Health Psychology
2011, Vol. 30, No. 1, 129–133

0278-6133/11/$12.00 DOI: 10.1037/a0021558

BRIEF REPORT

Naturalistically Observed Sighing and Depression in Rheumatoid Arthritis Patients: A Preliminary Study

Megan L. Robbins, Matthias R. Mehl, Shannon E. Holleran, and Shelley Kasle
University of Arizona

Objective: This study tested the degree to which naturalistically observed sighing in daily life is a behavioral indicator of depression and reported physical symptoms (i.e., experienced pain and flare days) in rheumatoid arthritis (RA) patients. ***Design:*** Thirteen RA patients wore the Electronically Activated Recorder (EAR), an observational ambulatory assessment tool, for two weekends (Friday through Sunday) approximately one month apart. The EAR periodically recorded snippets of ambient sounds from participants' momentary environments (50 s every 18 min). Sighs were coded from the sampled ambient sounds. ***Main Outcome Measures:*** Depression was assessed with the Center for Epidemiological Studies Depression Scale and the Beck Depression Inventory. Pain during the past month was assessed with a 10-cm visual-analog scale, and number of flare days during the prior 6 months was reported. ***Results:*** Sighing was significantly and strongly related to patients' levels of depression and nonsignificantly and less strongly related to their reported pain and number of flare days. ***Conclusion:*** The findings suggest that sighing can serve as an observable marker of depression in RA patients. Because the sample size was small, the findings should be considered preliminary.

Keywords: ambulatory assessment, ecological momentary assessment, electronically activated recorder, emotion

Rheumatoid arthritis (RA) is a chronic systemic inflammatory disorder characterized by pain and destruction of peripheral joints. As with physical health, RA exacts a heavy toll on mental health. About 40% of RA patients develop comorbid depression (Covic, Tyson, Spencer, & Howe, 2006), which tends to exacerbate disease activity and undermine health-related quality of life (Zautra, Burleson, Matt, Roth, & Burrows, 2004). Because depression most immediately affects people's inner moods and cognitive landscapes, it is often "invisible" to outsiders. Thus, depression's privacy can impede its early detection and thereby its adequate treatment. These issues are compounded when the social stigma surrounding depression leads patients to intentionally hide symptoms (National Institute of Mental Health, 2001). Therefore, identifying observable behavioral markers of depression is an important scientific endeavor with theoretical and clinical implications (Mehl, 2006).

This study sought to identify an observable behavioral marker of depression in RA patients. To focus on behavior that is accessible to outside observers, we employed a novel naturalistic observation sampling methodology, the Electronically Activated Recorder (EAR; Mehl, Pennebaker, Crow, Dabbs, & Price, 2001). The EAR is a digital audio recorder that periodically samples brief snippets of ambient sounds from participants' momentary environments. Participants wear the EAR while going about their lives, providing an "acoustic log" of their days as they naturally unfold.

Sighing is a behavior that has been phenomenologically defined as "an obvious exaggerated exhalation of breath" (Keefe & Block, 1982, p. 366), and it has been physiologically defined as a breath that is "at least 500 mL larger than the mean of the prior three breaths and at least 400 mL larger than the following breath" (Abelson, Weg, Nesse, & Curtis, 2001, p. 589). As such, sighing is a subtle expression that is potentially detectable by the EAR. Despite its intuitive tie to constructs such as psychological distress and depression, sighing has so far received very little scientific attention. The scarce research that exists on sighing suggests that it is conceptually and empirically linked to negative affect (Roth, 2005; Wilhelm, Trabert, & Roth, 2001). In-lab studies have shown that panic disorder patients sigh significantly more often than control participants (e.g., Abelson et al., 2001; Wilhelm et al., 2001), suggesting that sighing may be an indicator of anxiety. Further, in research with chronic pain patients, sighing is often used as a pain behavior. For example, Keefe and Block (1982) found spontaneous sighing during a physical exam to be correlated with pain ratings. Finally, Teigen (2008) found that healthy participants sighed frequently during a difficult or impossible in-lab task.

Accepted under the editorial term of Robert M. Kaplan.

Megan L. Robbins, Matthias R. Mehl, and Shannon E. Holleran, Department of Psychology, College of Science, University of Arizona; Shelley Kasle, Arizona Arthritis Center, University of Arizona.

