12-1-2020

Perceived Partner Responsiveness, Pain, and Sleep: A Dyadic Study of Military-Connected Couples

AnnaMarie S. O'Neill
Portland State University

Cynthia Mohr
Portland State University, cdmohr@pdx.edu

Todd Bodner
Portland State University, tbodner@pdx.edu

Leslie Hammer
Portland State University, hammerl@pdx.edu

Citation Details

Published as O'Neill, A. M. S., Mohr, C. D., Bodner, T. E., & Hammer, L. B. (2020). Perceived partner responsiveness, pain, and sleep: A dyadic study of military-connected couples. *Health Psychology*, *39*(12), 1089–1099. https://doi.org/10.1037/hea0001035

Perceived Partner Responsiveness, Pain and Sleep:

A Dyadic Study of Military-Connected Couples

AnnaMarie S. O'Neill[1], Cynthia D. Mohr[1], Todd E. Bodner[1], Leslie B. Hammer[1,2]

[1]Portland State University

[2]Oregon Health & Science University

The U.S. Army Medical Research Acquisition Activity, 820 Chandler Street, Fort Detrick MD 21702-5014 is the awarding and administering acquisition office. This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the USAMRMC Broad Agency Announcement under Award W81XWH-13-2-0020. Portions of this research were supported by the Grant T03OH008435. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense. Results of a draft of the article were presented at an academic conference in the form of a poster presentation (20th annual meeting for the Society for Personality and Social Psychology, Portland, OR, 2019). Correspondence concerning this article should be addressed to AnnaMarie O'Neill, Department of Psychology, Portland State University, Portland, OR 97201. E-mail: anne33@pdx.edu.

Abstract

Objective: The health-promoting influence of supportive close relationships has been extensively documented, yet the mechanisms of this effect are still being clarified. Leading researchers have theorized that examining particular interpersonal interactions and the mediating intrapersonal processes they facilitate is the key to understanding how close relationships benefit health. The purpose of this study was to investigate the influence of perceived partner responsiveness (PPR) on pain and sleep quality via affect in a sample of veterans and spouses (collectively called military-connected couples). **Method:** Military-connected couples (N = 162) completed 32 days of daily diaries. Mediated actor- partner interdependence models were conducted using multilevel structural equation modeling to assess the effects of PPR at baseline on the daily levels of positive affect, negative affect, pain, and sleep across the following 32 days. **Results:** Indirect effects emerged such that affect mediated the association between PPR and pain for veterans only whereas affect mediated the association between PPR and sleep quality for both partners. Daily direct effects emerged as well; for example, positive affect was positively associated with higher sleep quality for both partners and lower pain for veterans. Partner effects were revealed such as veteran PPR was positively associated with spouse positive affect. Overall, greater PPR was associated with positive health outcomes for military-connected couples. **Conclusion:** The implications of this study include providing insights for couple-oriented interventions for preventing and treating pain and sleep problems in couples who are at high risk of these health problems such as military-connected couples.

Keywords: couples, intimacy, military, pain, sleep

Trial registration: ClinicalTrials.gov identifier: NCT03085953

High-quality close relationships have been consistently associated with improved health but the mechanisms underlying this phenomenon are still being clarified. Researchers have argued that the key to addressing this gap is to examine social connection because it can facilitate downstream intrapersonal processes which ultimately impact health (Pietromonaco & Collins, 2017). The present study investigated whether perceived partner responsiveness (PPR) was associated with lower pain and higher sleep quality through affect (as depicted in Figure 1). We studied veterans and their spouses, collectively termed military-connected couples, who face unique relationship challenges and are at higher risk of pain and sleep disturbances.

Pain and sleep problems can cause difficulty in daily functioning and can degrade health over time. Evidence suggests that military populations may struggle with these problems more than civilian populations. For example, nationally representative studies have shown that the prevalence of severe pain (i.e., frequent and bothersome) is higher in veterans than nonveterans from the same age group (18 –39; Nahin, 2017). Regular military activities that involve extreme physical demands contribute to substantial wear and tear. Additionally, the post 9/11 generation of service members have higher incidence of pain compared to earlier generations, likely due to a confluence of factors such as the increased duration and pace of deployments and increased likelihood of survival of injuries due to advancements in medical care (Hosek, Kavanagh, & Miller, 2006).

Approximately one third of American adults do not meet the recommended minimum duration of seven hours per night (National Sleep Foundation, 2012). In the military population, the prevalence rate of short sleep duration may be twice as high (63%) with one large study of service members finding that 31% reported a six hour duration and an additional 32% reported durations of five hours or less (Troxel et al., 2015). Although the prevalence rates of sleep problems in civilian and military populations have not been compared in the same study evidence suggests sleep problems may be more prevalent in the latter population (Troxel et al., 2015). These researchers reviewed the contributing factors for sleep problems in the military, which include irregular schedules, crowded sleeping environments, combat exposure increasing likelihood of traumatic brain injuries and posttraumatic stress disorder, military cultural values like viewing sleep as a luxury, as well as difficulties with reintegration into civilian life. Military spouses also contend with factors causing sleep difficulties such as physical separation from their romantic partner, which contributes to them having lower sleep duration than their civilian counterparts (see Brooks Holliday, Haas, Shih, & Troxel, 2016, for review). Further, pain and sleep problems can exacerbate one another. This bidirectional influence has been replicated across the life span, in different countries, and with clinical and relatively healthy samples (Andersen, Araujo, Frange, & Tufik, 2018).

The social context of a romantic relationship can play a role in the development and maintenance of health problems in at least two ways. First, the health problems are interdependent in that the health issue of one can degrade the health of their partner (e.g., Lewis, Lamson, White, & Russoniello, 2013). For example, arthritic pain can degrade partner sleep quality (Martire, Keefe, Schulz, Parris Stephens, & Mogle, 2013), which is an example of a partner effect (i.e., the influence of a partner's predictor on one's own outcome). Second, social relationships strongly influence health in beneficial or deleterious ways, depending on the degree to which they satisfy core needs (such as belonging and being understood; see review by Pietromonaco & Collins, 2017). Researchers and clinicians have called for close relationships to be leveraged alongside more routinely targeted biological and psychological factors for an integrated approach informed by the biopsychosocial model in order to prevent and treat health problems (see review by Kiecolt-Glaser & Wilson, 2017).

One promising yet understudied mechanism linking close relationships to health outcomes, and particularly to pain and sleep, is intimacy. According to the intimacy process model proposed by Reis and Shaver (1988), intimacy is fostered through iterative and reciprocal interactions in which one person discloses emotional information and the other person responds to that disclosure in a way that makes the disclosing person feel that their partner cares for, understands and validates them (i.e., perceived partner responsiveness or PPR). Although the intimacy process and the resulting appraisal of PPR have been relatively understudied as a predictor of physical health, longitudinal studies have discovered promising results. For example, greater PPR predicted lower mortality 10 years later (Selcuk & Ong, 2013) and on the daily level, PPR has also been found to decrease anxiety and arousal (Selcuk, Stanton, Slatcher, & Ong, 2017).

PPR and the broader construct of intimacy are associated with relationship constructs (e.g., relationship quality and social support) that have been previously assessed in connection with both pain and sleep. The degree to which individuals appraise their relationship as high-quality depends heavily on having supportive interactions over time that fulfill their core social needs, which is tantamount to intimacy and PPR (Reis, 2012). Social support, another commonly studied health-relevant relationship construct, is only beneficial when it is responsive to the recipient’s needs (i.e., the matching-hypothesis) and further, received social support can be detrimental to health when it is unresponsive (Maisel & Gable, 2009). Therefore, the constructs of intimacy and PPR would, by definition, underlie relationship quality and also afford an unambiguous prediction of positive effects on health because it excludes unresponsive social support. Taken together, PPR is the most irreducible essence of what makes relationships close and rewarding, and therefore beneficial to health (Reis, 2012).

