Diurnal Variation in Pain Reports in Temporomandibular Disorder Patients and Control Subjects

Alan G. Glaros, PhD
Professor
Kansas City University of Medicine and Biosciences

Karen Williams, PhD
Professor
University of Missouri–Kansas City

Leonard Lausten, DDS
Associate Professor
University of Missouri–Kansas City

Correspondence to:
Dr Alan Glaros
Kansas City University of Medicine and Biosciences
1750 Independence Avenue
Kansas City, MO 64106
Fax: +816 283 2357
E-mail: aglaros@kcumb.edu

Aims: *To test the hypothesis that temporomandibular disorder (TMD) patients have characteristic diurnal patterns of pain that are associated with diurnal or nocturnal parafunctions.* ***Methods:*** *Experience sampling methods were used to obtain information on pain from subjects (n = 84) diagnosed, according to the Research Diagnostic Criteria for TMD, with myofascial pain, myofascial pain and arthralgia, disc displacement, and from non-TMD controls. Variations in pain as reported on the pager questionnaire form were modeled as linear, exponential, and quadratic effects.* ***Results:*** *Between 8.7% and 23.8% of TMD subjects with pain showed significant patterns to their daily pain reports, compared to 4.5% of non-TMD controls. Groups did not differ significantly in the proportions of those with increasing (59.5%) vs. decreasing (40.5%) pain levels. Self-reported clenching during the day and grinding at night were weakly associated with an increasing or decreasing pattern of pain during the day (*P *< .10). Pain levels during weekends were significantly lower for all groups.* ***Conclusions:*** *Strongly linear or curvilinear patterns of pain were not characteristic of this sample of subjects. More than half the subjects reported slightly increasing pain during the day, but the variability within groups was considerable. Increasing and decreasing patterns of pain were independent of self-reported daytime and nighttime clenching and grinding. Self-reported pain patterns may not be used to reliably infer the times when parafunctional activities occur. The presence of lower pain levels during the weekend probably reflects reduction in psychosocial stressors associated with the work week.* J OROFAC PAIN 2008;22:115–121

Key words: diurnal variation, experience sampling, modeling, pain, temporomandibular disorders

The pattern of pain reported by individuals diagnosed with temporomandibular disorders (TMD) is used clinically to provide insight into possible etiologic mechanisms of the pain for specific patients. For example, pain that is greatest in the morning may be attributed to nocturnal clenching or grinding, whereas pain that is greatest in the late afternoon or evening may be attributed to oral parafunctions and overuse such as clenching or excessive gum chewing, combined with the cumulative impact of common psychosocial stressors.

Most studies that have examined pain in TMD patients rely on retrospective reports. For example, Ahlberg et al[1] reported that orofacial pain was associated with bruxism in a large sample of individuals working in the Finnish Broadcasting Company. Magnusson et al[2] reported a significant relationship between bruxism and orofacial pain in their long-term study of children and adolescents. Miyake et al[3] reported that bruxism was associated with pain in their study of 3,557 Japanese university students. Other studies have suggested an association between TMD pain and stress.[4] In most of these studies, the pattern of pain during the day was rarely addressed.

Short-term studies using simple self-report to examine the impact of self-reported bruxism or stress on pain may suffer from various types of response bias. One form, recall bias, occurs when a research subject selects a particularly memorable event to report as evidence of a link between a parafunctional behavior and pain. This type of selective attention necessarily ignores the variability of pain associated with various events and might obscure relationships that indeed might exist between the parafunction and pain. For that reason, previous studies have shown that single-point pain recall may not strongly correlate with multiple within-subject evaluations of pain.[5,6] Another form of selection bias occurs when subjects report what each has been told by their provider. For example, if a dentist tells a patient that TMD pain is related to parafunction and stress, the patient may come to believe that the relationship is true for him or her. Additionally, patients who have reasons to minimize or exaggerate stress can replicate scores that are similar to those reported by patients with chronic pain.[7]

One method for reducing recall bias is to require frequent, real-time responses to questions about the subject's behaviors and states. One methodology, known as experience sampling methodology (ESM) or ecological momentary assessment, is characterized by frequent, repeated measurement of an individual's behavior in his or her natural environment.[8]

A study by van Grootel et al[9] utilized ESM-like methods for collecting data on pain from TMD patients. In this study, data were collected 4 times a day over a 2-week period. Only individuals with myogenous TMD pain participated in the study, and pain patterns were characterized by identifying when the highest level of pain occurred during the day. Two pain patterns were identified, with 79% of the subjects reporting maximal pain late in the day and the remainder reporting maximal pain early in the day. Both groups of subjects were similar with respect to a variety of demographic and psychosocial variables.

