Published in final edited form as:

J Psychosom Res. 2015 September ; 79(3): 202–206. doi:10.1016/j.jpsychores.2014.12.018.

The Within-day Relation Between Lonely Episodes and Subsequent Clinical Pain in Individuals with Fibromyalgia: Mediating Role of Pain Cognitions

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Abstract

Objective—This daily diary study of individuals with fibromyalgia (FM) examined whether morning increases in loneliness relate to worsened evening bodily pain through afternoon negative pain cognitions.

Methods—220 participants with FM completed electronic diaries 4 times a day for 21 days to assess loneliness, negative pain cognitions, bodily pain, and social enjoyment. Multilevel structural equation modeling was used to examine within-person relations of morning increases in loneliness, afternoon negative pain cognitions, and evening pain, controlling for morning pain.

Results—On mornings when individuals experienced higher than their usual levels of loneliness, they experienced higher levels of afternoon maladaptive pain cognitions, which in turn predicted increases in evening pain above the level of morning pain. Afternoon maladaptive pain cognitions fully mediated the relations between morning loneliness and evening pain.

Conclusions—Lonely episodes are associated with subsequent increases in negative patterns of thinking about pain, which in turn predict subsequent increases in bodily pain within a day. Because pain cognitions mediate the loneliness—pain link, FM interventions may benefit from addressing individuals' vulnerability to maladaptive cognitions following lonely episodes.

Keywords

daily diary; loneliness; pain cognitions; pain; chronic pain; fibromyalgia

When individuals feel socially disconnected, they experience a sense of loneliness that is associated with poorer psychological and physical health [1-3]. The social pain of loneliness has also been linked to the experience of physical pain. For example, loneliness is associated with chronic back pain [4] as well as chronic pain among cancer patients [5]. Further, exacerbations in one type of pain are accompanied by increases in the other [6-8], at least in

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part due to their shared neurobiological underpinnings [6]. Although links between loneliness and physical pain have been established, the mechanisms driving these connections have not been fully elaborated. Examining these links may be important in informing our understanding of ongoing adaptation to chronic pain.

Beyond their common neurobiological pathways [6], one plausible mechanism linking loneliness and physical pain is via maladaptive cognitions regarding the experience of pain and other stressors. To date, no research has examined the link between loneliness and cognitions in people with chronic pain. Data from healthy individuals indicates that loneliness is associated with lower levels of perceived control and self-efficacy and higher levels of rumination about a lack of control in stressful situations [9-11]. Among people with chronic pain, similar types of negative cognitions regarding pain increase risk for poor outcomes. For example, pain-related catastrophizing, which involves the belief that pain is overwhelming and unbearable, is linked with higher levels of pain and disability in individuals with a chronic pain condition [12, 13]. This is especially true when self-efficacy for managing pain is low [14]. In fact, maladaptive cognitions regarding pain are more potent predictors of physical functioning among individuals with chronic pain than are objective indicators of disease, such as inflammation [15, 16]. Further, negative pain cognitions are a key target of behavioral interventions for chronic pain [17, 18].

Accruing evidence has linked loneliness, maladaptive cognitions, and poor functioning, but the extent to which these associations hold in chronic pain populations has yet to be examined. One avenue forward is to focus on dynamic experiences in everyday life through the intensive examination of within-day experiences of individuals in chronic pain [19]. A previous study by our research group using daily diary data from *a subset of 118* individuals with fibromyalgia (i.e., the earliest enrollees) from the current sample reported associations between daily exacerbations in loneliness and increases in daily bodily pain [20]. The current study builds upon these previous findings by examining cognitive mechanisms that unfold across the day linking lonely episodes with increases in bodily pain, *and doing so in a much larger sample*. The primary goal of the current study is to assess the dynamic relations between lonely episodes, maladaptive pain cognitions, and clinical pain as they unfold over time within a day among individuals with chronic pain. This approach provides a means of elaborating the role of cognition in the process whereby loneliness impacts pain by establishing temporal ordering of the experiences of loneliness, cognitions, and pain. Electronic diary reports measured loneliness and clinical pain in the morning, pain cognitions in the afternoon, and clinical pain at the end of day. Data were collected for 21 days in 220 individuals with chronic pain due to fibromyalgia (FM), a chronic pain condition of unknown etiology characterized by widespread pain, fatigue, and affective disturbance [21-23]. Three hypotheses were tested (depicted in Figure 1): 1) days of higher than usual morning loneliness will predict higher levels of afternoon maladaptive pain cognitions; 2) days of higher than usual levels of afternoon maladaptive pain cognitions will predict higher levels of pain at the end of that day; and 3) afternoon maladaptive pain cognitions will mediate the relation between morning loneliness and end-of-day pain. The hypotheses were tested controlling for morning clinical pain.