Pain is an unpleasant experience created by the brain using input from biological, psychological and social factors to alert the person to actual or potential tissue damage so that sustained damage can be tended to and further damage can be avoided (i.e., biopsychosocial model of pain; Turk & Monarch, 2002). The influence of social relationships on pain is complex and they can both increase or ameliorate pain (see Krahé, Springer, Weinman, & Fotopoulou, 2013 for brief review). For example, invalidation in the forms of social rejection and critical responses to pain expressions can cause and increase pain, respectively. On the other hand, validating and positive experiences with close others can foster analgesic effects because these experiences positively impact emotional states (as reviewed in Krahé et al., 2013). Indeed, a wealth of evidence has suggested that the crux of close relationship's analgesic effects is the social regulation of emotion. A systematic review of laboratory studies in which pain was experimentally induced in healthy participants found that positive interactions (e.g., demonstrating empathy) promoted emotion-regulation to reduce pain (Krahé et al., 2013). Research with chronic pain samples has mirrored evidence from lab experiments; for example, one study of individuals with chronic pain and their significant others found that responsiveness to verbal expressions of pain (e.g., supportiveness rather than indifference or criticism) improved physical functioning, suggesting lower pain (Wilson, Martire, & Sliwinski, 2017). Taken together, validating interactions and supportive close others signal safety and drive the social regulation of emotion which, in turn, reduces pain.

It is important to differentiate responsiveness from the interpersonal process of solicitous responses (i.e., overly helpful) to pain expressions (e.g., wincing or talking about pain), which reinforces pain expressions. This dynamic has been extensively studied in couples and conceptualizes pain expression as a behavior that may be reinforced by spousal response if the person with chronic pain finds their spouse's response to be rewarding in some way. Yet, emotional validation and solicitousness are distinct constructs (reviewed by Cano & Williams, 2010). An example of a solicitous behavior would be for the spouse of a person recovering from surgery to tie her shoes without asking if that is what she needs, potentially undermining her sense of autonomy. In contrast, responsive behavior might include offering help but also encouraging her to keep trying and to reframe the pain as temporary and necessary to regaining flexibility. Unlike solicitousness, PPR is not limited to pain-related interactions, but rather is a global appraisal. The present study is about the somatization of PPR in the forms of lower pain and higher sleep quality in a nonclinical sample rather than an examination of pain communication in a clinical sample suffering from chronic pain.

The social context within which sleep occurs has been increasingly recognized as impacting the behavioral process of sleep (Troxel, 2010). Analogous to the growing call in the larger close relationship and health research, sleep research has begun to pinpoint particular interpersonal interactions that drive the influences of social relationships on sleep. Components of the intimacy process and the emotional changes they foster have been found to be especially sleep-relevant. Self-disclosures of negative events are predictive of improved sleep for both partners (Kane, Slatcher, Reynolds, Repetti, & Robles, 2014). Drawing from the same sample as the present study, Arpin, Starkey, Mohr, Greenhalgh, and Hammer (2018) found that responsive reactions to disclosures of good news (i.e., capitalization) predicted less sleep difficulty for spouses. In general, PPR has been associated with lower self-reported sleep problems through the mechanism of downregulation of vigilance, which is a relative lowering of emotional and physiological arousal that is essential for sleep (Selcuk et al., 2017). In sum, PPR promotes sleep quality, likely through the downregulation of vigilance.

The purpose of this study is to examine associations among PPR, affect, pain and sleep quality in military-connected couples. We assessed the influence of PPR on the health outcomes through the affective mediators with the Actor-Partner Interdependence Mediated Model (APIMeM; Ledermann, Macho, & Kenny, 2011; conceptual model presented in Figure 1). Positive affect (PA) and negative affect (NA) were analyzed in separate APIMeMs because they function independently (Deiner & Emmons, 1984). As reviewed above, the affective processes that PPR is hypothesized to facilitate are emotion-regulation and downregulation of vigilance in the contexts of pain and sleep, respectively, and these processes have many commonalities like the emotions resulting from them. Thus, we operationalized them with the resulting emotions, higher PA and lower NA, that would produce analgesic and sleep-fostering effects.

An actor effect is the influence of one's predictor on one's own outcome (e.g., veteran PPR predicting veteran pain). Regarding actor effects (which pertain to both partners of the couple), in the first APIMeM, we hypothesized that PA will mediate the relationships between PPR and lower pain (H1a) and higher sleep quality (H1b) on average over the 32-day period. Turning to the second APIMeM, we hypothesized that NA would mediate the relationships between PPR and lower pain (H2a) and higher sleep quality (H2b) on average over the 32-day period. Our hypotheses exclusively address indirect effects because this was the main focus of the study. The directional hypotheses were informed by experimental work showing that validating interactions or the priming of validating close others can reduce pain through promoting emotion-regulation (Krahé et al., 2013). Another study found that sleep benefits derived from PPR were mediated by decreased symptoms of depression and anxiety (Selcuk et al., 2017). Finally, we investigated the research question regarding the presence of associations for partner effects. Frequently, dyadic phenomena have been examined from an individualistic approach (Kenny, Kashy, & Cook, 2006) and thus, there was not the same empirical foundation to pose hypotheses about partner effects that there was for actor effects.

Method

Study Overview

Data for this study were collected as part of the Study for Employment Retention of Veterans (SERVe; ClinicalTrials.gov Identifier NCT03085953), a randomized controlled trial evaluating the effectiveness of the Veteran-Supportive Supervisor Training which was designed to increase employment retention and personal well-being for current or former service members. For more information about SERVe and our sample, see Hammer, Wan, Brockwood, Mohr, and Carlson (2017). We used preintervention data from the baseline survey of the larger SERVe study and preintervention data from the 32-day daily diary component study, the Daily Family Study (DFS). The baseline survey of SERVe was administered about one to two weeks before the DFS.

Participants

From the sample of 509 veterans participating in the baseline survey of SERVe, 395 veterans were invited to participate in the DFS because they were married or cohabiting with a romantic partner for at least six months. To be eligible to participate in the DFS, both partners of the couple had to complete the baseline SERVe survey, resulting in 260 eligible couples.[1] The sample was reduced from the 173 couples who participated in the DFS to the final analyzable sample of 162 couples after excluding couples who completed a pilot version of the survey (N = 9) and responded in a nonmatching reporting window (N = 2; see inclusion criteria below). On average, the participants were in their late thirties and were mostly Caucasian (83.3% of veterans; 80.9% of spouses). Most of the veterans were men (88.9%) and most of the spouses were women (89.5%). Although there were no inclusion criteria regarding sexual orientation, our sample almost exclusively consisted of opposite sex couples (99.4%). On average, couples reported a relationship length of 12 years (SD = 8.5), and a majority were parents (78.4%). See Table 1 for more descriptive statistics.

