behavior more negatively, which further disturbed their sleep.

In addition, we found other detrimental and beneficial combinations of patients' mood and partners' responses to pain. Daily negative mood of patients was marginally more associated with feeling less refreshed after sleep when a partner provided more punishing responses than usual to a patient's pain behaviors. These results are consistent with previous research showing that receiving punishing responses from a partner in response to pain is associated with poor marital satisfaction, depressive symptoms, and pain severity in chronic pain patients (Cano et al., 2000; Flor et al., 1989; Manne & Zautra, 1990). The present results demonstrate that more than usual partner expressions of ignorance and irritation in response to a patient's pain can aggravate the impact of a patient's daily negative mood on their sleep. In contrast, daily positive mood was associated with better sleep quality when patients received more empathic responses than usual. Empathic responses to pain are associated with healthy emotion regulation and greater perceived spousal support among pain patients (Cano et al., 2008; Cano & Williams, 2010). Given the connection between a partner's empathy and emotion regulation, the results suggest that being validated for their pain experiences may enable chronic pain patients to better maintain their positive mood, leading to better sleep quality.

We observed a low correlation between patients' perception of their partner's punishing responses and the punishing responses reported by partners, which is consistent with previous research. A previous study with non-depressed pain patients and their spouses suggests that patients tend to underrate the frequency of their partner's negative responses to

their pain as compared to what partners themselves report (Cano et al., 2004). The current study showed that patients' perception of partners' punishing responses was negatively correlated with the concurrent positive mood of the patient, and both patient and partner perceptions of these punishing responses were correlated with higher negative mood of the patients. This may indicate that a patient's mood may bias him/her to perceive more or less punishing responses, or that a partner is more likely to respond in negative ways when a patient is in a more negative mood.

Limitations

As described earlier, the effects observed in the present study were small, with a 9–20 % greater chance of having poorer sleep conferred by the effects of mood and interactions with partner responses. However, the effects observed in this research may well have clinical importance given that they are within-subjects effects that likely accumulate over time. It may be viewed as a limitation that present study used subjective measures of sleep quality, which may be influenced by reporting bias and did not include objective assessments such as actigraphy or polysomnography. However, the items that were used in this study have been proven effective in identifying individuals with clinical insomnia (Alsaadi et al., 2013) and are predictive of all-cause mortality and psychological well-being (Chien et al., 2010; Kawada, 2012). Self-reported sleep is moderately correlated with physiological measures of sleep, including EEG measures of different stages of sleep and changes in body temperature during sleep (Åkerstedt et al., 1994). In an effort to reduce participant burden, patients' use of sleep and pain medication were not assessed daily but at baseline. Another limitation is that the couples in the present sample were mostly Caucasians who were in a stable relationship with high average marital satisfaction, which limits generalizability of our findings. We also did not examine alternative directions of associations between sleep, mood, and partner's response. It is important to recognize that there are multiple determinants of mood and sleep and that these are often bi-directional. For example, sleep deprivation may lead to increased negative emotional states the next day and an impaired ability to recognize and respond to other's emotion (O'Brien et al., 2011; van der Helm et al., 2010). Finally, we did not assess the utilization of Continuous Positive Airway Pressure (CPAP) utilization, which would have been a useful additional covariate as the noise of these devices can impair sleep quality of patients and partners.

Conclusion

This study examined the dynamic association of daily positive and negative mood and daily sleep quality of older adults with moderate to severe pain from knee OA, providing an in-depth analysis of how mood and relationship dynamics jointly influence sleep among older adults with chronic pain. Sleep is considered an important target for biobehavioral interventions for enhancing health and well-being of OA patients and overall physical health among older adults. The present results demonstrate that daily fluctuations in negative and positive mood among individuals with chronic pain can carry over to their night's sleep, with negative mood relating to worse sleep quality and positive mood relating to reports of more refreshing sleep. The present results further illustrate the complex ways by which partners can influence the emotional and physical health of older adults with chronic pain

with whom they live. The findings of this study suggest that daily sleep of older adults with chronic pain may be improved by helping them regulate their moods and by providing their partners with advice on how to regulate their own responses to pain behaviors to promote the health of chronic pain patients.

