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Momentary pain and coping in temporomandibular disorder pain: Exploring mechanisms of cognitive behavioral treatment for chronic pain

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ABSTRACT

The purpose of this study was to determine whether cognitive–behavioral treatment (CBT) operates by effecting changes in cognitions, affects, and coping behaviors in the context of painful episodes. Patients were 54 men and women with temporomandibular dysfunction-related orofacial pain (TMD) enrolled in a study of brief (6 weeks) standard conservative treatment (STD) or standard treatment plus CBT (STD + CBT). Momentary affects, pain, and coping processes were recorded on a cell phone keypad four times per day for 7 days prior to treatment, and for 14 days after treatment had finished, in an experience sampling paradigm. Analyses indicated no treatment effects on general retrospective measures of pain, depression, or pain-related interference with lifestyle at post-treatment. However, mixed model analyses on momentary pain and coping recorded pre- and post-treatment indicated that STD + CBT patients reported greater decreases in pain than did STD patients, significantly greater increases in the use of active cognitive and behavioral coping, and significantly decreased catastrophization. Analyses of experience sampling data indicated that post-treatment momentary pain was negatively predicted by concurrent active coping, self-efficacy, perceived control over pain, and positive-high arousal affect. Concurrent catastrophization was strongly predictive of pain. Active behavioral coping and self-efficacy reported at the prior time point (about 3 h previously) were also protective, while prior catastrophization and negative-high arousal mood were predictive of momentary pain. The results suggest that CB treatment for TMD pain can help patients alter their coping behaviors, and that these changes translate into improved outcomes.

1. Introduction

Cognitive–behavioral therapies (CBTs) have demonstrated effectiveness for a number of chronic pain problems. However, it has not always been clear how CBT has achieved improvements in symptoms. CBT is intended to teach patients to reduce the extent to which they catastrophize about their pain problem, and to teach behavioral and cognitive strategies for managing it [22]. Relatively little research has been conducted to determine if cognitive–behavioral treatments actually lead to these kinds of changes, and if so, whether those changes are accounting for symptom reduction.

In an effort to evaluate process variables that mediate the effects of CBT for chronic pain patients, Turner and colleagues [25] measured pain beliefs, catastrophizing, and self-efficacy for managing pain in a trial of brief CBT vs. an attention control condition for chronic temporomandibular disorder (TMD) pain. The authors reported that the CBT condition yielded significantly greater improvements at 1 year than the attention control condition in several outcomes. The authors further reported that, in tests of mediation, baseline to 6-month changes in almost all prospective mediators, particularly control beliefs and self-efficacy, mediated the effects of CBT on outcomes at 1 year. The authors concluded that the results provide support for the cognitive–behavioral model of pain management.

The Turner et al. [25] results may be misleading, however. It is not clear that an active non-CBT treatment would not also result in adaptive changes in mediating variables. The changes in general orientations toward pain that appeared at 6 months may have been the result of symptom improvement rather than the result of specific practices or skills learned in CBT. Indeed, one of the least effective mediators in the Turner et al. study was the one most directly taught in CBT, namely the use of relaxation as a coping strategy to manage pain.

Additionally, not all cognitive–behavioral treatments have performed as well as that of Turner et al. [25]. In their review and meta-analysis Morley et al. [10] concluded that CBT did not always yield improvements in several domains that are typically targeted, including mood, cognitive coping, and negative appraisals such as catastrophization.

The purpose of the present study was to determine the extent to which skills taught in a CB treatment for chronic TMD pain would

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be brought to bear in pain episodes, and whether changes in these skills would predict momentary pain. To explore these questions patients with TMD pain were recruited from the community and randomly assigned to one of two 6-week treatments: standard care (STD), or standard care plus CBT (STD + CBT).

Coping skills were measured prior to the start of treatment, and again after treatment was completed, using an experience sampling protocol via cell phones. During each call patients were asked about their level of pain and the actions they took to manage pain. It was expected that those assigned to the STD + CBT condition would show increases from pre- to post-treatment in adaptive coping, and that these changes would be related to decreases in momentary pain.