This research was supported by an intramural seed grant, NIH Grant R03CA137975 (Matthias R. Mehl), and an Arthritis Foundation grant (Shelley Kasle).

Correspondence concerning this article should be addressed to Megan L. Robbins, Department of Psychology, College of Science, University of Arizona, P.O. Box 210068, Tuscon, AZ 85721-0068. E-mail: mrobbins@email.arizona.edu

The scarcity of research on sighing seems partly due to methodological challenges surrounding its assessment. Global and retrospective self-reports asking participants to report how often they sigh are problematic given that people tend to be unaware of when and how much they sigh (Teigen, 2008). Even ecological momentary assessments (Ebner-Priemer & Trull, 2009; Conner et al., 2006) struggle in the case of sighing, as the act of monitoring and reporting sighs can reactively affect its measurement and undermine its validity (e.g., via inducing self-awareness). The EAR allows for an unobtrusive observational assessment of subtle and highly automatic behaviors, such as sighing, in their natural ecological context (Mehl, Vazire, Holleran, & Clark, 2010; Mehl, Vazire, Ramírez-Esparza, Slatcher, & Pennebaker, 2007).

The present study tested whether sighing is an observable marker of depression in RA patients. Participants wore the EAR for two weekends separated by one month. The frequency with which they sighed in their daily lives was determined from the sampled ambient sounds. Depression and physical symptoms were assessed with self-reports.

The study addressed the following research questions: (1) To what extent is sighing related to depression? Consistent with the notion that sighing expresses negative affect (Wilhelm et al., 2001), we predicted that sighing would be positively related to depression. (2) To what extent is sighing related to the experience of physical symptoms? Based on prior research with chronic pain patients (Keefe & Block, 1982), we predicted that sighing would be positively related to physical symptoms.

Method

Participants

Thirteen married female RA patients living in the larger Tucson, Arizona area were recruited for this study from a larger prospective study (Kasle, Wilhelm, & Zautra, 2008). The sample size was constrained by the limited funds that were available for this project from a small intramural seed grant. The average age was 56 years (SD = 13). Twelve patients were Caucasian and one was Latina. The mean RA duration was 6.9 years (SD = 4.3).

Procedures

In the initial session, which was scheduled for a Friday afternoon, participants were informed that the purpose of the study was to investigate how arthritis affects patients' daily lives. Sighing was not mentioned as a topic of investigation. They provided written consent, which included the permission to use their data from the prospective study. They then completed a questionnaire battery that included a measure of depression. Next, they were informed about the EAR and were asked to wear it for the weekend, from the time they left the lab until they went to bed Sunday night. The device was then activated. Participants returned the devices early the next week and scheduled a 1-month follow-up for a second EAR-monitoring with identical procedures.

EAR Monitoring

The EAR consisted of a Personal Digital Assistant (PDA; Dell Axim ×50) that ran the EAR software and a lapel microphone (RadioShack Tie-Clip Omnidirectional Microphone). The EAR software was programmed to record 50 s every 18 min. Each participant carried the PDA in a shock-protected case clipped to her waistline and the microphone was clipped to her shirt. They were encouraged to wear the EAR as much as possible during their waking hours. It was impossible for participants to sense when the EAR was recording. At the end of the study, they had an opportunity to review their recordings and erase any parts of them. Only one participant erased one sound file. The sampling resulted in a total of 2,948 compliant (i.e., coded as wearing the EAR), waking (i.e., not coded as sleeping) sound files or, on average, 115 (SD = 31) compliant, waking sound files per person during the first weekend and 121 (SD = 19) during the second weekend—indicating that compliance was high and comparable to past EAR studies (Mehl & Holleran, 2007).

Measures

Depression. Depression was assessed in two ways. First, the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) was administered prior to each EAR monitoring to assess current depressive symptoms. Participants' scores were aggregated into a measure of depression over the 1-month period. Second, depression data were also obtained from the prospective study (see Figure 1 for a study timeline). There, participants completed the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), to assess depressive symptoms over the past week, twice separated by 6 months with the first CES-D assessment being on average 68 days (SD = 20 days) prior to the first BDI assessment. Participants' scores were aggregated into a measure of depression over the 6-month period. Participants' aggregated BDI and CES-D scores were correlated, r = .90 (see Table 1 for reliability information and descriptive statistics for all measures).