Acknowledgments

The present study was supported by the National Institutes of Health R01 AG026010 (L. M. Martire). The first author is currently a postdoctoral fellow at the Social and Behavioral Research Branch at the National Human Genome Research Institute and was supported by a Kligman Graduate Fellowship via the College of Health and Human Development at The Pennsylvania State University (S. Song).

References

- Affleck G, Tennen H, Urrows S, Higgins P. Person and contextual features of daily stress reactivity: Individual differences in relations of undesirable daily events with mood disturbance and chronic pain intensity. *Journal of Personality and Social Psychology*. 1994; 66:329–340. [PubMed: 8195989]
- Åkerstedt T, Hume K, Minors D, Waterhouse J. The subjective meaning of good sleep, an intraindividual approach using the Karolinska Sleep Diary. *Perceptual and Motor Skills*. 1994; 79:287–296. [PubMed: 7991323]
- Åkerstedt T, Hume KEN, Minors D, Waterhouse JIM. Good sleep—Its timing and physiological sleep characteristics. *Journal of Sleep Research*. 1997; 6:221–229. [PubMed: 9493521]
- Alsaadi SM, McAuley JH, Hush JM, Bartlett DJ, Henschke N, Grunstein RR, Maher CG. Detecting insomnia in patients with low back pain: Accuracy of four self-report sleep measures. *BMC Musculoskeletal Disorders*. 2013; 14:196–205. [PubMed: 23805978]
- Alsaadi SM, McAuley JH, Hush JM, Lo S, Bartlett DJ, Grunstein RR, Maher CG. The bidirectional relationship between pain intensity and sleep disturbance/quality in patients with low back pain. *Clinical Journal of Pain*. 2014; 30:755–765. [PubMed: 24451630]
- Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: Evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *American Journal of Preventive Medicine*. 1994; 10:77–84. [PubMed: 8037935]
- Arden N, Nevitt MC. Osteoarthritis: Epidemiology. *Best Practice & Research Clinical Rheumatology*. 2006; 20:3–25. [PubMed: 16483904]
- Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: A health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *Journal of Rheumatology*. 1988; 15:1833–1840. [PubMed: 3068365]
- Bolger N, Zuckerman A, Kessler RC. Invisible support and adjustment to stress. *Journal of Personality and Social Psychology*. 2000; 79:953. [PubMed: 11138764]
- Buyse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*. 1989; 28:193–213. [PubMed: 2748771]
- Campbell P, Tang N, McBeth J, Lewis M, Main CJ, Croft PR, Dunn KM. The role of sleep problems in the development of depression in those with persistent pain: A prospective cohort study. *Sleep*. 2013; 36:1693–1698. [PubMed: 24179303]
- Cano A, Barterian JA, Heller JB. Empathic and nonempathic interaction in chronic pain couples. *Clinical Journal of Pain*. 2008; 24:678–684. [PubMed: 18806532]
- Cano A, Johansen AB, Geisser M. Spousal congruence on disability, pain, and spouse responses to pain. *Pain*. 2004; 109:258–265. [PubMed: 15157686]
- Cano A, Weisberg JN, Gallagher RM. Marital satisfaction and pain severity mediate the association between negative spouse responses to pain and depressive symptoms in a chronic pain patient sample. *Pain Medicine*. 2000; 1:35–43. [PubMed: 15101962]