2. Method

2.1. Participants

Participants were 46 women and 8 men seeking treatment for a complaint of either bilateral pain or unilateral pain in the area of the temporomandibular joint that had persisted and were noticeable on a daily basis for a period of at least 3 months. Subjects were recruited from the dental clinics in our university-based school of dental medicine (10%), from other dental referrers (<5%), and from the greater Hartford metropolitan area via newspaper and web-based advertisements offering free short-term treatment. None were referred from specialized facial pain clinics. To be eligible subjects needed to have a positive axis I diagnosis on the Research Diagnostic Criteria (RDC; [4]) for temporomandibular disorders (positive on at least one Group), and could have no contraindications to TMD treatment (as determined by the consulting oral surgeon, e.g., oral cancer that would require immediate treatment). Patients were excluded for any of the following: lack of fluency in English (as determined by inability to read and understand a statement of informed consent); previous surgery for treatment of TMD pain; history of rheumatoid disease; extensive anatomical destruction or deterioration of the TM joint; diagnosed as having pain of neuropathic or odontogenic origin; carrying a diagnosis of psychosis; current use of antidepressants or anxiolytics; taking narcotic pain medication; or pregnancy (due to prescription of non-steroidal anti-inflammatory drugs). The 54 participants included in this study were those who completed both pre-treatment and post-treatment experience sampling of pain, affects, and cognitions (see below) in the context of a larger treatment study of 101 patients with TMD-related pain. These patients did not differ from those who did not provide complete data on age, sex, marital status, ethnicity, pain severity or years of pain.

The mean age of the sample was 41.0 years (SD = 11.9). The majority of participants were white (86%), with 7% black and 7% of Hispanic origin. Fifty-two percent were married or cohabiting. The average years of education was 15.3 (SD = 2.3). The participants reported having chronic TMD pain for 5.6 years on average (SD = 5.4), with a mean pain intensity rating of 3.5 on a scale to 6 (SD = 1.7).

2.2. Measures and instruments

2.2.1. General outcome variables: pain, depression, and interference

Ratings of pain experience were collected using the Multidimensional Pain Inventory (MPI; [6]). Characteristic pain intensity was calculated on a scale from 0 to 6 by averaging ratings of current pain, average pain, and worst pain in the past week [26].

Depression symptoms were measured using the 20-item Center for Epidemiological Studies Depression scale (CES-D; [11]). The CES-D is well suited for use in a population with medical problems such as chronic pain in that it relies less than other measures on physical symptoms of depression. In the current sample the CES-D had an internal reliability of $\alpha = 0.94$.

Interference with activities was measured using the interference scale from the MPI. The interference subscale consists of 13 items scored on a Likert-type scale that ask the respondent the degree to which his/her pain problem has interfered or changed work life, family life, and social life. In our sample the scale had a reliability of $\alpha = 0.91$.

2.2.2. Experience sampling (ES) of pain, coping, and affects via interactive voice response (IVR)

The use of experience sampling (ES) in both the STD and STD + CBT treatment groups allowed us to assess the use of coping skills, while avoiding many of the problems inherent in retrospective recording. The ES design of this study was based on that of a pilot study conducted by our group to evaluate coping and pain in untreated patients [9]. In that study 30 patients responded to prompts and recorded their pain, affects, cognitions, and coping behaviors on a palmtop computer prior to beginning treatment for TMD. The items used in that ES study were refined for the present study of treatment-related changes.

Experience sampling was conducted through the use of interactive voice response (IVR) technology, in which assessments were made using a computerized system that called participants on cellular telephones, asked a series of questions, and recorded responses. Cellular telephones were issued to participants upon entry into the study, at which time they were trained in their use. During the training session participants were instructed to answer each question with as little reflection as possible. This paradigm was designed to obtain momentary information about pain, cognitions, and affects without the biases and social demands that may influence retrospective reports of pain and coping processes [19].