Procedure and Measures

The DFS was a 32-day web-based diary survey. Survey links were emailed to participants once daily for 32 days and were required to be completed between 5:00 PM and 11:00 PM. For the veterans who did not work regular hours (i.e., shift workers; 18% of sample), both partners completed their surveys during the 5:00 AM to 11:00 AM reporting window. The survey took 5–10 min to complete. Participants were asked to complete their surveys separately and to refrain from discussing survey responses with their partner. On average, participants completed

[1] Note that there were no significant differences between the baseline sample of the larger SERVe study (N = 260) and the subsample who participated in the baseline DFS (N = 173) on relevant study variables that we administered in both surveys (e.g. PPR, pain, sleep quality).

approximately 24 survey days, resulting in an average compliance of 78%. All research activities were approved by an Institutional Review Board and the U.S. Army Medical Research and Material Command, Human Research Protection Office. Each member of couple could receive up to $90 for their participation depending on the number of completed surveys.

Perceived partner responsiveness. An adapted form of the 3-item measure from Laurenceau and colleagues (1998) was administered at one time point, in the SERVe baseline survey which was collected prior to the DFS. An example item is, "To what degree do you feel understood by your spouse/partner?" Response options ranged from 1 ("not at all") to 7 ("very much"). Higher scores indicated higher PPR and the three items were averaged to create a composite score (α = .87; M = 5.86, SD = 1.25 for veterans; M = 6.12, SD = 0.98 for spouses).

Pain. Pain was assessed in the DFS with a single item. The participants were asked to rate their "average level of pain experienced" on a single-item visual analog scale (VAS) ranging from 0 ("no pain") to 100 ("unbearable pain"; Mattacola, Perrin, Gansneder, Allen, & Mickey, 1997).[2] Veterans reported an average of 17.80 (SD = 21.02) and spouses reported 13.30 (SD = 17.67) for pain.

Positive and negative affect. Moods were assessed in the DFS using items from various scales (e.g., Watson & Clark, 1999). Respondents were asked to indicate the extent to which they are currently feeling: angry, ashamed, grateful, guilty, happy, lonely, relaxed and sad. Response options ranged from 1 ("not at all") to 5 ("extremely"). These mood items were grouped into

[2] Since the pain variable referred to pain experienced over the past 24 hours and that this variable was collected at the same time as affect, there was some overlap in these variables. Alternative analyses featuring a pain outcome that was not reverse-lagged were conducted and the results were mostly the same except that daily associations between affect and pain were significant for spouses in those models. Our final analyses feature reverse-lagged pain because it was more consistent with the temporal precedence ideal for mediation models.

categories of PA (grateful, happy, relaxed) and NA (angry, ashamed, guilty, lonely and sad) and then averaged by the number of items in the category. We computed the day-level internal consistency for both the PA subscale and the NA subscale on 3 days representing the beginning (Day 3), middle (Day 16), and end (Day 29) of the diary recording period, with resulting alpha reliabilities of .80, .80, and .77, respectively for PA and .74, .72, and .75, respectively for NA. Mean PA for our sample was M = 2.88 (SD = 0.99) for veterans and M = 3.14 (SD = 0.99) for spouses. Mean NA was M = 1.16 (SD = 0.33) for veterans, and M = 1.19 (SD = 0.42) for spouses. Sleep quality. A single-item adapted from the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) was administered in the DFS. The item was “How would you rate last night’s sleep quality overall?” The response options ranged from 1 (“very bad”) to 4 (“very good”). On average, sleep quality was 2.73 (0.68) for veterans and 2.79 (SD = 0.76) for spouses.

Data Analytic Strategy

The dyadic daily diary data was assessed at two levels with the observations within dyad members at the lower level (also referred to as level 1 or the daily level) and the dyad members at the higher level (also referred to as level 2, the aggregate or average level over the 32 days). We conducted APIMeMs (Ledermann et al., 2011) using multilevel structural equation modeling (Preacher, Zyphur, & Zhang, 2010) in order to account for this nesting, differentiate daily from aggregate effects, estimate partner effects in addition to actor effects, as well as to estimate multiple outcomes in the same model. Our focal predictor, PPR, was a level 2 variable (assessed once, in the baseline survey of SERVe) whereas the mediators and the outcomes were level 1 variables (assessed daily in the DFS) and therefore the resulting APIMeMs were 2–1–1 multilevel mediation models. Level 2 predictors were grand-mean centered whereas level 1 predictors were person-mean centered. Given that the reports of pain and sleep quality referred to the previous day's experiences (e.g., today's report of sleep quality referred to yesterday's sleep period), these variables were reverse-lagged by one day so these outcomes followed the mediators temporally.[2] Military status was the distinguishing variable between partners (Kenny et al., 2006). We conducted our analyses with Mplus Version 8 (Muthén & Muthén, 2018). Maximum likelihood estimation was used to estimate and test the individual model parameters and Bayesian estimation was used to create 95% credibility intervals for the hypothesized indirect effects. Fit indices are not reported because the models were just identified. We reviewed the close relationships-pain and -sleep literature and did not find uniformly used covariates or theoretical rationale from which covariates were drawn; rather, we identified covariates that have been previously used that would be theoretically important for our study, which we controlled for (age, deployment history, parental status, and relationship length). See Table 2 for correlations between covariates and primary study variables.

Results

Model parameters are reported in Table 3. The indirect effects are reported in Table 4. We present figures of the results of the two APIMeMs (Figures 2S and 3S) as well as results from the preliminary analyses in the online supplemental materials. In brief, preliminary analyses showed that PPR was negatively associated with pain for veterans and positively associated with sleep quality for both members of the couple.

APIMeM 1: PPR - Positive Affect—Pain and Sleep Quality

The first APIMeM featured PA as the mediator through which PPR was associated with pain and sleep quality over the 32-day study. The majority of hypotheses, which only concerned actor effects, were fully supported. The indirect effect in which PA was found to mediate the association between PPR and pain emerged for veterans ($b = -1.60, p < .01$; see row 1 of Table 4; explaining 18.20% of the total effect (TE)) but not for spouses ($b =$ —*0.10, ns*; see row 8 of Table 4), thus providing partial support to H1a. Full support was found for H1b such that PA mediated the association between PPR and sleep quality emerged for veterans ($b = 0.05, p < .001$; Table 4, row 9; explaining 40.66% of the TE) and for spouses ($b = 0.07, p < .001$; Table 4, row 16; explaining 27.78% of the TE).

Multiple partner effects emerged, affirming the research question regarding the presence of partner effects. The indirect effect from veteran PPR to spouse sleep quality through spouse PA ($b = 0.04, p < .05$; Table 4, row 14; explaining —31.09%[3] of the TE). Veteran PPR was associated with spouse PA in the aggregate level ($b = 0.13, p < .01$; Table 3, row 2). Veteran PA was negatively associated with spouse sleep quality in the daily level ($b =$ —*0.05*, $p < .05$; Table 3, row 7).

APIMeM 2: PPR - Negative affect – Pain and Sleep Quality

The second APIMeM featured NA as the mediator through which PPR was associated with pain and sleep quality over the 32-day study. The majority of the hypotheses in this model were at least partially supported. NA was found to mediate the association between PPR and pain

[3] This percentage of the total effect explained is negative. This may seem unusual but it is consistent with the concept of inconsistent mediation (MacKinnon, 2008) which suggests that two competing component processes of a mediation result in the total effect incorrectly appearing like no mediational processes are occurring. In this case, PPR-positive affect has a positive association whereas positive affect-pain has a negative association, resulting in this negative value of percentage of total effect explained.

for veterans (*b* = *—2.66, p* < *.001*; see row 17 of Table 4; explaining 3.27% of the TE) but this effect did not emerge for spouses (*b* = *—0.31, ns*; see row 24 of Table 3), thus lending partial support to H2a. Full support was found for H2b such that NA mediated the association between PPR and sleep quality for veterans (*b = 0.03, p* < *.001*; Table 4, row 25; explaining 8.01% of the TE) and spouses (*b = 0.05, p* < *.001*; Table 4, row 32; explaining 12.23% of the TE). Turning to the research question about the presence of partner effects, the partner effect that emerged was veteran PPR being associated with higher spouse pain (*b = 2.33, p* < *.05*; Table 3, row 11). Beyond results pertaining to hypotheses and the research question, there were some interesting findings worth noting such as daily fluctuations in NA being associated with sleep quality for spouses (*b* = *—0.08, p* < *.05*; Table 3, row 17) but not veterans (*b = 0.73, ns*; Table 3, row 16).