Physical symptoms. Data on participants' physical symptoms were obtained from the prospective study. Participants reported the degree of pain they had experienced during the past month using a 10-cm visual-analog scale (0 = *no pain*; 100 = *worst pain*). Participants also reported the number of flare days they had experienced during the prior 6 months. A flare was defined as a period of at least 7 days in which symptoms, including pain, stiffness, and fatigue, were considerably worse than the preceding weeks. Both measures were assessed twice, separated by approximately 6 months. Participants' aggregated reports of pain and flare days were correlated, r = .50 (see Table 1).

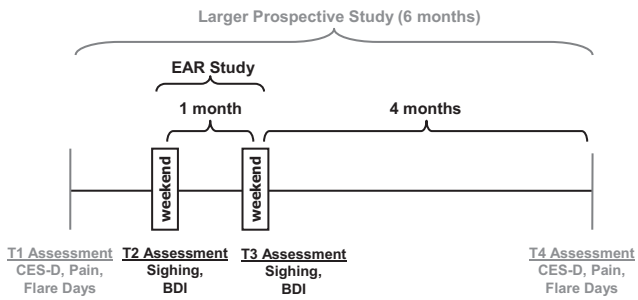

Figure 1. Timeline for the larger prospective study and the EAR study.

Table 1
Reliability Information and Descriptive Statistics About the Study Measures

	Reliability		Descriptive statistics		
Parameters	Int. Cons.	r_{tt}	*M* (*SD*)	Min	Max
Depression					
BDI	.94[a]	.89*	7.8 (5.9)	0.5	19.5
CES-D	.95[a]	.92*	12.3 (11.2)	2.0	41.5
Physical symptoms					
Pain	—	.46	37.4 (25.9)	4.5	72.5
Flare days	—	.84*	18.7 (30.4)	0.0	110.0
Observed behavior					
Sighing	.84[b]	.52	3.2 (2.0)	0.6	7.8

Note. BDI scores are averages based on two assessments approximately one month apart. CES-D scores, flare days, and pain reports are averages based on two assessments approximately six months apart. The sighing measure is the average of two weekend EAR monitoring sessions approximately one month apart. Int. Cons. = internal consistency; r_{tt} = test–retest reliability; Min = minimum; Max = maximum.
[a] Reliability is Cronbach's alpha. [b] Reliability is intraclass correlation (ICC[2,1]).
* $p < .01$.

Sighing. Each sound file was double-coded for whether or not participants audibly sighed. The codings were aggregated across all of a participant's compliant waking sound files. The number of sighs per hour was estimated from the aggregated measure by multiplying it by 3600 s per hour divided by 50 s per sound file (see Table 1).[1]

Results

As shown in Panel A of Figure 2, sighing was strongly related to participants' levels of depression.[2] This was true for both the BDI assessments, which spanned approximately 1 month ($r = .71$, $p = .01$), and the CES-D assessments (from the prospective study), which spanned approximately 6 months ($r = .68$, $p = .01$).

Further, sighing was moderately, yet nonsignificantly, related to participants' physical symptoms. Sighing was correlated, $r = .40$, with their reported pain and, $r = .41$, with the number of flare days. Due to the small sample size, these correlations failed to meet conventional standards for statistical significance ($ps > .15$; Panel B of Figure 2). Finally, we compared the magnitude of the sighing–depression correlations to the sighing–physical symptoms correlations using Hotelling's *t* test (with Williams Modification; one-tailed). The results of this exploratory analysis indicated that sighing was significantly more strongly related to depression than to the number of flare days (BDI: $p = .04$; CES-D: $p = .02$). The respective tests for reported pain approached significance (BDI: $p = .07$) and just failed to be statistically significant (CES-D: $p = .11$).