- Cano A, Williams ACdC. Social interaction in pain: Reinforcing pain behaviors or building intimacy? *Pain*. 2010; 149:9–11. [PubMed: 19892466]
- Chien KL, Chen PC, Hsu HC, Su TC, Sung FC, Chen MF, Lee YT. Habitual sleep duration and insomnia and the risk of cardiovascular events and all-cause death: Report from a community-based cohort. *Sleep*. 2010; 33:177–184. [PubMed: 20175401]
- Cohen S. Social relationships and health. *The American Psychologist*. 2004; 59:676–684. [PubMed: 15554821]
- Davis MC, Thummala K, Zautra AJ. Stress-related clinical pain and mood in women with chronic pain: Moderating effects of depression and positive mood induction. *Annals of Behavioral Medicine*. 2014; 48:61–70. DOI: 10.1007/s12160-013-9583-6 [PubMed: 24532393]
- Feldman SI, Downey G, Schaffer-Neitz R. Pain, negative mood, and perceived support in chronic pain patients: A daily diary study of people with reflex sympathetic dystrophy syndrome. *Journal of Consulting and Clinical Psychology*. 1999; 67:776–785. [PubMed: 10535244]
- Flor H, Turk DC, Rudy TE. Relationship of pain impact and significant other reinforcement of pain behaviors: The mediating role of gender, marital status and marital satisfaction. *Pain*. 1989; 38:45–50. [PubMed: 2780062]
- Goubert L, Craig KD, Vervoort T, Morley S, Sullivan MJL, Williams ACdC, et al. Facing others in pain: The effects of empathy. *Pain*. 2005; 118:285–288. [PubMed: 16289804]
- Hamilton NA, Karlson C, Luxton D, Preacher KJ, Templin JL, Affleck G, Tennen H. Fibromyalgia: The role of sleep in affect and in negative event reactivity and recovery. *Health Psychology*. 2008; 27:490–497. DOI: 10.1037/0278-6133.27.4.490 [PubMed: 18643007]
- Hawker GA, French MR, Waugh EJ, Gignac MAM, Cheung C, Murray BJ. The multidimensionality of sleep quality and its relationship to fatigue in older adults with painful osteoarthritis. *Osteoarthritis and Cartilage*. 2010; 18:1365–1371. [PubMed: 20708004]
- Hawker GA, Wright JG, Coyte PC, Williams JI, Harvey B, Glazier R, Badley EM. Differences between men and women in the rate of use of hip and knee arthroplasty. *New England Journal of Medicine*. 2000; 342:1016–1022. [PubMed: 10749964]
- Hedeker D, Demirtas H, Mermelstein RJ. A mixed ordinal location scale model for analysis of Ecological Momentary Assessment (EMA) data. *Statistics and its Interface*. 2009; 2:391–401. [PubMed: 20357914]
- Joiner, TE., Timmons, KA. Depression in its interpersonal context. In: Gotlib, IH., Hammen, C., editors. *Handbook of depression*. New York, NY: The Guilford Press; 2009. p. 322–340.
- Kawada T. Feeling refreshed by sleep can predict psychological wellbeing assessed using the General Health Questionnaire in male workers: A 3-year follow-up study. *Psychiatry Investigation*. 2012; 9:418–421. [PubMed: 23251209]
- Kerns RD, Haythornthwaite J, Southwick S, Giller EL. The role of marital interaction in chronic pain and depressive symptom severity. *Journal of Psychosomatic Research*. 1990; 34:401–408. [PubMed: 2142961]
- Kerns RD, Turk DC, Rudy TE. The west haven-yale multidimensional pain inventory (WHYMPI). *Pain*. 1985; 23:345–356. [PubMed: 4088697]
- Kothari DJ, Davis MC, Yeung EW, Tennen HA. Positive affect and pain: Mediators of the within-day relation linking sleep quality to activity interference in fibromyalgia. *Pain*. 2015; 156:540–546. DOI: 10.1097/01.j.pain.0000460324.18138.0a [PubMed: 25679472]
- Lawrence RC, Felson DT, Helmick CG, Arnold LM, Choi H, Deyo RA, Hunder GG. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States: Part II. *Arthritis and Rheumatism*. 2008; 58:26–35. [PubMed: 18163497]
- Leonard MT, Cano A, Johansen AB. Chronic pain in a couples context: A review and integration of theoretical models and empirical evidence. *Journal of Pain*. 2006; 7:377–390. [PubMed: 16750794]
- Manne SL, Zautra AJ. Couples coping with chronic illness: Women with rheumatoid arthritis and their healthy husbands. *Journal of Behavioral Medicine*. 1990; 13:327–342. [PubMed: 2246781]
- Martire LM, Stephens M, Mogle J, Schulz R, Brach J, Keefe F. Daily spousal influence on physical activity in knee osteoarthritis. *Annals of Behavioral Medicine*. 2013; 45:213–223. DOI: 10.1007/s12160-012-9442-x [PubMed: 23161472]