Discussion

This dyadic daily diary study of veterans and their spouses suggests that supportive relationships foster analgesic and sleep- promoting effects through the social regulation of emotion. The hypothesized indirect effects for pain emerged for veterans only whereas indirect effects emerged for both partners for sleep quality. These findings are consistent with the affective states (such as greater relaxation and less sadness) that would be expected to result from social regulation of emotion resulting from having a responsive partner. Additionally, partner effects emerged, which demonstrated pathways of interdependence.

A number of asymmetrical patterns emerged in our results, including some actor effects that were different between veterans and spouses, as well as between the daily and aggregated levels that warrant discussion. The analgesic effect of PPR was limited to veterans in both

APIMeMs, and we believe that this does not mean responsive relationships would not lower pain in spouses but rather that is likely reflective of a floor effect given that spouses had significantly lower pain than veterans. Similarly, differential patterns were found for NA between partners in that daily NA was predictive of daily sleep quality for the spouses but not the veterans. In contrast, the analogous paths for PA did not show such patterns in that daily PA was associated with at least some daily health outcomes for both partners. This may also be due to spouses having significantly higher NA than veterans and thus, a floor effect may be present for veterans.

Two of the four partner effects that emerged suggested a beneficial effect such that veteran PPR was associated with higher spouse PA and higher aggregated sleep quality through spouse PA. In contrast, veteran PA was associated with lower spouse sleep quality in the daily level and veteran PPR was associated with worsened spouse pain in the aggregate level. These results may indicate some nuanced dynamics relating to responsive support-giving. Specifically, the beneficial partner effects (e.g., veteran PPR providing both mood and sleep benefits on the aggregate level) suggest that responding to a partner's needs can provide emotional and health benefits to the support-giver over the long-term whereas the detrimental partner effects (e.g., veteran PA lowering sleep quality for their partners on the daily level) may suggest that the social regulation of emotion can also have short-term costs for the responsive support-giver. Alternately, spouses who have higher PA in general may be perceived as responsive to their veteran partners. In regard to why similar effects did not emerge for veterans (e.g., spouse PPR–veteran PA), it is possible the association found in the raw data with bivariate correlations, $r = .23, p < .001$ is not significant enough to be significant in a larger regression model in which estimates for each pathway controls for all other pathways.

Although the present study has many strengths like our use of dyadic daily diary data and an advanced analytic approach that parsed apart distinct sources of variance, it also has limitations. Gender is confounded with the distinguishing variable of military status because the majority of veterans were men and the majority of spouses were women. Thus, we were not able to examine gender effects. Our use of single-item measures for the outcomes, which we did to reduce participant burden, is a methodological limitation. However, single-item scales have been utilized in assessing daily sleep outcomes (e.g., Lee, Crain, McHale, Almeida, & Buxton, 2017) and have demonstrated high construct validity when compared to other measures of pain intensity and pain behaviors (Turk & Melzack, 2011). Finally, the purpose of this study was to test how responsive relationships promote health through intrapersonal mechanisms as guided by current relationship theory (Pietromonaco & Collins, 2017). However, alternative models featuring the reverse direction in which pain and sleep were specified to influence PPR are plausible, such that a restless night could impede relationship functioning or partner perception. Such an alternative model is outside the scope of this paper and further, PPR was assessed before the daily variables.

The present study contributes to the pain and sleep literature in a few ways that may help inform future work. Our findings complement experimental work documenting the social modulation of pain (see Krahé et al., 2013) with more ecologically valid evidence of this process occurring naturalistically in couples at high risk of health problems. We believe our work complements the operant pain model, which focuses on problematic spousal behaviors reinforcing pain expressions. Rather than conflicting with this model, our findings highlight the need to broaden the focus from problematic couple or social support interactions to consider other close relationships processes that can alter pain. For more about the intimacy process applied to the context of chronic pain communication, see Cano and Williams (2010).

Turning to the sleep literature, we built on previous work establishing that capitalization-related PPR promotes sleep (Arpin et al., 2018) and here we broadened our scope by examining PPR more generally and by investigating the intrapersonal mediator of affect. Our mediational model focusing on the critical role of the downregulation of vigilance was informed by Selcuk et al. (2017). We replicated their work with a dyadic sample to uncover interdependence, a daily experience method to see how this process unfolds over time, a new operationalization of downregulation of vigilance with less severely worded NA items (e.g., “sad” instead of “depressed”) and by adding items reflecting PA (e.g., “relaxation”) to represent the range of emotional experiences of vigilance and its downregulation, respectively, and by establishing these associations occurring closer in time (e.g., PPR was collected 1–2 weeks before the mediators and outcomes, which were both assessed each day in the DFS) thus providing more foundation for causality. This study is the first to our knowledge to test a dyadic model reflecting the bidirectional influences of pain and sleep, both within-person and within-couple.

We believe that the present study has made several unique theoretical contributions to the literature. First, although affective processes have emerged as one of the most powerful drivers of health-relevant effects of relationships, as the direct associations between close relationships and affect as well as between affect and health have been extensively established, the complete indirect path connecting these phenomena has been underestablished (Farrell, Imami, Stanton, & Slatcher, 2018). Therefore, our study contributes to the burgeoning body of literature aiming to connect these pieces in a mediational model. Second, we expanded the recently growing literature connecting PPR to health outcomes, and this is important because PPR is a critical construct that underlies many other constructs in relationship science, and it is the essence of what makes close relationships satisfying. Further, these findings demonstrate that health benefits of close relationships are not limited to the context of buffering the effects of stress through processes like social support (stress-buffering hypothesis), but rather close relationships also promote health through satisfying a variety of interpersonal needs (e.g., need to belong and to be understood; main effects hypothesis). Third, our approach of utilizing multilevel structural equation modeling to assess dyadic daily diary data enabled us to parse apart daily effects from aggregated effects and allowed for potential interdependence in these phenomena to be revealed.