The study reported here was designed to improve upon the methodology of van Grootel et al.[9] Four groups were examined, 2 groups of TMD patients diagnosed with myofascial pain and 2 groups of individuals without pain. Pain ratings were collected approximately 6 times per day, and pain was modeled using linear and curvilinear techniques to better characterize the pattern of pain for each subject. The primary purpose of this study was to test the hypothesis that TMD patients have characteristic diurnal patterns of pain that are associated with diurnal or nocturnal parafunctions. If bruxism, particularly nighttime clenching and grinding, are significant contributors to pain, pain would be expected to diminish as the day progresses. If, on the other hand, daytime parafunctions are important contributors to pain, pain should increase during the day. The contribution of psychosocial stressors to pain was also examined by comparing self-reported pain levels during the portion of the week when stress levels are purported to be high (ie, during the work week) with pain levels during the portion of the week when stress levels are expected to be lower (ie, during the weekend).

Materials and Methods

Subjects

Subjects (initial n = 113) were selected from patients of the University of Missouri–Kansas City Facial Pain Center or recruited from the general population. Exclusion criteria for the study included any history of major trauma to the head or neck, current use of an intraoral appliance, active orthodontic treatment, any other chronic pain condition, or current, daily use of any analgesic, antidepressant, or muscle relaxant medication. Ten individuals failed to complete their participation in the study.

Screening Examination

All individuals were assessed using the Research Diagnostic Criteria for TMD (RDC/TMD).[10] Each individual was assessed by 2 independent examiners, and each examiner was blind to the diagnosis provided by the other. The time between examinations was approximately 30 minutes. Agreement between raters that a specific condition was present ranged between 64.3% for arthralgia and 88.9% for myofascial pain.[11] The presence of disc displacement was inconsistent in 3 subjects, and raters therefore failed to agree on a diagnosis for these 3 individuals.

Sixteen muscle sites accessible extraorally (left and right anterior temporalis, middle temporalis, posterior temporalis, origin of masseter, body of masseter, insertion of masseter, posterior mandibular region, and submandibular region), and 4 muscle sites accessible intraorally (left and right temporalis tendon and lateral pterygoid areas) were palpated according to the techniques described in the RDC/TMD. A subject's report of pain during muscle palpation was scored on a 0-to-3 scale, with 0 signifying no pain. The presence of reproducible clicking on vertical opening, closing, lateral excursion, and protrusion was determined by palpation, as was the presence of coarse crepitus. Pain in the temporomandibular joint (TMJ) was determined by palpation and rated on a 0-to-3 scale. Pain-free unassisted mandibular opening and maximum unassisted opening were measured in mm. Only those individuals who received the same diagnosis from the raters were eligible to participate in the study. Individuals who received a diagnosis of osteoarthritis or osteoarthrosis of the TMJ according to RDC/TMD criteria were excluded from participation.

Based on the results of the screening examination and subject self-report data, subjects who qualified for participation were assigned to 1 of 4 groups based on RDC/TMD criteria: *(1)* myofascial pain; *(2)* myofascial pain and arthralgia; *(3)* disc displacement; and *(4)* non-TMD controls. Within each of the 3 TMD groups, subjects received only the diagnosis/diagnoses contained within the group's title and no other RDC/TMD diagnosis.

Experience Sampling Methodology

To obtain more accurate measures of pain and other states, ESM was used. The hallmark of ESM is repeated assessment of subjects in their natural environment.

Subjects carried pagers in this study. The pagers were 1-way devices that beeped or vibrated when contacted. A custom-programmed executable (.exe) derived from the Paradox database (Corel Corporation) was used to place calls to pagers. The mean time between calls was 120 minutes, with a 40-minute window of variability within which a specific call could be placed; a specific call to a subject could occur up to 20 minutes earlier or up to 20 minutes later than would be expected on a fixed schedule. The variability of calls was based on a random number generator that produced an equal distribution of values on either side of the expected call time. Variability in calling schedules reduced the possibility that subject behavior would be affected by the anticipation of a call at a fixed point in time.