Methods

Participants

Individuals with chronic widespread pain were recruited from the Phoenix metropolitan area using newspaper advertisements, online postings, and flyers distributed in physician offices to participate in an ongoing a randomized trial of psychological treatments for FM. Individuals were eligible for participation if they: (1) were between the ages of 18 and 72 years; (2) reported that they had pain for three months or more in at least three of four quadrants of the body, or in two quadrants of the body and substantial sleep disturbance and fatigue; (3) reported pain in at least 11 of 18 tender points during a tender point exam (described below), consistent with diagnostic criteria for FM established by the American College of Rheumatology [23]; (4) did not have any autoimmune pain disorders; (5) were not currently enrolled in other research trials or receiving psychotherapy for pain or mood problems; and (6) were not pursuing litigation related to their pain condition. Seven hundred and sixteen individuals were initially screened by phone. Of those screened, 444 did not meet inclusionary criteria, primarily due to lack of interest and/or time to complete the study requirements. The remaining 272 completed the screening process by undergoing a tender point exam conducted by a research nurse during a home visit. These individuals reported pain in at least 11 of 18 tenderpoints, consistent with the American College of Rheumatology criteria for fibromyalgia [23], and were enrolled in the study. Two hundred and twenty of those enrolled proceeded to complete the initial diary assessments. The majority of the 52 individuals who dropped after enrollment and provided an explanation for their withdrawal cited time constraints as the primary reason. The sample for the current study comprised 220 individuals who were enrolled in the study and completed the pre-intervention diaries (described below).

Procedure

All procedures were approved by Institutional Review Board at Arizona State University. Interested individuals were initially screened by phone regarding their age, pain and fatigue levels, co-morbid autoimmune disorders, and involvement in other research protocols, psychotherapy, and litigation. Individuals who passed initial screening received a home visit from a registered nurse who consented them and administered a tender point exam using a dolorimeter that delivered 4 kg of pressure to each of 18 tender points and 3 control points [23]. To qualify for study enrollment, participants had to report experiencing pain in response to pressure on at least 11 of 18 tenderpoints.

Upon enrollment, participants completed an initial questionnaire packet that included measures of physical health, emotional health, and bodily pain. Participants were subsequently interviewed by phone regarding depressive symptoms and exposure to traumatic life events, and then completed pre-intervention assessments that included: (1) a laboratory assessment of physiological and affective responses to pain and emotion stimuli; (2) 21 days of diary reports regarding interpersonal events, loneliness, pain, fatigue, sleep quality, mood, and coping; and (3) questionnaires regarding current symptoms and physical and emotional functioning. Participants were then randomly assigned to one of three 7-week treatment conditions. Following completion of treatment, they underwent post-intervention

assessments identical to those in pre-assessment, and completed six- and twelve-month follow-up questionnaires. The current study drew on pre-intervention diary assessment data.

To initiate the pre-intervention diary assessment, a member of the research team met with participants to provide them with a cell phone and detailed instructions and training on how to complete the phone diaries. Participants were prompted to complete diary reports four times per day for up to 21 days via an automated system that called the cell phone, delivered audio-recorded questions, and collected responses via phone keypad input from participants. The morning call time was chosen by the participant to occur 30 minutes after usual wake time, and the remaining calls occurred at 11:00am (late morning call), 4pm (afternoon call), and 7:00pm (evening call). The call upon awakening only assessed sleep and was therefore not included in the study analyses. The remaining three calls (i.e., late morning, afternoon, and evening) were used in analyses. If participants missed a call, they could call into the system within three hours of the automated call to complete the questions. The average time interval between 4 pm and end-of-day calls across 3374 observations was 3 hours, 24 minutes (SD = 1 hour, 5 minutes; range = 17 minutes to 7 hours, 44 minutes). Call completions were monitored by study staff members, who routinely checked in with each participant on his/her progress. If participants missed calls across two days, they were contacted immediately by study staff members to remedy any potential barriers to consistent completion. Participants were paid \$2 for each day they completed diaries, with a bonus of \$1/day for rates of completion that were >50%. Participants completed 11,469 out of a total of 13,860 possible observations (83%). Pain and loneliness were assessed in the morning, pain cognitions were assessed in the afternoon, and pain was assessed again in the evening. The effect of morning pain on afternoon pain cognitions was included in the model to control for the possibility of pain cognition scores being due to pain earlier in the day.