Participants were asked to carry the cellular telephone at all times in Week 1 (after baseline interviews, but before treatment started), and again for 14 days immediately after completion of treatment. The cell phones were password protected such that outgoing calls were not possible. To promote protocol compliance at the end of the post-treatment follow-up period subjects were paid $5.00 for every day of at least 50% of scheduled recordings completed. The telephone-based interactive voice response system used to place calls, administer assessment questions, and record responses was developed by Telesage (Chapel Hill, NC).

The system was programmed to call subjects' cell phones on a quasi-random basis four times per day, with one randomly scheduled call in each of four 210-min time periods from 8:00 AM to 10:00 PM. This frequency of recording was chosen to enable us to capture as many moments in a patient's day as possible without being disruptive [8]. Subjects had the option of delaying responding to a call for 5, 10 or 15 min when answering was inconvenient.

2.2.3. ES recording format

Participants responded to recorded questions using the cell phone keypad. For every recording the subject was prompted to record perceptions along a 7-point scale ranging from "0 = Not at all" to "6 = Very much." Responses were time-and-date-stamped, and entry of out-of-range data was not allowed. If data entry was abandoned in the midst of an assessment, the system called the participant back and resumed the assessment. Assessment data were electronically stored in spreadsheet format on a system server and backed up nightly. Data from each participant engaged in ES monitoring were examined each day for missing responses by a research assistant. If a participant missed two calls in a row, the research assistant contacted the individual by phone. The compliance rates for experience sampling were as follows: at

pre-treatment 72% of calls were completed (range: 4–100%; 5 cases responding below 50%); at post-treatment 71% of calls were completed (range: 20–100%; 5 cases responding below 50%).

2.2.4. ES data

Patients responded during ES to items related to pain (right and left sides of the face) and unpleasantness experienced (right and left sides), and two items related to perceived control over pain (“am able to decrease pain;” “am able to control pain”). Catastrophization was assessed using two items that reflected key features of the construct, affective intensity and cognitive intrusiveness or “overappraisal” of the negative aspects or consequences of the pain experience (see e.g., Turk et al. [22]). The two items, borrowed and modified from the Coping Strategies Questionnaire (CSQ; [13]) catastrophization subscale, were “Worried about Pain” and “Pain is Terrible,” (internal reliability $\alpha = 0.87$).

Current affective state was recorded using 12 items. The affect items were derived from a semantic space analysis of adjectives in the circumplex model of affective experience ([7,14]). For the purpose of analysis affective states were classed along two major dimensions: pleasantness (negative vs. positive) and arousal (high arousal vs. low arousal). Four quadrants of affects were thus created: positive-high arousal items (active, peppy, and happy); positive-low arousal (quiet, relaxed, and calm); negative-high arousal (nervous, angry, and panicky); and negative-low arousal (bored, sad, and hopeless). The items were combined by quadrant to yield four reliable affect composites (internal reliability alphas exceeded 0.80 for all four affect subscales).

Coping responses were recorded by asking the subject what if anything he or she had done to help manage any pain they might have experienced since the last call. Potential coping responses were presented sequentially and the patient was instructed to press “1” for each coping action he/she used. (If the person did not experience pain, all responses were coded as “0”.) The coping response items were derived from inventories assessing coping in pain patients (e.g., the CSQ), and from informal surveys of patients in TMD pain treatment.

Two independent raters sorted the coping response items into four rational subscales. The four subscales were active behavioral (“I used ice or heat,” “I took a medication,” “I took an alcoholic drink, or used a drug,” “Relaxed”); active cognitive (“I thought pleasant thoughts,” “I told myself it would end,” “Prayed”); acceptance/resignation (a single item, “I just accepted the pain”); and distraction (“I distracted myself,” “I looked for support from someone”). One item also recorded if “Nothing” was done to deal with the pain. The interrater reliability of the subscale sorting process was kappa = 0.76. Internal consistency reliabilities of the coping subscales exceeded $\alpha = 0.65$.