Discussion

This study tested whether sighing is an observable marker of depression in RA patients. Using a novel, naturalistic observation sampling method, we found that the frequency with which participants sighed in their daily lives was strongly and robustly related to their levels of depression. More sighing was also moderately but not reliably related to more physical symptoms. Finally, there was an interesting exploratory trend for sighing to be more closely linked to depression than to physical symptoms.[3]

Our finding that sighing is related to depression is consistent with past literature linking sighing to negative affect (Roth, 2005; Wilhelm et al., 2001). However, our exploratory finding that sighing was more closely related to depression than pain appears to contradict Keefe and Block's (1982) finding that sighs occur more frequently among chronic pain patients than depression patients. However, this study did not correlate sighing frequency with depressive symptoms but instead compared overall sighing rates across groups. Therefore, it is possible that our findings complement Keefe and Block's (1982) findings such that *among* chronic pain patients, like *among* those with RA, higher sighing rates may be associated with more experienced depressive symptoms.

On the surface, our results also seem to contradict experimental evidence that sighing follows relief, rather than distress states, in rats (Soltysik & Jelen, 2005) and humans (Vlemincx et al., 2009). In this context, it is important to consider that our between-person effects are conceptually and empirically independent of potential within-person associations between affect and sighing. In other words, it is possible that instances of sighing indicate (i.e., precede) a state of relief within a person and that more frequent sighing is related to higher levels of depression among individuals, presumably because they indicate a more frequent *need* for temporary relief.

Limitations

First, the small sample size limited the statistical power of our tests, precision of the parameter estimates, and generalizability of the results. Therefore, the findings must be interpreted cautiously

[1] To validate that sighing is acoustically detectable, four coders who were blind to the research question coded segments of social interaction videos from a past in-lab study. Two coders coded sighing from both the audio and visual channels. Two other coders coded sighing based on the audio channel only. To emulate the EAR paradigm, 81 50-s segments (roughly the equivalent of one day of EAR recording) were sampled from the videos. Consistent with the idea that sighing is acoustically detectable, the intercoder agreement among the two audio-only coders (ICC[2,k] = .79) was highly comparable to the intercoder agreement among the two audiovisual coders (ICC[2,k] = .64).

[2] The larger study included a measure of anxiety, the Beck Anxiety Inventory (Beck et al., 1988). The correlation between sighing and anxiety was substantial in magnitude but only marginally significant ($r = .52$, $p = .07$).

[3] An alternative explanation for why sighing was more strongly related to depression than to physical symptoms could be a greater reliability of the depression measures compared to the physical symptom measures. Whereas the test–retest reliability of the pain measure was lower than that of the depression measures, the flare-days measure and the BDI had comparable test-retest reliabilities. Further, the more stable flare-days measure did not correlate more strongly with depression than the less stable pain measure. Finally, a highly internally consistent physical disability measure (Health Assessment Questionnaire; $\alpha = .93$) correlated with sighing at a level comparable to what we found with the pain and flare-days measures ($r = .37$, $p = .21$). Thus, reliability differences are unlikely to explain why sighing correlated more strongly with depression than with pain.

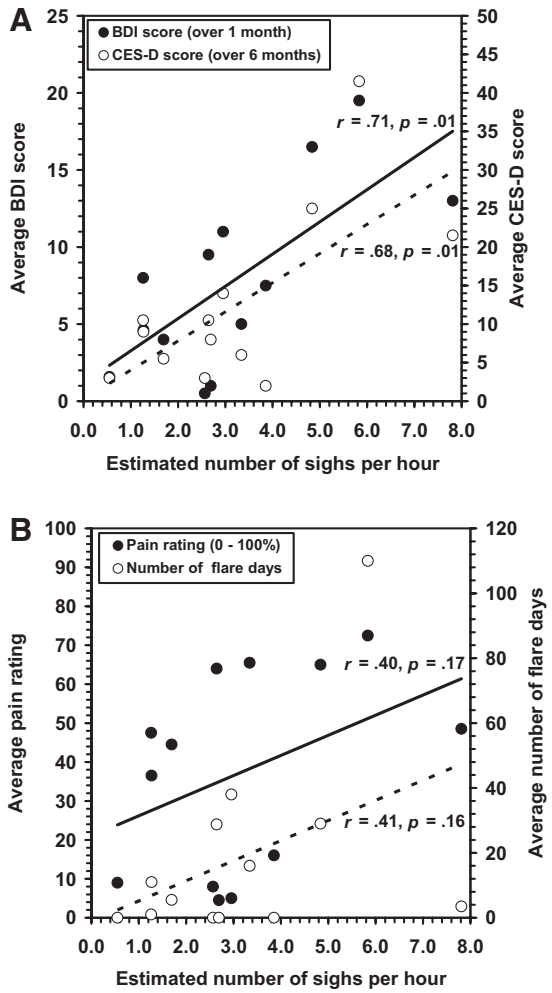

Figure 2. Scatterplots and linear trends for the regression analyses predicting participants' levels of depression (A) and physical symptoms (B) from their sighing.