- Mason JH, Anderson JJ, Meenan RF, Haralson KM, Lewis-Stevens D, Kaine JL. The rapid assessment of disease activity in rheumatology (RADAR) questionnaire. *Arthritis and Rheumatism*. 1992; 35:156–162. [PubMed: 1734905]
- Morin CM, Gibson D, Wade J. Self-reported sleep and mood disturbance in chronic pain patients. *Clinical Journal of Pain*. 1998; 14:311–314. [PubMed: 9874009]
- Murphy L, Schwartz TA, Helmick CG, Renner JB, Tudor G, Koch G, Jordan JM. Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Care & Research*. 2008; 59:1207–1213. [PubMed: 18759314]
- Naughton F, Ashworth P, Skevington SM. Does sleep quality predict pain-related disability in chronic pain patients? The mediating roles of depression and pain severity. *Pain*. 2007; 127:243–252. [PubMed: 17055168]
- Newth S, Delongis A. Individual differences, mood, and coping with chronic pain in Rheumatoid Arthritis: A daily process analysis. *Psychology and Health*. 2004; 19:283–305.
- Newton-John T, Williams A. Chronic pain couples: Perceived marital interactions and pain behaviours. *Pain*. 2006; 123:53–63. [PubMed: 16563628]
- O'Brien EM, Waxenberg LB, Atchison JW, Gremillion HA, Staud RM, McCrae CS, Robinson ME. Intraindividual variability in daily sleep and pain ratings among chronic pain patients: Bidirectional association and the role of negative mood. *Clinical Journal of Pain*. 2011; 27:425–433. DOI: 10.1097/AJP.0b013e318208c8e4 [PubMed: 21415723]
- Raudenbush, SW., Bryk, AS. Hierarchical linear models: Applications and data analysis methods. Vol. 1. Beverly Hills: Sage; 2002.
- Romano JM, Turner JA, Jensen MP, Friedman LS, Bulcroft RA, Hops H, Wright SF. Chronic pain patient-spouse behavioral interactions predict patient disability. *Pain*. 1995; 63:353–360. [PubMed: 8719536]
- Schuster TL, Kessler RC, Aseltine RH Jr. Supportive interactions, negative interactions, and depressed mood. *American Journal of Community Psychology*. 1990; 18:423–438. [PubMed: 2264558]
- Smith MT, Haythornthwaite JA. How do sleep disturbance and chronic pain inter-relate? Insights from the longitudinal and cognitive-behavioral clinical trials literature. *Sleep Medicine Reviews*. 2004; 8:119–132. [PubMed: 15033151]
- Smith MT, Perlis ML, Smith MS, Giles DE, Carmody TP. Sleep quality and presleep arousal in chronic pain. *Journal of Behavioral Medicine*. 2000; 23:1–13. [PubMed: 10749008]
- Spanier GB. Measuring dyadic adjustment: New scales for assessing the quality of marriage and similar dyads. *Journal of Marriage and the Family*. 1976; 38:15–28.
- Stephens MAP, Martire LM, Cremeans-Smith JK, Druley JA, Wojno WC. Older women with osteoarthritis and their caregiving husbands: Effects of pain and pain expression on husbands' well-being and support. *Rehabilitation Psychology*. 2006; 51:3–12.
- Thomas DL, Diener E. Memory accuracy in the recall of emotions. *Journal of Personality and Social Psychology*. 1990; 59:291–297.
- Totterdell P, Reynolds S, Parkinson B, Briner RB. Associations of sleep with everyday mood, minor symptoms, and social-interaction experience. *Sleep*. 1994; 17:466–475. [PubMed: 7991960]
- Turk DC, Kerns RD, Rosenberg R. Effects of marital interaction on chronic pain and disability: Examining the down side of social support. *Rehabilitation Psychology*. 1992; 37:259–274.
- van der Helm E, Gujar N, Walker MP. Sleep deprivation impairs the accurate recognition of human emotions. *Sleep*. 2010; 33:335–342. [PubMed: 20337191]
- Waters WF, Adams SG, Binks P, Varnado P. Attention, stress and negative emotion in persistent sleep-onset and sleep maintenance insomnia. *Sleep*. 1993; 16:128–136. [PubMed: 8446832]
- Zautra AJ, Johnson LM, Davis MC. Positive affect as a source of resilience for women in chronic pain. *Journal of Consulting and Clinical Psychology*. 2005; 73:212–220. [PubMed: 15796628]
- Zautra AJ, Smith B, Affleck G, Tennen H. Examinations of chronic pain and affect relationships: Applications of a dynamic model of affect. *Journal of Consulting and Clinical Psychology*. 2001; 69:786–795. [PubMed: 11680555]
- Zawadzki MJ, Graham JE, Gerin W. Rumination and anxiety mediate the effect of loneliness on depressed mood and sleep quality in college students. *Health Psychology*. 2013; 32:212–222. [PubMed: 22823068]