2.3. Treatment

Treatment in both conditions consisted of six sessions conducted over 6 weeks (though patients could take up to 9 weeks to complete treatment). Treatment was delivered by four Master’s level therapists with at least 2 years experience in cognitive–behavioral therapy with medical patients. The same therapists provided both the study treatments in order to minimize therapist effects. Both the treatments were manual driven. A detailed outline of each session gave the therapists specific guidelines as to what material to cover, what points to emphasize, and the specific kinds of homework to be assigned. The precise content of therapy sessions depended on the individual patient’s circumstances and experiences. All treatment sessions in both conditions were audiotaped and reviewed for adherence to treatment protocol by the first author. Supervision of therapists was conducted biweekly throughout the course of the study.

2.3.1. Standard conservative treatment (STD)

Standard Treatment consisted of splint therapy plus soft diet and oral anti-inflammatory agents (as per Stack and Stack [16]). Patients were told that the treatment was intended to change oral habits with respect to clenching and bruxing, and to provide a sufficient respite from pain to allow more adaptive oral habits to emerge. Subjects in this group received the intraoral splint during the first treatment visit, 1–2 weeks after the baseline visit, with instructions to keep it in place continuously (except for eating) for the succeeding 4 weeks.

After 4 weeks it was recommended to patients that they start to taper the splint (e.g., use only as a night guard) in preparation for discontinuing the splint altogether. The purpose of the early discontinuation was to prevent the patient from adapting to the splint or clenching or bruxing on the splint itself. However, patients were allowed to retain the splint, and continue its use, if they preferred (as was the case in about 50% of patients).

In addition to the splint, subjects were also given a 5-week course of non-steroidal anti-inflammatory medication (NSAIDs; naproxen sodium 550 mg po BID). Extra strength acetaminophen was substituted for naproxen for those patients who reported having difficulty with NSAIDs or who had gastric ulcer disease. A soft diet was also prescribed, with special attention paid to avoiding foods that require extreme jaw opening (e.g., large sandwiches) or foods that had caused pain in the past (e.g., steak). Patients were asked to continue the NSAIDs and the soft diet until the end of the 6-week treatment period, after which they were informed that they could alter the treatment as they saw fit, but with a recommendation that the soft diet be continued.

Patients were seen once a week during this treatment. However, whereas STD + CBT patients received weekly CB treatment, STD patients received weekly “progress checks” in which a therapist inquired as to the patient’s status and monitored the patient’s adherence to the basic treatment recommendations, i.e., medication use, splint use, and soft diet. These progress checks served to control for the amount of time and attention received by participants in the STD + CBT condition. As “homework,” patients were asked to keep records of their medication and splint use, and their diets each week. The therapist took care to not deliver any kind of cognitive–behavioral treatment to these patients. Complaints, if any, were met by expressions of sympathy, and encouragement to adhere to the standard care recommendations.

2.3.2. Standard treatment + cognitive–behavioral treatment (STD + CBT)

The STD + CBT condition included all aspects of the STD treatment described above. In addition, patients received a brief cognitive–behavioral program that focused on relaxation training, stress management, and cognitive restructuring. Treatment was intended to promote self-efficacy, to reduce catastrophization, and to increase the use of adaptive coping responses and habit modification. The program addressed the three most significant cognitive factors in TMD pain identified by Turner et al. [24]; beliefs or appraisals, coping and catastrophizing, and a significant behavioral factor, orofacial relaxation (e.g., [3]). The cognitive–behavioral program was based on brief programs developed by Turk et al. [23] and Mishra et al. [9], who reported that a brief (6-session) CB treatment that employed masseter EMG biofeedback was more effective than standard care or CB or biofeedback alone.

The cognitive behavioral program was intended to teach skills to keep the patient from returning to old habits and clenching, bruxing, and catastrophizing cognitions that contribute to TMD pain and distress. Sessions covered an introduction and rationale

for treatment, relaxation training and self-efficacy enhancement, masseter EMG biofeedback-assisted relaxation with an emphasis on relaxing the masseter muscles, habit modification (especially clenching and bruxing), combating negative thoughts and catastrophization, and stress management. Homework each week took the form of practicing skills discussed in the treatment sessions. Relaxation practice was assigned as homework every week.