and considered preliminary in nature. Yet, sighing is an important affect-associated expressive behavior that is rarely studied empirically. Therefore, the fact that the relationship between ecologically assessed (i.e., naturalistically observed) sighing and self-reported depression emerged significantly and robustly across two measures of depression over periods of 1 and 6 months speaks to the potential generalizability of the effect. Future research should replicate the results using larger samples of female and male RA patients, including clinical assessments of depression and objective measures of symptom severity (Evers et al., 2003; Zautra et al., 2004).

Another important question for future research concerns the degree to which sighing is related to depression and pain in samples without their comorbidity. An EAR study comparing clinically depressed patients to chronic pain patients could determine whether sighing is primarily a pain behavior (as suggested by Keefe & Block, 1982), primarily a depression behavior, or whether it occurs most frequently when both are present. Though sighing has traditionally been construed as a pain behavior, Keefe, Wilkins, and Cook (1984) found that when it was considered in a model of several pain behaviors to predict pain levels, sighing did not significantly contribute to the model. In conjunction with our results, this suggests that sighing may be a sign of depressive symptoms among chronic pain patients, though more solid evidence is needed.

Further, while employing state-of-the-art observational ambulatory assessments for sighing, we used less-than-optimal retrospective assessments for physical symptoms. An ideal study would collect experience sampling or daily diary data on pain and emotions concurrently with the EAR assessment (Conner et al., 2006).

Finally, the EAR method is limited in capturing certain clinically relevant aspects of sighing. For example, breath holding often happens when people feel threatened, which may be an important precursor to sighing (Wilhelm et al., 2001) that distinguishes it from other exhalations, like yawning. Using a multimethod approach combined with respiratory monitoring would help in the investigation of such clinically important aspects of sighing and also help discriminate sighs from other exhalations.

Another potential mechanism underlying the sighing–depression link is disengagement as a coping response. This idea is supported by Teigen's study (2008) in which participants listed "giving up" as the most common reason for sighing. Disengagement is an emotion-focused coping strategy that people use when they appraise a stressful situation as out of their control (Folkman & Lazarus, 1980). It is a common coping strategy among RA patients because of the disease's chronic and debilitating nature, and it is related to poorer adjustment (Covic et al., 2006). This mediational pathway between sighing and depression should be tested in a study with a larger sample.

As an observable marker of depression, sighing can provide an important signal to patients' social support networks that help is needed (Roth, 2005). Martire et al. (2006) found that partners' accurate perceptions of arthritis patients' pain was considered helpful by the patients. Thus, a critical step toward providing adequate support—the beneficial effects of which are well documented (Holtzman & DeLongis, 2007; Kasle, Wilhelm, & Zautra, 2008; Zautra et al., 1994)—is to accurately perceive symptoms that require help. Our findings suggest that sighing can be an important cue for this.

References

Abelson, J. L., Weg, J. G., Nesse, R. M., & Curtis, G. C. (2001). Persistent respiratory irregularity in patients with panic disorder. *Biological Psychiatry, 49,* 588–595.

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology, 56,* 893–897.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4,* 561–571.

Conner, T. S., Tennen, H., Zautra, A. J., Affleck, G., Armeli, S., & Fifield, J. (2006). Coping with rheumatoid arthritis pain in daily life: Within-person analyses reveal hidden vulnerability for the formerly depressed. *Pain, 126,* 198–209.

Covic, T., Tyson, G., Spencer, D., & Howe, G. (2006). Depression in rheumatoid arthritis patients: Demographic, clinical, and psychological predictors. *Journal of Psychosomatic Research, 60,* 469–476.

Ebner-Priemer, U. W., & Trull, T. J. (2009). Ecological Momentary

Assessment of mood disorders and mood dysregulation. *Psychological Assessment, 21,* 463–475.