Fig. 1.

The moderating effect of partners' solicitous responses on the association between daily negative mood and **a** subjective sleep quality/**b** feeling refreshed after sleep and the moderating effect of solicitous response on the association between daily positive mood and **c** sleep quality/**d** feeling refreshed after sleep. *Note:* sleep quality was on a scale from 0 = very good to 3 = very bad. Feeling refreshed after sleep was rated on a scale of 0 = not at all to 6 = extremely. The *arrows* on the Y-axes point in the direction of better sleep outcomes. Estimated values are presented for the within-individual association between daily mood and sleep outcome of those with chronic pain with one SD above and below the mean partner response. The *error bars* indicate the SE of the estimated values. Those 1 SD above and below the mean points were only used to present the patterns of interactions, but continuous scores of mood and partner response scales were used to make the coefficient estimations in the models

Fig. 2. The moderating effect of daily partner's punishing responses on the association between negative mood and feeling refreshed after sleep. (see *Note* in Fig. 1)

Fig. 3. The moderating effect of daily partner's empathic responses on the association between positive mood and sleep quality. (see *Note* in Fig. 1)

Table 1

Demographic characteristics of participants and their partners (N = 143)

Variable	Individuals with knee OA	Partners
	M (SD) or %	M (SD) or %
Age	65.5 (9.6)	65.4 (11.4)
Gender = men	42 %	58 %
Years of education	16.0 (2.0)	15.8 (2.1)
Race = caucasian	87.4 %	86 %
Years married/in relationship	34.6 (16.6)	
Marital satisfaction	39.61 (6.26)	38.94 (6.47)
Mean range for household income	\$40,000–59,999	
Currently employed	42 %	45.5 %
Body mass index	31.3 (5.9)	28.7 (4.7)
Duration of knee OA (years)	12.8 (11.4)	
Baseline depressed mood (brief CES-D)	6.58 (5.28)	
Baseline sleep quality (PSQI)	7.1 (4.2)	

Full-time employment status was defined as typically working 30 h or more per week