Measures

Pain—Clinical pain was measured on a 101-point numerical scale used in numerous studies of chronic pain [24]. Participants were asked, “What was your overall level of pain?” during the last 2-3 hours for the late morning call and across the day for the evening call. Pain was rated on a scale of 0 (no pain) to 100 (pain as bad as it can be).

Loneliness—Loneliness in the last 2-3 hours for the late morning call was measured with the question, “How lonely did you feel?” Scores were rated on a 5-point scale from 1 (not at all) to 5 (completely).

Negative Pain Cognitions—Negative pain cognitions in the last 2-3 hours of the afternoon were measured using three items rated on a 5-point scale from 1 (not at all) to 5 (completely). Cognitions included pain catastrophizing, pain irritation, and self-criticism. Pain catastrophizing was assessed by asking participants to rate the statement, “You felt your pain was so bad you couldn't stand it anymore” and was drawn from the Pain Catastrophizing Scale [25]. Pain irritation was assessed with the item: “How much were you irritated by your pain” and self-criticism was assessed with the item: “How much have you told yourself that you shouldn't be feeling the way you're feeling about pain.” All items

were coded so that higher scores indicated greater intensity of maladaptive pain cognitions. The within-person reliability across the three pain cognition items was .58.

Data Analysis

Because the data have a hierarchical structure with up to 21 daily observations nested within each of the 220 participants, the hypotheses were tested using multi-level structural equation modeling (MSEM). Full information maximum likelihood (FIML) was employed to estimate direct and mediated models. This estimation routine separates the total variance into two independent components: within-person and between-person components. The within-person component is equivalent to person-centering. These two components are simultaneously modeled to produce unbiased parameter estimates and standard errors. This model includes an analysis of both within-person (e.g., “when” people are lonely) and between-person (e.g., “who” feels lonely) levels (see Figure 1). FIML via an accelerated EM algorithm routine used in Mplus version 7 is robust to non-normality, missing data, and unbalanced cluster size of data [26, 27].

Although the MSEM analysis tested both within and between-person models, the focus of the current paper is on the within-person relations, and therefore only the within-person findings are reported. Loneliness and clinical pain were measured variables and the factor representing negative pain cognitions was latent. The path from morning loneliness to afternoon pain cognitions (the a_1 path in the mediational chain), the path from morning pain to afternoon pain cognitions (the a_2 path in the mediational chain), the path from afternoon pain cognitions to end-of-day pain (the b path in the mediational chain), and the mediated path (i.e., the $a_1 b$ path and the $a_2 b$ path in Figure 1) were estimated. The mediated (indirect) effect for each predictor (i.e., morning pain and loneliness) was computed using the product of the coefficients of the relevant a and b paths. The distribution of the ab paths are asymmetrical and vary across the values of the correlation between the a and b paths. Therefore, it is important to incorporate these correlations into analyses to obtain unbiased inference statistics [28]. The asymmetric confidence intervals for the mediating effects in these MSEMs were computed using RMediation [29].

Results

Sample Characteristics and Descriptive Analyses

The mean age of participants was 51 years ($SD = 11.02$). Most participants were female (87%), married or partnered (56%), Caucasian (78%), and employed (51%). The modal years of education was 1-3 years of college. The modal annual family household income of participants was between \$30,000 and \$39,999.

Means, standard deviations, and intraclass correlations of study variables are presented in Table 1. Intercorrelations for within-person measures are presented in Table 2. In general, mornings of elevated pain and loneliness were characterized by higher levels of negative pain cognitions in the afternoon and of pain in the evening. Elevations in maladaptive pain cognitions were also related to higher evening pain.