Beyond these theoretical contributions, we believe that this study builds on a body of literature that has practical implications for public health. Our findings suggest that harnessing the health-promoting power of responsive social relationships could be an essential part of complete biopsychosocial interventions from those aiming to promote good health in well populations (i.e., primary intervention), prevent health problems in people at heightened risk of developing them (i.e., secondary intervention), and ameliorate symptoms in unwell populations (i.e., tertiary intervention). Given that our sample is from a high-risk population, our findings especially warrant future investigation of secondary interventions and specifically those that elevate the focus from the individual to the couple. Such a couple-oriented intervention could optimize relationship functioning and intimacy in order to help military-connected couples better overcome the barriers to intimacy they face (e.g., long separations; Baptist et al., 2011), in order to ultimately prevent the development of health problems for which they are at higher risk. Indeed, there are growing calls to address such individual-level health issues with a couple-oriented or family-oriented approach (e.g., Lewis et al., 2013). To our knowledge, couple-oriented interventions have been reserved for tertiary interventions, and thus we cannot speak to the efficacy of such interventions at the secondary stage of intervention or how its benefits would offset the additional costs involved. However, the efficacy of couple-oriented tertiary interventions aimed at treating chronic health problems has been demonstrated with effect sizes that rival and sometimes exceed those of individual-level conventional psychosocial interventions or usual care on relevant biopsychosocial factors [such as higher relationship functioning ($d = 0.17, p < .01$) and lower pain ($d = 0.19, p < .01$)] (Martire, Schulz, Helgeson, Small, & Saghafi, 2010; Smith et al., 2019). These effect sizes emerged despite considerable variation in the content of the interventions (e.g., partner education, relaxation techniques). A step toward improving their efficacy would be to compare specific intervention strategies (Smith et al., 2019) and further, these authors proposed that enhancing empathy (i.e., understanding and compassion) would be critical in the context of chronic pain. Regarding particular intervention strategies to enhance couple-oriented interventions with health promotion or treatment aims, we advocate for strategies that optimize the intimacy process and we believe that PPR would serve as helpful assessment tool that addresses the essence of whether close relationships will be health-promoting or not—the degree to which they satisfy our core social needs. Given our recommendation of a new proximal target of intervention as well as an assessment tool, our study fits into the Phase 1a of ORBIT, a model aimed at translating empirical research findings to inform behavioral interventions (Czajkowski et al., 2015).

Conclusion

The dominant health paradigm is the biopsychosocial model and yet, social influences of health are sometimes neglected in research and are often not incorporated into prevention and treatment. The present study highlights the importance of close relationships in connection to pain and to sleep quality. Romantic partners are an enduring, frequent interaction partner as well as the primary source of support for most adults. Therefore, optimizing these interactions so they are more responsive and therefore satisfying of core social needs could foster far-reaching health benefits. The present study investigated these processes with military-connected couples who contend with worsened sleep, and higher rates of pain; yet our findings likely generalize to a larger, nonmilitary population also at heightened risk of experiencing these difficulties. This study lends support for the approach of investigating relationship influences on health in couples and further, raises awareness that supporting one another has far-reaching benefits for health.

References

Andersen, M., Araujo, P., Frange, C., & Tufik, S. (2018). Sleep disturbance and pain: A tale of two common problems. Chest, 154, 1249 –1259. http://dx.doi.org/10.1016/j.chest.2018.07.019

Arpin, S. N., Starkey, A. R., Mohr, C. D., Greenhalgh, A. M. D., & Hammer, L. B. (2018). "A well spent day brings happy sleep": A dyadic study of capitalization support in military-connected couples. Journal of Family Psychology, 32, 975–985. http://dx.doi.org/10.1037/fam0000469

Baptist, J. A., Amanor-Boadu, Y., Garrett, K., Nelson Goff, B. S., Collum, J., Gamble, P., . . . Wick, S. (2011). Military marriages: The aftermath of operation Iraqi freedom (OIF) and operation enduring freedom (OEF) deployments. Contemporary Family Therapy, 33, 199 –214. http://dx.doi.org/10.1007/s10591-011-9162-6

Brooks Holliday, S., Haas, A., Shih, R. A., & Troxel, W. M. (2016). Prevalence and consequences of sleep problems in military wives. Sleep Health: Journal of the National Sleep Foundation, 2, 116 –122. http:// dx.doi.org/10.1016/j.sleh.2016.03.004

Buysse, D. J., Reynolds, C. F., III, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Research, 28, 193–213. http://dx.doi.org/10.1016/0165-1781(89)90047-4

Cano, A., & Williams, A. C. de C. (2010). Social interaction in pain: Reinforcing pain behaviors or building intimacy? Pain, 149, 9 –11. http://dx.doi.org/10.1016/j.pain.2009.10.010

Czajkowski, S. M., Powell, L. H., Adler, N., Naar-King, S., Reynolds, K. D., Hunter, C. M.,... Charlson, M. E. (2015). From ideas to efficacy: The ORBIT model for developing behavioral treatments for chronic diseases. Health Psychology, 34, 971–982. http://dx.doi.org/10.1037/ hea0000161

Deiner, E., & Emmons, R. A. (1984). The independence of positive and negative affect. Journal of Personality and Social Psychology, 47, 1105–1117. http://dx.doi.org/10.1037/0022-3514.47.5.1105

Farrell, A. K., Imami, L., Stanton, S. C., & Slatcher, R. B. (2018). Affective processes as mediators of links between close relationships and physical health. Social and Personality Psychology Compass, 12(7), e12408. http://dx.doi.org/10.1111/spc3.12408

Hammer, L. B., Wan, W. H., Brockwood, K. J., Mohr, C. D., & Carlson, K. F. (2017). Military, work, and health characteristics of separated and active service members from the study for employment retention of veterans (SERVe). Military Psychology, 29, 491–512. http://dx.doi.org/ 10.1037/mil0000196

Hosek, J., Kavanagh, J. E., & Miller, L. L. (2006). How deployments affect service members. Washington, DC: Rand Corporation. http://dx.doi.org/ 10.1037/e660572007-001

Kane, H. S., Slatcher, R. B., Reynolds, B. M., Repetti, R. L., & Robles, T. F. (2014). Daily self-disclosure and sleep in couples. Health Psychology, 33, 813–822.http://dx.doi.org/10.1037/hea0000077

Kenny, D. A., Kashy, D. A., & Cook, W. L. (2006). Dyadic data analysis. New York, NY: Guilford Press.

Kiecolt-Glaser, J. K., & Wilson, S. J. (2017). Lovesick: How couples’ relationships influence health. Annual Review of Clinical Psychology, 13, 421– 443. http://dx.doi.org/10.1146/annurev-clinpsy-032816-045111

Krahé, C., Springer, A., Weinman, J., & Fotopoulou, A. (2013). The social modulation of pain: Others as predictive signals of salience - a systematic review. Frontiers in Human Neuroscience, 7, 1–21. http://dx.doi.org/10.3389/fnhum.2013.00386

Laurenceau, J., Barrett, L. F., & Pietromonaco, P. R. (1998). Intimacy as an interpersonal process: The importance of self-disclosure, partner disclosure, and perceived partner responsiveness in interpersonal exchanges. Journal of Personality and Social Psychology, 74, 1238 –1251. http://dx.doi.org/10.1037/0022-3514.74.5.1238

Ledermann, T., Macho, S., & Kenny, D. A. (2011). Assessing mediation in dyadic data using the actor-partner interdependence model. Structural Equation Modeling, 18, 595– 612. http://dx.doi.org/10.1080/10705511.2011.607099

Lee, S., Crain, T. L., McHale, S. M., Almeida, D. M., & Buxton, O. M. (2017). Daily antecedents and consequences of nightly sleep. Journal of Sleep Research, 26, 498 –509. http://dx.doi.org/10.1111/jsr.12488

Lewis, M. E., Lamson, A. L., White, M. B., & Russoniello, C. (2013). Contextualizing military health and trauma: Recommendations for integrated care and couple-centered interventions. Military Behavioral Health Journal, 1, 167–172. http://dx.doi.org/10.1080/21635781.2013.839923

MacKinnon, D. (2008). Introduction to statistical mediation analysis (Multivariate applications book series). Hoboken, NJ: Erlbaum.