Subjects were instructed to fill out a preprinted 3" × 5" card each time they were paged, unless doing so would jeopardize their safety. Subjects were asked to report on pain in the jaw, face, or head; the presence and intensity of tooth contact; tension in the jaw, face, or head; mood; and stress. Except for tooth contact, all measures were recorded on an 11-point (0-to-10) numeric rating scale. The anchors for the pain measures were "No pain" and "Severe pain," the anchors for the tension measure were "Completely relaxed" and "Extremely tense," and the anchors for the 2 mood measures were "Irritable" and "Cheerful" for 1 scale (Mood 1) and "Happy" and "Sad" for the other (Mood 2). The 2 mood scales were reversed-scored as a measure of response validity. The anchors for stress were "No stress" and "Extremely high stress." Tooth contact was scored on a 4-point scale: no contact, "just barely" touching, "mild to moderate clenching," and "strong clenching." Subjects were instructed that they could turn off the pager if they went to bed early or stayed in bed late or were in an environment in which paging would be dangerous or disruptive.

Procedure

After obtaining informed consent, a research assistant blind to the subject's diagnosis was introduced to the subject. Following a written script, the assistant instructed the subject on the use of the pager. Each subject was given multiple opportunities to interact with the device and to demonstrate competence in turning on the device, responding to a page, changing the battery, and filling out the questionnaire form. Subjects were asked when they become fully alert and capable of responding to a page after awakening, and they were also asked when they typically retired for the evening. This allowed for individual flexibility in generating call schedules appropriate for each subject.

The first day of paging for each subject varied randomly from Monday through Sunday and continued for 1 week. The times when subjects were willing to receive a page in the morning and were no longer willing to receive a page in the evening were biased toward values on the hour (eg, 7:00 AM) or on the half-hour (eg, 10:30 PM). Values requested by subjects were randomized by up to 15 minutes on either side of the requested time prior to being entered into the dialer program. Subjects were not contacted during their normal sleep hours.

Table 1 Number of Significant Effects ($P \leq .05$) for 3 Descriptive Models

Group	Linear	Quadratic	Exponential
Myofascial pain (n = 23)	2	1	2
Myofascial pain and arthralgia (n = 21)	3	5	3
Disc displacement (n = 18)	2	2	2
Non-TMD control (n = 22)	1	1	1

Statistical Analysis

Curve estimation techniques available in SPSS (version 13), a statistical software analysis program, were used to model variations in pain as reported on the pager questionnaire form. Linear, quadratic, and exponential models were developed for each subject, and the beta coefficients for each model were used to characterize the pattern of pain. Linear models test whether patterns of pain steadily increase or decrease during the day. An exponential model tests whether the rate of increase or decrease changes as the day progresses. A quadratic model tests whether pain follows a curvilinear function in which pain is highest early in the morning and in the late evening, or is highest at mid-day, with lower values in the morning and evening. Data were examined by day of participation (1st day of recording, 2nd day, etc.) to check for reactive effects of observation. To examine daily patterns of pain, data were analyzed by aggregating all data for a subject into a single "day." Weekday data were compared to weekend data. Alpha was set to .05 for this study.

Results

The final sample contained 84 subjects (Table 1). Pain levels between groups were examined using an analysis of variance. On a 0-to-10 scale of pain, mean pain levels (± SD) were 2.91 (± 1.55) for the myofascial pain group, 2.94 (± 1.61) for the myofascial pain and arthralgia group, 1.34 (± 1.14) for the disc displacement group, and 0.48 (± 0.49) for the non-TMD control group. The mean number of responses per subject generated by the ESM procedure was greater than 42, and this number of data points per subject should provide sufficient power to detect any linear or nonlinear effects that may be present. Diagnosis groups differed significantly ($F[3,76] = 16.66$, $P < .001$, partial $\eta^2 = 0.40$) with the 2 myofascial pain groups reporting significantly more pain than the disc displacement and non-TMD control groups.