Within-person Analyses of Relations from Morning Loneliness to Afternoon Pain Cognitions to End-of-day Pain

We tested whether afternoon pain cognitions mediated the relation between morning loneliness and evening pain, as well as between morning pain and evening pain (See Figure 1). The within-person results were consistent with our predictions. Days of higher than usual levels of morning loneliness predicted higher levels of afternoon maladaptive cognitions, a_1 path ($p < .001$), which, in turn, predicted higher levels of end-of-day pain, b path ($p < .001$). Higher than usual levels of morning loneliness did not predict evening pain after afternoon negative pain cognitions were taken into account, c_1' path ($p = .67$). Thus, the relation between morning loneliness and end-of-day pain was significantly and fully mediated by afternoon maladaptive pain cognitions ($a_1b = 1.16$, $SE = .25$, $p < .001$), reflected in the asymmetric confident intervals of the mediated path of cognitions [.68, 1.69], taking into account the correlation between the a_1 and b paths of .06.

Days of higher than usual morning pain levels predicted higher levels of afternoon maladaptive cognitions, a_2 path ($p < .001$), which, in turn, predicted higher levels of end-of-day pain, b path ($p < .001$). Higher than usual morning pain levels significantly predicted evening pain even after afternoon negative pain cognitions were taken into account, c_2' path ($p < .000$). Therefore, the relation between morning pain and end-of-day pain was significant, but only partially mediated by afternoon maladaptive pain cognitions ($a_2b = .17$, $SE = .02$, $p < .001$), reflected in the asymmetric confident intervals of the mediated path of cognitions [.14, .20], taking into account the correlation between the a_2 and b paths of -.15.

Further, we contrasted the a paths to determine whether morning loneliness or morning pain had a stronger effect on afternoon pain cognitions. The a_1 path was stronger than the a_2 path indicating that morning loneliness had a stronger effect on afternoon pain cognitions compared to morning pain (estimate = .07, $SE = .02$, $p < .000$). Lastly, we contrasted the mediation effects to determine whether afternoon pain cognitions were a stronger mediator between morning loneliness and evening pain (a_1b) or between morning pain and evening pain (a_2b). Results indicated that pain cognitions more strongly mediated the path between morning loneliness and evening pain (a_1b) than the path between morning pain and evening pain (a_2b) (estimate = .99, $SE = .25$, $p < .000$).

Discussion

The current study sought to determine whether daily increases in morning loneliness relate to increases in evening reports of bodily pain through afternoon pain cognitions, over and above the influence of morning bodily pain among individuals with FM. On mornings when individuals experienced higher than their usual levels of loneliness or bodily pain, they experienced more intense maladaptive pain cognitions, such as catastrophizing about pain, which in turn, predicted higher evening pain levels. Further, negative pain cognitions in the afternoon fully mediated the relations between increases in morning loneliness and higher levels of evening bodily pain and partially mediated the relations between increases in morning bodily pain and higher levels of evening bodily pain. These results are in line with those derived from healthy individuals linking loneliness to negative cognitions about

managing stress [11], as well as findings derived from patients with chronic pain tying negative pain cognitions to bodily pain [12].

Our findings suggest that one way social pain, in the form of loneliness, may be associated with increased physical pain lies in its link with the way individuals subsequently think about their pain. Feeling lonely may propel individuals into a spiral of maladaptive thinking about and poor coping with their pain as the day goes on. This process may then fuel higher levels of bodily pain at the end of the day. Further, the links between increased morning loneliness, afternoon pain cognitions, and subsequent bodily pain exists even when accounting for increased morning bodily pain earlier. This suggests that in addition to bodily pain, social pain may be an important influence on how individuals cope with their pain across the day.