Maisel, N. C., & Gable, S. L. (2009). The paradox of received social support: The importance of responsiveness. Psychological Science, 20, 928 –932. http://dx.doi.org/10.1111/j.1467-9280.2009.02388.x

Martire, L. M., Keefe, F. J., Schulz, R., Parris Stephens, M. A., & Mogle, J. A. (2013). The impact of daily arthritis pain on spouse sleep. Pain, 154, 1725–1731. http://dx.doi.org/10.1016/j.pain.2013.05.020

Martire, L. M., Schulz, R., Helgeson, V. S., Small, B. J., & Saghafi, E. M. (2010). Review and meta-analysis of couple-oriented interventions for chronic illness. Annals of Behavioral Medicine, 40, 325–342. http://dx.doi.org/10.1007/s12160-010-9216-2

Mattacola, C. G., Perrin, D. H., Gansneder, B. M., Allen, J. D., & Mickey, C. A. (1997). A comparison of visual analog and graphic rating scales for assessing pain following delayed onset muscle soreness. Journal of Sport Rehabilitation, 6, 38 – 46. http://dx.doi.org/10.1123/jsr.6.1.38

Muthén, L. K., & Muthén, B. O. (1998 –2017). Mplus user's guide (8th ed.). Los Angeles, CA: Author.

Nahin, R. L. (2017). Severe pain in veterans: The effect of age and sex, and comparisons with the general population. The Journal of Pain, 18, 247–254. http://dx.doi.org/10.1016/j.jpain.2016.10.021

National Sleep Foundation. (2012). Bedroom poll: Summary of findings. Washington, DC: Author. Retrieved from https://sleepfoundation.org/ sleep-polls-data/other-polls/2012-bedroom-poll

Pietromonaco, P. R., & Collins, N. L. (2017). Interpersonal mechanisms linking close relationships to health. American Psychologist, 72, 531– 542. http://dx.doi.org/10.1037/amp0000129

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. Psychological Methods, 15, 209 –233. http://dx.doi.org/10.1037/a0020141

Reis, H. T. (2012). Perceived partner responsiveness as an organizing theme for the study of relationships and well-being. In L. Campbell & T. J. Loving (Eds.), Interdisciplinary research on close relationships: The case for integration (pp. 27–52). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/13486-002

Reis, H. T., & Shaver, P. (1988). Intimacy as an interpersonal process. In S. D. Duck (Ed.), Handbook of personal relationships: Theory, research and interventions (pp. 367–389). Oxford, England: Wiley.

Selcuk, E., & Ong, A. D. (2013). Perceived partner responsiveness moderates the association between received emotional support and all-cause mortality. Health Psychology, 32, 231–235. http://dx.doi.org/10.1037/ a0028276

Selcuk, E., Stanton, S. C. E., Slatcher, R. B., & Ong, A. D. (2017). Perceived partner responsiveness predicts better sleep quality through lower anxiety. Social Psychological and Personality Science, 8, 83–92. http://dx.doi.org/10.1177/1948550616662128

Smith, S. M., Li, R., Wolfe, H., Swanger-Gagne, M. S., Bonham, A. D., Kreher, D. A., & Poleshuck, E. L. (2019). Couple Interventions for Chronic Pain. The Clinical Journal of Pain, 35, 916 –922. http://dx.doi.org/10.1097/AJP.0000000000000752

Troxel, W. M. (2010). It's more than sex: Exploring the dyadic nature of sleep and implications for health. Psychosomatic Medicine, 72, 578 – 586. http://dx.doi.org/10.1097/PSY.0b013e3181de7ff8

Troxel, W. M., Shih, R. A., Pedersen, E. R., Geyer, L., Fisher, M. P., Griffin, B. A., . . . Steinberg, P. S. (2015). Sleep in the military: Promoting healthy sleep among U.S. servicemembers. Rand Health Quarterly. Retrieved from https://www.rand.org/pubs/research_reports/ RR739.html.

Turk, D. C., & Melzack, R. (Eds.). (2011). Handbook of pain assessment. New York, NY: Guilford Press.Turk, D. C., & Monarch, E. S. (2002). Biopsychosocial perspective on chronic pain. In D. C. Turk & R. J. Gatchel (Eds.), Psychological approaches to pain management: A practitioner's handbook (pp. 3–29). New York, NY: Guilford Press.

Watson, D., & Clark, L. A. (1999). The PANAS-X: Manual for the positive and negative affect schedule-expanded form. Iowa City: University of Iowa. Retrieved from https://ir.uiowa.edu/cgi/viewcontent.cgi?referer= &httpsredir=1&article=1011&context=psychology_pubs

Wilson, S. J., Martire, L. M., & Sliwinski, M. J. (2017). Daily spousal responsiveness predicts longer-term trajectories of patients' physical function. Psychological Science, 28, 786 – 797. http://dx.doi.org/10.1177/0956797617697444

Table 1. Descriptive statistics about the primary study variables and demographic variables.

Primary study variables	**Veteran M(SD)**	**Spouse M(SD)**	**Paired t-test**
Perceived partner responsiveness	5.86 (1.25)	6.12 (0.98)	t(159) = -2.71**
Positive affect	2.88 (0.99)	3.14 (0.99)	t(3,330) = -11.38***
Negative affect	1.16 (0.33)	1.19 (0.42)	t(3,330) = 3.19***
Pain	17.80 (21.02)	13.20 (17.67)	t(3,270) = 11.26***
Sleep quality	2.73 (0.68)	2.79 (0.76)	t(3,329) = -4.13***
Demographic variables	**Veteran M(SD) or Freq(%)**	**Spouse M(SD) or Freq(%)**	
Age	38.2 (9.10)	36.4 (9.10)	
Gender			
Male	144 (88.9%)	17 (10.5%)	
Female	18 (11.1%)	145 (89.5%)	
Race/ethnicity			
American Indian/Alaskan Native	2 (1.2%)	1 (0.6%)	
Asian	0 (0%)	8 (4.9%)	
Black or African American	2 (1.2%)	2 (1.2%)	
White or Caucasian	135 (83.3%)	131 (80.9%)	
Hispanic	1 (0.6%)	2 (1.2%)	
Other	1 (0.6%)	0 (0%)	
Multiple	21 (13.0%)	18 (11.1%)	
Education			
Less than high school	0 (0%)	3 (1.9%)	
High school diploma/GED	9 (5.6%)	11 (6.8%)	
Some college, no degree	42 (25.9%)	41 (25.3%)	
Completed college with degree/certificate	77 (47.5%)	81 (50.0%)	
Graduate study in progress or completed	34 (21.0%)	26 (16.0%)	
Deployment history			
Never deployed	24 (14%)	--	
Deployed 1 or more times	138 (85.2%)	--	
Dyadic demographic variables	**Dyad M(SD) or Freq(%)**		
Relationship length (in years)	12.00 (8.53)		
Marital status			
In a committed relationship (not cohabitating)	2 (1.2%)		
Cohabitating (but not married)	13 (8.0%)		
Married	146 (90.1%)		
Civil commitment or union	1 (0.6%)		
Parental status			
At least one partner indicated children	127 (78.4%)		
Neither partner indicated children	35 (21.6%)		

Table 2. Within-veteran, within-spouse, inter-partner correlations and among study variables