2.3.3. Adherence to treatment

Eighty-seven percent of patients attended six sessions, with no significant differences in attendance by treatment condition. Percent adherence to treatment prescriptions common to both treatments, i.e., diet, medication and splint use, was scored by the patient's therapist as Yes or No for each day of the week. Adherence to medication was scored as Yes if any of the prescribed medication was taken that day, and any reported splint use was considered adherent. Rates of adherence were as follows: Soft diet = 92%; Medication = 86%; and Splint use = 73%. There were no between treatment differences in these measures.

2.4. Procedure

2.4.1. Intake session

Persons meeting initial eligibility criteria were seen for an intake assessment session in the Dental Clinical Research Center (DCRC) of the University of Connecticut Health Center. Potential subjects were examined by an oral surgeon to rule out neuropathic or odontogenic pain and to classify the person according to the RDC for TMD. Individuals meeting all inclusion/exclusion criteria at this point were told of all procedures involved and were administered a consent form. Baseline measures of the general dependent variables were then administered, and impressions were taken for an acrylic, flat-plane disoccluding splint. Patients were given $40.00 for completion of the baseline measures.

2.4.2. Assignment to treatment

Those who agreed to participate were randomized to either the Standard Treatment group (STD; $n = 22$) or the Standard + Cognitive–Behavioral Treatment group (STD + CBT; $n = 32$) using a computerized urn randomization procedure [21]. The two conditions were balanced on gender, age, ethnic background, pain level recorded at baseline, and RDC axis I diagnoses. The Project Coordinator entered the urn data during the intake session and informed the participants of their treatment assignments. The first treatment appointment was then scheduled for 1–2 weeks later, coinciding with the delivery of the splint.

2.4.3. Data collection

After randomization, subjects in both conditions were issued cell phones and instructed in the use of interactive voice response system. Self-monitoring began on the baseline day, and continued for the next 7 days. Participants were asked to carry the cell phones with them at all times. The experience sampling period ended prior to start of treatment. Following treatment participants were again issued cell phones and asked to record for the succeeding 14 days at a rate of four quasi-randomly scheduled calls per day. Following the 14-day experience sampling period post-treatment measures of the general dependent variables were administered.

2.4.4. Data analysis

Changes in the general dependent variables (pain, depressive symptoms, interference) from pre- to post-treatment were evaluated using multivariate analysis of covariance (MANCOVA), with univariate post-tests. Baseline levels of the dependent variables served as the covariates in the model.

Changes in momentary ratings of pain, momentary coping and catastrophizing subscale scores, and momentary affect and cognition scores were analyzed using a hierarchical linear modeling procedure (SAS Proc MIXED [15]). For each analysis the momentary score was the repeated dependent variable, and was analyzed as a function of time of day (coded as 1–4), day of the period, follow-up period (pre- vs. post-treatment), treatment condition (STD vs. STD + CBT), and the interaction of period × condition. An autoregressive covariance structure (AR 1) was adopted for the repeated measures model. In the analyses of coping change, only those records in which pain was non-zero and coping was recorded were included.

Hierarchical linear models were also used in analyses of predictors of momentary post-treatment pain ratings. Separate analyses were conducted for different sets of predictors. The first set tested consisted of the coping and catastrophization subscale scores. The second set consisted of momentary affect subscale scores. The third set tested consisted of adaptive cognitions (self-efficacy and perceived control over pain). A final model contained the significant predictors from each of the three sets. For each analysis momentary pain during the post-treatment recording period was evaluated as a function of time of day (coded 1–4), day of the follow-up period, time of day × day, treatment condition, and the scores for each coping, affect or cognition variable from the same time (concurrent) and from the time immediately preceding the pain rating (lagged). Lagged predictors were used to determine the extent to which pain at any given moment was a function of coping (or affects or cognitions) in the immediately preceding time period (up to 3.5 h prior). Records were chosen such that lagged predictors had to be recorded on the same day as the pain rating (that is, coping scores from the evening before were not used to predict morning pain).

3. Results

3.1. Pre–post changes in general dependent variables

Means, standard deviations, and results of the MANCOVA on the three general dependent variables, pain, depression score and interference, are shown in Table 1. Although the STD + CBT treatment tended to effect greater decreases in symptom scores than did the STD treatment, these differences were not significant at post-treatment.