OA osteoarthritis

Table 2

Within-dyad correlations among daily measures of mood, sleep, partner responses, and pain

	1.	2.	3.	4.	5.	6.	7.	8.
1. Daily PM	1							
2. Daily NM	-.42***	1						
3. Sleep quality	-.03	0.03	1					
4. Refreshed after sleep	0.07**	-.07**	-.65**	1				
5. Punishing response	-.03	0.10***	0.01	-.02	1			
6. Solicitous response	0.003	0.05*	0.05*	-.02**	-.01**	1		
7. Empathic response	0.05*	0.01	0.04	.02	-.02**	0.40**	1	
8. Daily pain	-.01	0.06**	0.02	-.02	-.002	0.06*	0.05*	1

PM positive mood, *NM* negative mood* $p < 0.05$;** $p < 0.01$;*** $p < 0.001$

Table 3

The interaction effect models of daily mood and partner's responses to pain on sleep quality and feeling refreshed after sleep

	Sleep quality Estimate (SE)	Refreshing sleep Estimate (SE)
<i>Model 1</i>		
Daily NM	0.01 (0.01) *	-0.02 (0.01) †
Daily solicitous response	0.03 (0.02)	-0.05 (0.03)
Daily NM × solicitous response	0.01 (0.01) *	-0.03 (0.01) *
Baseline depressed mood	0.03 (0.01) **	-0.08 (0.02) ***
Baseline pain medication use	—	-0.34 (0.17) *
<i>Model 2</i>		
Daily PM	-0.004 (0.01)	0.03 (0.01) **
Daily solicitous response	0.03 (0.02)	-0.05 (0.03)
Daily PM × solicitous response	-0.01 (0.01) *	0.02 (0.01) †
Baseline depressed mood	0.02 (0.01) **	-0.07 (0.02) ***
Baseline pain medication use	—	-.34 (0.17) †
<i>Model 3</i>		
Daily NM	0.02 (0.01) *	0.03 (0.01) *
Daily punishing response	0.01 (0.03)	0.002 (0.06)
Daily NM × punishing response	0.02 (0.01)	-0.04 (0.02) †
Baseline depressed mood	0.02 (0.01) **	-0.08 (0.02) ***
Baseline pain medication use	—	-.33 (0.17) *
<i>Model 4</i>		
Daily PM	-0.004 (0.01)	0.03 (0.01) **
Daily punishing response	0.02 (0.03)	-0.03 (0.06)
Daily PM × punishing response	-0.01 (0.01)	0.01 (0.01)
Baseline depressed mood	0.02 (0.01) **	-0.08 (0.02) ***
Baseline pain medication use	—	-.34 (0.17) †
<i>Model 5</i>		
Daily NM	0.02 (0.01) *	-0.03 (0.01) *
Daily empathic response	0.01 (0.02)	0.04 (0.03)
Daily NM × empathic response	0.003 (0.01)	0.002 (0.01)
Baseline depressed mood	0.02 (0.01) **	-0.08 (0.02) ***
Baseline pain medication use	—	-.33 (0.17) *
<i>Model 6</i>		
Daily PM	-0.003 (0.01)	0.03 (0.01) **
Daily empathic response	0.01 (0.02)	0.04 (0.03)
Daily PM × empathic response	-0.01 (0.005) *	0.01 (0.01)

	Sleep quality Estimate (SE)	Refreshing sleep Estimate (SE)
Baseline depressed mood	0.02 (0.01) **	-0.08 (0.02) ***
Baseline pain medication use	–	-.32 (0.17) †

$N_{\text{patients}} = 134$, $N_{\text{observations}} = 1607$

Gender: 1 men, 2 women, *NM* negative mood, *PM* positive mood, sleep quality ranges 0 = very good to 3 = very bad

Pain medication use (non-steroid anti-inflammatory drug) was not included in the final interaction model for sleep quality due to its non-significance;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$;

† $0.05 < p < 0.10$