	Veteran								
Spouse	1. PPR	2. Pain	3. PA	4. NA	5. Sleep	6. Age	7. Dep. Hx	8. Parent Stat.	9. Relat. Length
1.	**.42*****	-.19***	.42***	-.39***	.28***	-.04*	-.08***	-.09***	-.06***
2.	-.13.***	**.16*****	-.30**	.39***	-.39***	.03	.12***	.09***	-.14***
3.	.40***	-.08*	**.39*****	-.32***	.49***	.12***	-.18***	.06***	.06***
4.	-.31***	.19***	-.36***	**.51*****	-.38**	-.11***	-.04**	-.04**	-.22**
5.	.24***	-.23***	.50***	-.35***	**.19*****	.02*	-.12***	-.05**	.16***
6.	-.08***	-.02	.00	-.11***	.14***	**-.08*****	-.02	.26***	.70***
7.	.07***	.05***	-.11***	-.04**	-.05***	-.04**	**1.00*****	-.13***	-.01
8.	-.12***	-.01	.06***	.05***	-.04**	.26***	-.13***	**1.00*****	.26***
9.	-.10***	-.06***	-.09***	-.14***	.11***	.72***	-.01	.25***	**1.00*****

Note: Interpartner correlations presented along the diagonal, within-veteran correlations presented above the diagonal, and within-spouse correlations presented below the diagonal. PPR = perceived partner responsiveness; PA = positive affect; NA = negative affect; Sleep = sleep quality; Dep. Hx = deployment history of the veteran (never deployed/deployed 1 or more times); Parent Stat.= at least one partner indicated that they were a parent (yes/no); Relat. Length = relationship length in years; *significant at p < .05; ** significant at p <.01; *** significant at p <.001.

Table 3. Estimates for direct effects of perceived partner responsiveness, positive affect and negative affect on pain and sleep quality.

APIMeM 1: PPR - Positive Affect – Pain and Sleep Quality

		Veteran Positive Affect		Spouse Positive Affect		Veteran Pain		Spouse Pain		Veteran Sleep Quality		Spouse Sleep Quality	
		b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI
	Level 2												
1	Intercepts	-0.17** (0.06)	-0.28, -0.06	0.11* (0.06)	0.01, 0.22	17.35*** (1.46)	14.48, 20.22	13.14*** (1.19)	10.82, 15.47	2.76*** (0.03)	2.70, 2.81	2.75*** (0.03)	2.69, 2.81
2	V PPR	**0.26*** (0.05)**	**0.15, 0.36**	**0.13** (0.05)**	**0.03, 0.23**	-1.19 (1.34)	-3.83, 1.45	1.81 (1.17)	-0.48, 4.11	0.02 (0.03)	-0.02, 0.07	-0.03 (0.03)	-0.08, 0.03
3	S PPR	0.06 (0.07)	-0.07, 0.20	**0.26*** (0.07)**	**0.13, 0.39**	-0.06 (1.67)	-3.34, 3.23	-2.61 (1.36)	-5.28, 0.06	-0.03 (0.03)	-0.09, 0.03	0.05 (0.04)	-0.02, 0.12
4	V PA	-	-	-	-	**-6.59*** (2.06)**	**-10.63, -2.55**	-1.07 (1.67)	-4.35, 2.21	**0.20*** (0.04)**	**0.12, 0.27**	-0.01 (0.04)	-0.09, 0.08
5	S PA	-	-	-	-	0.31 (2.12)	-3.84, 4.46	-0.35 (1.20)	-3.69, 2.99	0.04 (0.04)	-0.03, 0.12	**0.29*** (0.04)**	**0.20, 0.37**
6	Residual Variance	0.51*** (0.06)	0.40, 0.63	0.49*** (0.06)	0.38, 0.61	299.78*** (34.27)	232.61, 366.95	192.35*** (22.40)	148.44, 236.26	0.08*** (0.01)	0.06, 0.10	0.11*** (0.02)	0.08, 0.14
	Level 1												
7	V PA	-	-	-	-	**-1.05*** (0.33)**	**-1.69, -0.41**	0.08 (0.36)	-0.63, 0.79	**0.06** (0.02)**	**0.02, 0.10**	**-0.05* (0.02)**	**-0.09, -0.01**
8	S PA	-	-	-	-	-0.07 (0.31)	-0.68, 0.53	-0.37 (0.33)	-1.01, 0.27	-0.02 (0.02)	-0.06, 0.02	**0.07*** (0.02)**	**0.03, 0.11**
9	Residual Variance	-	-	-	-	90.25*** (2.17)	85.99, 94.51	107.15*** (2.52)	102.21, 112.10	0.34*** (0.01)	0.33, 0.36	0.41*** (0.01)	0.39, 0.42

APIMeM 2: PPR - Negative Affect – Pain and Sleep Quality

		Veteran Negative Affect		Spouse Negative Affect		Veteran Pain		Spouse Pain		Veteran Sleep Quality		Spouse Sleep Quality	
		b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI	b (SE)	95% CI
	Level 2												
10	Intercepts	0.01 (0.02)	-0.3, 0.04	0.05 (0.03)	-0.01, 0.11	18.73*** (1.32)	16.15, 21.32	13.06*** (1.12)	10.86, 15.25	2.72*** (0.03)	2.67, 2.78	2.80*** (0.03)	2.74, 2.86
11	V PPR	**-0.07*** (0.02)**	**-0.10, -0.04**	-0.01 (0.03)	-0.06, 0.04	-0.11 (1.26)	-2.58, 2.36	**2.33* (1.13)**	**0.11, 4.54**	0.05 (0.03)	-0.00, 0.10	0.01 (0.03)	-0.05, 0.07
12	S PPR	-0.02 (0.02)	-0.06, 0.02	**-0.13*** (0.03)**	**-0.19, -0.06**	-0.60 (1.58)	-3.71, 2.50	-2.30 (1.35)	-4.95, 0.35	-0.01 (0.03)	-0.07, 0.06	0.07 (0.04)	-0.01, 0.14
13	V NA	-	-	-	-	**43.79*** (7.80)**	**28.50, 59.08**	9.55 (6.50)	-3.19, 22.28	**-0.54*** (0.16)**	**-0.85, -0.22**	-0.10 (0.19)	-0.47, 0.26
14	S NA	-	-	-	-	-8.00 (4.44)	-16.71, 0.71	3.41 (3.74)	-3.93, 10.75	0.10 (0.10)	-0.08, 0.29	**-0.42*** (0.11)**	**-0.64, -0.20**
15	Residual Variance	0.04*** (0.01)	0.03, 0.05	0.12*** (0.02)	0.09, 0.15	256.60*** (30.42)	196.96, 316.23	184.87*** (21.67)	142.40, 227.34	0.09*** (0.01)	0.07, 0.12	0.13*** (0.02)	0.10, 0.16
	Level 1												
16	V NA	-	-	-	-	0.06 (0.70)	-1.31, 1.21	-0.29 (0.76)	-1.78, 1.21	-0.07 (0.04)	-0.15, 0.02	-0.06 (0.05)	-0.15, 0.03
17	S NA	-	-	-	-	0.35 (0.58)	-0.79, 1.31	0.73 (0.63)	-0.50, 2.00	0.00 (0.04)	-0.07, 0.07	**-0.08* (0.04)**	**-0.15, -0.01**
18	Residual Variance	-	-	-	-	90.58*** (2.18)	86.31, 94.85	107.16*** (2.52)	102.21, 112.10	0.35*** (0.01)	0.33, 0.36	0.41*** (0.01)	0.39, 0.42

Note. Estimates are unstandardized per recommendations from Kenny and colleagues (2006). See Figures 2S and 3S for a graphical depiction of these results. Bold text indicates significant path estimates. V = Veteran, S = Spouse, PPR = perceived partner responsiveness; * significant at p<.05, ** significant at p<.01, *** significant at p<.001.