To assess reactive effects of observation, the mean level of pain for the first day of monitoring, second day of monitoring, and so forth were entered into a linear regression. These preliminary analyses produced beta coefficients describing change in pain within the 1-week observation period. The mean beta coefficients (± SD) were 0.083 (± 0.261) for the myofascial pain group, 0.026 (± 0.296) for the myofascial pain and arthralgia group, 0.073 (± 0.294) for the disc displacement group, and 0.017 (± 0.291) for the non-TMD control group. Negative coefficients indicate decreased pain over time, and positive coefficients indicate increased pain with time. The size of the coefficient reflects the degree of change from day to day, with larger absolute values indicating greater change. The mean coefficients were not significantly different from zero, and an analysis of variance showed no differences among groups.

To examine variation in pain levels within a day, pain data were modeled as linear, quadratic, and exponential effects. A summary of significant effects is presented in Table 1; groups did not differ in the proportions of models showing significant effects. Every instance of a significant linear effect (n = 8) was accompanied by an exponential effect, and there were no significant exponential models without an accompanying significant linear model. Based on this pattern of results, exponential models were not analyzed further. All but 1 of the significant linear effects was also accompanied by a significant quadratic effect. Two individuals in the myofascial pain and arthralgia group had significant quadratic models without accompanying significant linear or exponential models. Because of the small number of subjects with only significant quadratic effects, no further analyses on this model were carried out. The proportion of TMD patients with well-characterized (ie, statistically significant) diurnal pain patterns varied from 8.7% for the myofascial pain group to 23.8% for the myofascial pain and arthralgia group. Figures 1 and 2 provide illustrative examples of subjects showing statistically significant and no significant patterns to their pain, respectively.

Table 2 Weekday Versus Weekend Pain Levels				
	Weekday		Weekend	
Group	Mean	SD	Mean	SD
Myofascial pain	2.61	1.32	2.49	1.44
Myofascial pain and arthralgia	3.01	1.65	2.92	1.89
Disc displacement	1.40	1.32	1.07	1.00
Non-TMD control	0.56	0.50	0.42	0.56

Note: Pain scored on an 11-point scale (0 to 10).

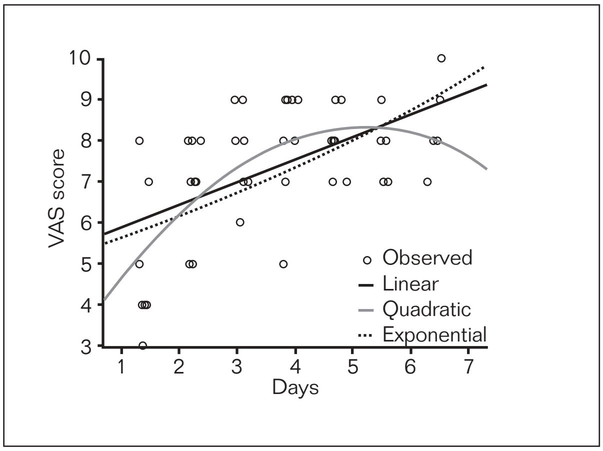

Fig 1 Subject from myofascial pain and arthralgia group showing statistically significant linear, quadratic, and exponential patterns to reported pain.

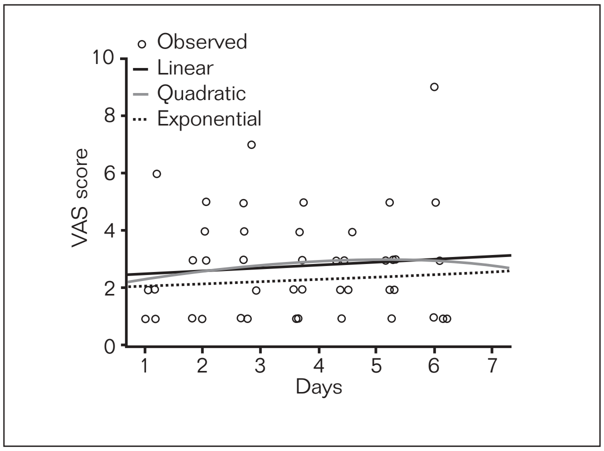

Fig 2 More typical subject, from myofascial pain group, showing no significant linear, quadratic, or exponential patterns to reported pain.