The current study has some important limitations. First, loneliness was assessed with a one item measure rather than a comprehensive scale [30]. Using a multidimensional scale of loneliness could provide a more nuanced evaluation of the aspects of loneliness that are relevant for pain management. Similarly, more extensive measures of pain cognitions beyond the three items used in the current study may offer more information about how lonely people think about their pain. However, the use of few questions to assess loneliness and cognitions reduces participant burden during daily diaries, allowing for more frequent daily assessments of these constructs so that the impact of fluctuating levels can be seen across the day. Second, the sample comprised individuals with FM who were seeking treatment so the sample may not be generalizable to all chronic pain populations. However, participants in the current study share similar pain levels and demographics to chronic pain samples in other studies [21, 31-33] suggesting that loneliness may function similarly across chronic pain populations. Third, due to the correlational nature of the data, we cannot make causal statements about the relations among the variables. Although temporal precedence is established by the sequence of within-day measures, only experimental manipulation of loneliness or pain experiences can establish a causal relation between these experiences, pain cognitions, and subsequent pain. In particular, the impact of loneliness on pain cognitions and bodily pain over and above the influence of pain levels should be replicated, preferably using an experimental paradigm. Fourth, as is typical of relations among variables in daily diary studies, the within-day associations in the study are small; the clinical meaning of relations of this magnitude remains to be determined. Finally, participants were able to complete diary calls at different times throughout the day if they missed the scheduled call, which introduces variation in the time between responses within day. However, such flexibility in call completion also allows for a balance of capturing life as it is lived with adequate consistency across participants by requiring them to complete calls within a similar, albeit not identical, time frame.

The study also has some important strengths. Perhaps most noteworthy is that multiple assessments within a day permitted temporal ordering of the predictor, mediator, and outcome to examine the dynamic loneliness-pain relation. Moreover, assessment of daily experiences increases the ecological validity of the findings. Perceived social context has been linked with a host of health outcomes. The current findings suggest that one such context, the experience of loneliness, may have implications for daily symptom

management. In particular, how individuals with FM think about their pain episodes when they are feeling lonely may be one mechanism by which loneliness increases their pain. Thus, interventions for FM may benefit from incorporating strategies that help individuals to deal not only with the general loneliness and bodily pain that comes from having a pain condition, but also with the challenges associated with lonely episodes as a way to prevent greater bodily pain. Helping individuals limit the maladaptive thoughts that may result from loneliness flares represents one potential intervention strategy. Such strategies are in line with findings from treatment studies for lonely individuals suggesting that interventions need to address maladaptive cognitions that prevent beneficial social interactions [34]. The current study findings further suggest that it is not only social cognitions, but pain cognitions as well, that need to be addressed among those with chronic pain. Teaching individuals with chronic pain who are feeling lonely both to think more adaptively and to reach out to others for support may be key to weakening the link between social and physical pain. Future research can provide insight into the potential cognitive and social coping strategies that may be effective in reducing the impact of lonely flares on pain cognitions and bodily pain among individuals with FM.

Acknowledgments

This study was supported by grant R01 AR053245 from the National Institute of Arthritis and Musculoskeletal and Skin Diseases.

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Highlights

- We examined the impact of loneliness on pain cognitions and bodily pain in fibromyalgia.
- Analyses included multilevel structural equation modeling of daily diary data.
- Increases in morning loneliness predicted more intense afternoon negative pain cognitions.
- Afternoon negative pain cognitions predicted worsened evening pain.
- Afternoon pain cognitions mediated the relations between morning loneliness and evening pain.

Note: Coefficients are displayed with standard errors in parentheses. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 1.

Morning loneliness predicting end of day pain mediated by afternoon negative pain cognitions.

Note: Coefficients are displayed with standard errors in parentheses. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 1

Means, Standard Deviations, and Intraclass Correlations (n = 220)

Measures	<i>M</i>	<i>SD</i>	<i>ICC</i>
Morning Pain	48.90	24.30	.49
End-of-day Pain	53.68	24.08	.54
Loneliness	1.67	1.07	.47
Catastrophizing	2.17	1.14	.51
Pain Irritation	2.86	1.31	.54
Self-criticism	2.24	1.39	.70

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

Table 2

Intercorrelations of Within-person Study Variables (n=220)

Measures	1	2	3	4	5	6
1. Morning Pain	-					
2. End-of-day Pain	.45	-				
3. Loneliness	.16	.12	-			
4. Catastrophizing	.31	.42	.10	-		
5. Pain Irritation	.27	.38	.14	.45	-	
6. Self-criticism	.13	.16	.10	.22	.31	-

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