Table 4. Path estimates for indirect effects of perceived partner responsiveness on pain and sleep quality through positive affect in APIMeM 1 and through negative affect in APIMeM 2.

APIMeM 1: PPR - Positive Affect – Pain and Sleep Quality

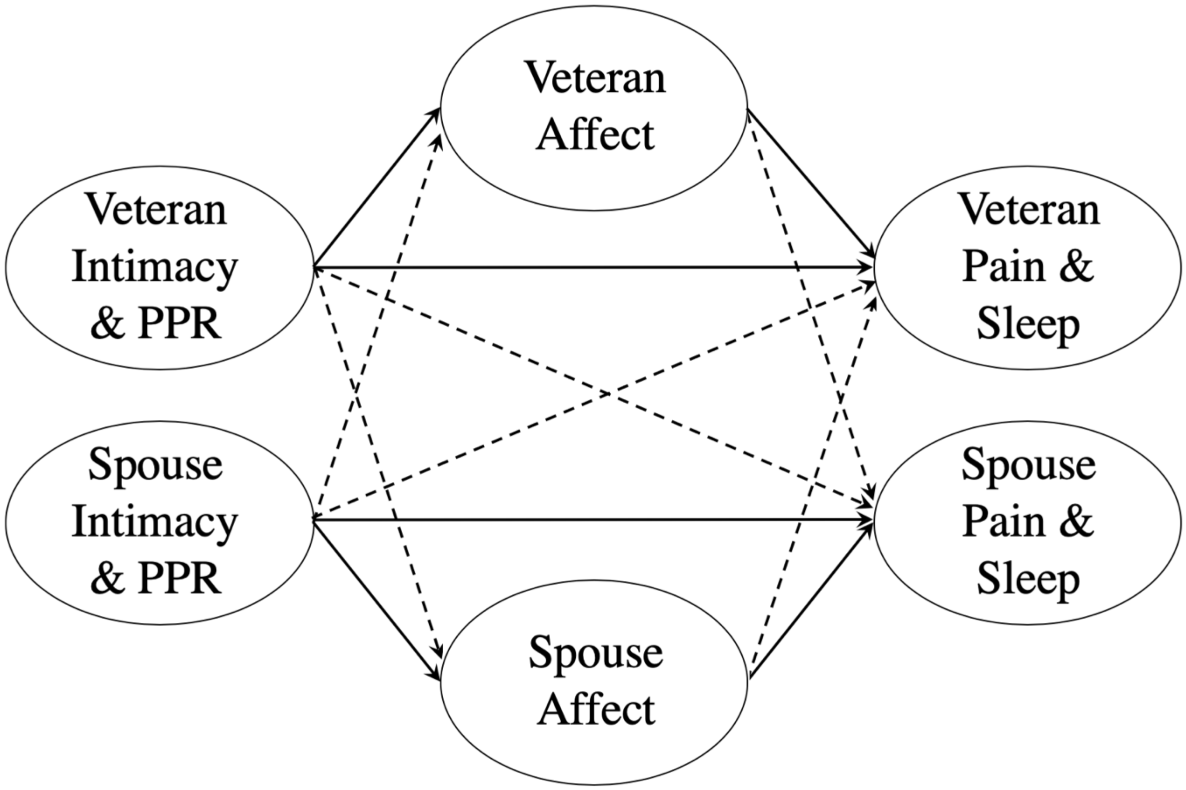
Row	Predictor	Mediator	Outcome	Estimate (SE)	95% CI
1	**V PPR**	**V PA**	**V Pain**	**-1.60** (0.69)**	**-3.23, -0.56**
2	V PPR	S PA	V Pain	0.02 (0.36)	-0.82, 0.72
3	S PPR	V PA	V Pain	-0.37 (0.53)	-1.58, 0.63
4	S PPR	S PA	V Pain	0.06 (0.68)	-1.26, 1.44
5	V PPR	V PA	S Pain	-0.26 (0.47)	-1.20, 0.75
6	V PPR	S PA	S Pain	-0.04 (0.27)	-0.65, 0.51
7	S PPR	V PA	S Pain	-0.04 (0.16)	-0.42, 0.23
8	S PPR	S PA	S Pain	-0.10 (0.50)	-1.03, 0.91
9	**V PPR**	**V PA**	**V Sleep**	**0.05*** (0.02)**	**0.02, 0.08**
10	V PPR	S PA	V Sleep	0.01 (0.01)	-0.01, 0.02
11	S PPR	V PA	V Sleep	0.01 (0.02)	-0.02, 0.05
12	S PPR	S PA	V Sleep	0.01 (0.01)	-0.01, 0.04
13	V PPR	V PA	S Sleep	0.00 (0.01)	-0.03, 0.02
14	**V PPR**	**S PA**	**S Sleep**	**0.04* (0.02)**	**0.01, 0.08**
15	S PPR	V PA	S Sleep	0.00 (0.00)	-0.01, 0.01
16	**S PPR**	**S PA**	**S Sleep**	**0.07*** (0.02)**	**0.03, 0.13**

APIMeM 2: PPR - Negative Affect – Pain and Sleep Quality

Row	Predictor	Mediator	Outcome	Estimate (SE)	95% CI
17	**V PPR**	**V NA**	**V Pain**	**-2.66*** (0.90)**	**-4.77, -1.15**
18	V PPR	S NA	V Pain	0.04 (0.24)	-0.50, 0.60
19	S PPR	V NA	V Pain	-0.82 (0.90)	-2.78, 0.82
20	S PPR	S NA	V Pain	0.77 (0.70)	-0.19, 2.38
21	V PPR	V NA	S Pain	-0.56 (0.48)	-1.74, 0.24
22	V PPR	S NA	S Pain	-0.00 (0.14)	-0.39, 0.23
23	S PPR	V NA	S Pain	-0.13 (0.29)	-0.88, 0.28
24	S PPR	S NA	S Pain	-0.31 (0.47)	-1.28, 0.53
25	**V PPR**	**V NA**	**V Sleep**	**0.03*** (0.01)**	**0.01, 0.07**
26	V PPR	S NA	V Sleep	0.00 (0.01)	-0.01, 0.01
27	S PPR	V NA	V Sleep	0.01 (0.01)	-0.01, 0.04
28	S PPR	S NA	V Sleep	-0.01 (0.01)	-0.04, 0.02
29	V PPR	V NA	S Sleep	0.01 (0.01)	-0.10, 0.17
30	V PPR	S NA	S Sleep	0.00 (0.01)	-0.02, 0.03
31	S PPR	V NA	S Sleep	0.00 (0.01)	-0.01, 0.02
32	**S PPR**	**S NA**	**S Sleep**	**0.05*** (0.02)**	**0.01, 0.10**

Notes. Bold text indicates significant path estimates. V = Veteran, S = Spouse, PPR = perceived partner responsiveness, PA = Positive Affect, NA = Negative Affect; * significant at p<.05, ** significant at p<.01, *** significant at p<.001.

Figure 1. Conceptual model



Conceptual model depicting the theorized actor-partner mediational associations between intimacy and PPR, affect and the health outcomes of pain and sleep quality. The solid lines depict actor effects whereas the dashed lines depict partner effects. The two health outcomes were tested simultaneously in each model whereas the affective mediators were tested in two separate models, one for positive affect and one for negative affect.