Subjects were split into groups based on linear models showing increasing versus decreasing pain during the day. Fifteen individuals in the myofascial pain group showed an increasing pattern of pain during the day, and 8 showed a decreasing pattern. The corresponding values for the other groups were 14 (increasing) and 7 (decreasing) for the myofascial pain and arthralgia group, 7 and 11 for the disc displacement group, and 14 and 8 for the non-TMD control group. Groups did not differ in the proportions of those with increasing versus decreasing pain levels. The impact of self-reported nocturnal clenching or grinding and daytime clenching or grinding on jaw pain was examined by entering subject self-reports as covariates. This analysis, which included all 4 groups, showed weak effects ($P < .10$) for clenching during the day and grinding at night and no significant effects for clenching at night or grinding during the day. Removing the latter 2 covariates and restricting the analysis to the myofascial pain and myofascial pain and arthralgia groups resulted in no significant difference in pain reports between the 2 groups. Clenching during the day or grinding at night did not account for a significant proportion of the variance in jaw pain ratings ($P < .10$). Neither self-reported clenching during the day nor grinding at night was associated with an increasing or decreasing pattern of pain during the day, as assessed by ESM.

Weekday and weekend pain levels were compared using a repeated measures analysis of variance. These data are reported in Table 2. This analysis showed a significant effect for time of week ($F[1,76] = 4.11$, $P < .05$, partial $\eta^2 = .05$) and for diagnosis group ($F[3,76] = 18.06$, $P < .001$, $\eta^2 = .42$). Pain levels during weekends were slightly and consistently lower for all groups.

Discussion

In this sample of subjects, patterns of pain were quite variable. The degree of variability can be seen in the small number of subjects for whom curve estimation failed to produce a significant model.

Data showing strongly linear or curvilinear patterns of pain were not characteristic of this sample of subjects, although the sign of the coefficient obtained from linear models provides a general indication of change in pain during the day. Approximately two thirds of the pain patients reported increasing pain during the day, with the remainder showing decreasing pain. These results are similar to those reported by van Grootel et al.[9] Other studies have also reported considerable variation in the pain patterns of TMD patients.[12,13]

Pain that is greatest in the morning and that decreases during the day is often presumed to be related to nocturnal clenching and grinding. Patients presumably engage in high levels of oral parafunctional behaviors during sleep, and these behaviors purportedly produce significant soreness and pain upon awakening. In the absence of nocturnal clenching or grinding, pain should diminish as the day progresses. This hypothesis was tested by comparing frequencies of individuals reporting nocturnal grinding against the frequencies of patients who reported increasing and decreasing patterns of pain. This analysis showed that the variables were independent of each other. Several studies have investigated the relationship between nocturnal oral parafunctions and TMD pain, but no consistent pattern has emerged from these efforts.[14,15] Pain that increases during the day may be attributable to daytime clenching. However, self-reports of daytime clenching were not associated with increasing patterns of pain during the day, as assessed by ESM.

The failure to find a relationship between patterns of pain and parafunctions may reflect multiple factors. Work performed in laboratories has shown that the behavioral meaning of terms such as "clenching" may vary considerably from individual to individual.[16] "Clenching" may imply intense tooth contact to one individual but only slight contact between the teeth for another. When the behavioral definitions of parafunctions vary considerably, summary verbal reports in response to a question such as "Do you clench during the day?" may be unreliable. When subjects report on levels of tooth contact (for example, a numeric rating scale of contact rather than a summary "yes" or "no") on a frequent, random basis, the data show a very strong relationship between these daytime oral parafunctions and TMD pain.[17] Perhaps the use of more sensitive measures (eg, numeric rating scales) would increase the likelihood of detecting a relationship between nocturnal oral parafunctions and daily pain patterns. The failure to find a relationship may also reflect type II error. It is possible that nocturnal parafunctions are associated with high initial levels of pain, but a larger sample may be needed to confirm this hypothesis.

The coefficients describing changes in pain across the 7 days of monitoring were small. If regression to the mean were an important contributor to these coefficients,[18] the 2 groups diagnosed with myofascial pain would have a higher degree of change than the other 2 groups with low pain levels. Because the pain levels reported by the 2 myofascial pain groups were significantly higher, there would be more opportunity for these values to fall over the 7 days of monitoring as compared to the other 2 groups. However, the results show that the coefficients were similar across all 4 groups.

The presence of lower pain levels during the weekend may reflect reduction in psychosocial stressors associated with the work week. Stress is among the significant predictors of pain in TMD patients,[17] and reduction in time pressures associated with work, child care, and the like accompanied by an increase in pleasurable recreational or spiritual activities may be responsible for the reduction in pain. As indicated by the partial η^2 value, the proportion of variance accounted for by weekday-weekend effects was small but statistically significant.