Evers, A. W., Kraaimaat, F. W., Geenen, R., Jacobs, J. W., & Bijlsma, J. W. (2003). Pain coping and social support as predictors of long-term functional disability and pain in early rheumatoid arthritis. *Behaviour Research and Therapy, 41,* 1295–1310.

Folkman, S., & Lazarus, R. S. (1980). An analysis of coping in a middle-aged community sample. *Journal of Health and Social Behavior, 21,* 219–239.

Holtzman, S., & DeLongis, A. (2007). One day at a time: The impact of daily satisfaction with spouse responses on pain, negative affect and catastrophizing among individuals with rheumatoid arthritis. *Pain, 131,* 202–213.

Kasle, S., Wilhelm, M. S., & Zautra, A. J. (2008). Rheumatoid arthritis patients' perceptions of mutuality in conversations with spouses/partners and their links with psychological and physical health. *Arthritis and Rheumatism, 58,* 921–928.

Keefe, F. J., & Block, A. R. (1982). Development of an observation method for assessing pain behavior in chronic low back pain patients. *Behavior Therapy, 13,* 363–375.

Keefe, F. J., Wilkins, R. H., & Cook, W. A. (1984). Direct observation of pain behavior in low back pain patients during physical examination. *Pain, 20,* 59–68.

Martire, L. M., Keefe, F. J., Schulz, R., Ready, R., Beach, S., Rudy, T., & Starz, T. (2006). Older spouses' perceptions of partners' chronic arthritis pain: Implications for spousal responses, support provision, and caregiving experiences. *Psychology and Aging, 21,* 222–230.

Mehl, M. R. (2006). The lay assessment of subclinical depression in daily life. *Psychological Assessment, 18,* 340–345.

Mehl, M. R., & Holleran, S. E. (2007). An empirical analysis of the obtrusiveness of and participants' compliance with the Electronically Activated Recorder (EAR). *European Journal of Psychological Assessment, 23,* 248–257.

Mehl, M. R., Pennebaker, J. W., Crow, M. D., Dabbs, J., & Price, J. H. (2001). The Electronically Activated Recorder (EAR): A device for sampling naturalistic daily activities and conversations. *Behavior Research Methods, Instruments, and Computers, 33,* 517–523.

Mehl, M. R., Vazire, S., Holleran, S. E., & Clark, C. S. (2010). Eavesdropping on happiness: Well-being is related to having less small talk and more substantive conversations. *Psychological Science, 21,* 539–541.

Mehl, M. R., Vazire, S., Ramírez-Esparza, N., Slatcher, R. B., & Pennebaker, J. W. (2007). Are women really more talkative than men? *Science, 317,* 82.

National Institute of Mental Health. (2001). *The invisible disease: Depression* (NIH Publication No. 01-4591). Retrieved from http://www.nimh.nih.gov/publicat/invisible.cfm

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1,* 385–401.

Roth, W. T. (2005). Physiological markers for anxiety: Panic disorder and phobias. *International Journal of Psychophysiology, 58,* 190–198.

Soltysik, S., & Jelen, P. (2005). In rats, sighs correlate with relief. *Physiology & Behavior, 85,* 598–602.

Teigen, K. H. (2008). Is a sigh "just a sigh"? Sighs as emotional signals and responses to a difficult task. *Scandinavian Journal of Psychology, 49,* 49–57.

Vlemincx, E., Van Diest, I., De Peuter, S., Bresseleers, J., Bogaerts, K., Fannes, S., . . . Van Den Bergh, O. (2009). Why do you sigh? Sigh rate during induced stress and relief. *Psychophysiology, 46,* 1005–1013.

Wilhelm, F. H., Trabert, W., & Roth, W. T. (2001). Characteristics of sighing in panic disorder. *Biological Psychiatry, 49,* 606–614.

Zautra, A. J., Burleson, M. H., Matt, K. S., Roth, S., & Burrows, L. (1994). Interpersonal stress, depression, and disease activity in rheumatoid arthritis and osteoarthritis patients. *Health Psychology, 13,* 139–148.

Zautra, A. J., Yocum, D. C., Villanueva, I., Smith, B., Davis, M. C., Attrep, J., & Irwin, M. (2004). Immune activation and depression in women with rheumatoid arthritis. *Journal of Rheumatology, 31,* 457–463.