The exclusion criteria used in the study ensured that reports of pain would not be affected by extraneous factors such as intraoral appliances or analgesic medications. In this regard, the patients in the present study were probably more similar to those who present for initial care of their complaints than those who have failed initial treatment and subsequently come to the attention of tertiary care programs. Whether individuals with very longstanding TMD also fail to have characteristic pain patterns during the day is yet to be determined.

Acknowledgments

The authors thank Asha Stephens and the staff of the Facial Pain Center at the University of Missouri–Kansas City for their help. Portions of this paper were presented at the annual meeting of the International Association for Dental Research, New Orleans, Louisiana, March 2007. This work was supported by grant DE13563 from the National Institutes of Health to the first author.

References

1. Ahlberg K, Ahlberg J, Kononen M, Alakuijala A, Partinen M, Savolainen A. Perceived orofacial pain and its associations with reported bruxism and insomnia symptoms in media personnel with or without irregular shift work. Acta Odontol Scand 2005;63:213–217.
2. Magnusson T, Egermark I, Carlsson GE. A prospective investigation over two decades on signs and symptoms of temporomandibular disorders and associated variables: A final summary. Acta Odontol Scand 2005;63:99–109.
3. Miyake R, Ohkubo R, Takehara J, Morita M. Oral parafunctions and association with symptoms of temporomandibular disorders in Japanese university students. J Oral Rehabil 2004;31:518–523.
4. Suvinen TI, Ahlberg J, Rantala M, et al. Perceived stress, pain and work performance among non-patient working personnel with clinical signs of temporomandibular or neck pain. J Oral Rehabil 2004;31:733–737.
5. Gendreau M, Hufford MR, Stone AA. Measuring clinical pain in chronic widespread pain: Selected methodological issues. Best Pract Res Clin Rheumatol 2003;17:575–592.
6. Kikuchi H, Yoshiuchi K, Miyasaka N, et al. Reliability of recalled self-report on headache intensity: Investigation using ecological momentary assessment technique. Cephalalgia 2006;26:1335–1343.
7. Robinson ME, Myers CD, Sadler IJ, Riley JL, Kvall SA, Geisser ME. Bias effects in three common self-report pain assessment measures. Clin J Pain 1997;13:74–81.
8. Shiffman S, Stone AA. Ecological momentary assessment in health psychology. Health Psychol 1998;17:3–5.
9. van Grootel RJ, van der Glas HW, Buchner R, de Leeuw JRJ, Passchier J. Patterns of pain variation related to myogenous temporomandibular disorders. Clin J Pain 2005;21:154–165.
10. Dworkin SF, LeResche L. Research Diagnostic Criteria for Temporomandibular Disorders: Review, criteria, examinations and specifications, critique. J Craniomandib Disord 1992;6:301–355.
11. Lausten LL, Glaros AG, Williams K. Inter-examiner reliability of physical assessment methods for assessing temporomandibular disorders. Gen Dent 2004;52:509–513.
12. Raphael KG, Marbach JJ. A year of chronic TMPDS: Evaluating patients' pain patterns. J Am Dent Assoc 1992; 123:53–58.
13. Raphael KG, Marbach JJ. A year of chronic TMPDS: Relating patient symptoms and pain intensity. J Am Dent Assoc 1992;123:49–55.
14. Lobbezoo F, Lavigne GJ. Do bruxism and temporomandibular disorders have a cause-and-effect relationship? J Orofac Pain 1997;11:15–23.
15. Manfredini D, Cantini E, Romagnoli M, Bosco M. Prevalence of bruxism in patients with different research diagnostic criteria for temporomandibular disorders (RDC/TMD) diagnoses. Cranio 2003;21:279–285.
16. Glaros AG, Waghela R. Psychophysiological definitions of clenching. Cranio 2006;24:252–257.
17. Glaros AG, Williams K, Lausten L. Predicting facial pain: Role of parafunctions, emotions and stress. J Am Dent Assoc 2005;136:451–458.
18. Aaron LA, Turner JA, Mancl L, Brister H, Sawchuk CN. Electronic diary assessment of pain-related variables: Is reactivity a problem? J Pain 2005;6:107–115.