3.2. Pre–post changes in momentary pain

Fig. 1 shows the mean pain levels by day for each day of experience sampling at the pre-treatment and post-treatment periods. The hierarchical linear model analysis yielded no effects for time of day, or for day of recording, and no main effect for treatment condition. There was a significant effect for follow-up period [$F(1, 3187) = 109.09$, $p < 0.001$], such that post-treatment momentary pain levels were significantly lower than those at pre-treatment. A significant follow-up period × condition interaction also emerged [$F(1, 3187) = 8.89$, $p < 0.01$], indicating that STD + CBT patients recorded significantly less pain at post-treatment than did the STD patients.

3.3. Pre–post changes in momentary coping responses

Fig. 2 shows the proportion change from baseline in momentary coping response scores aggregated over all recording times and days, by treatment condition. The figure illustrates the magnitude of the coping changes that occurred in each condition. Results of analyses of hierarchical linear models showed that significant

Table 1
Pre-treatment and post-treatment means (and standard deviations) of general dependent variables by treatment condition ($N = 54$). Test statistics are derived from MANCOVA.[a]

Dependent variable	STD		STD + CBT		Univariate F[b] ($df = 1, 53$)
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	
MPI pain	2.11 (0.86)	1.50 (1.36)	2.63 (1.26)	1.23 (0.98)	2.21
CES-D score	12.17 (12.05)	10.94 (10.66)	14.69 (12.56)	11.03 (10.80)	0.87
MPI interference	1.07 (0.78)	1.00 (0.96)	1.83 (1.35)	1.65 (1.35)	0.37

Note: df, degrees of freedom.
[a] MANCOVA Wilks' Lambda = 0.95; multivariate $F = 0.75$.
[b] Univariate F for individual ANCOVA results.

changes from pre- to post-treatment were recorded in both treatments in all coping scores except for the "Did Nothing" response. No effects were seen for time of day, or day of recording period, in any of the analyses. Additionally, no main effects for treatment condition emerged in any analysis.

Significant period × condition effects did emerge for several scores. Patients in the STD condition actually reported declines in using active cognitive and active behavioral coping at post-treatment, whereas STD + CBT patients recorded increases at post-treatment in active cognitive coping [$F_{\text{interaction}}(1, 3081) = 13.04$, $p < 0.001$] and active behavioral coping [$F_{\text{interaction}}(1, 3096) = 10.20$, $p < 0.01$]. STD + CBT patients also reported a significantly greater decrease in catastrophization at post-treatment than did the STD patients [$F_{\text{interaction}}(1, 3151) = 7.44$, $p < 0.01$].

3.4. Pre–post changes in momentary affects and cognitions

Proportion changes from baseline in aggregated affect and cognition scale scores are shown in Fig. 3. Hierarchical linear models on affect scale scores yielded significant main effects for follow-up period (pre- to post-treatment change) on all variables except positive-low arousal affect. There were no main effects for treatment condition. All analyses revealed significant effects for time of day and for day of recording. Negative affect tended to be lower in the morning, rising throughout the day, and tended to be higher in the first days of the recording period, leveling out toward the end of the period. Positive affect scores showed the reverse pattern. Significant follow-up period × condition interactions emerged for negative-high arousal affect [$F_{\text{interaction}}(1, 3135) = 5.60$, $p < 0.05$], and for positive-high arousal affect [$F_{\text{interaction}}(1, 3109) = 5.95$, $p < 0.05$], such that STD + CBT patients reported significantly less negative-high arousal affect (e.g., anger) and significantly more positive-high arousal mood (e.g., happiness) at post-treatment than did STD patients.

Analyses of self-efficacy to manage pain and perceived control over pain both yielded main effects for follow-up period (pre- to post-treatment change). Main effects for treatment condition were not significant for either cognitive variable. There were no main effects in either analysis for time of day, but both analyses showed main effects for day of recording. There was significant variation in both self-efficacy and perceived control over the days of recording such that both confidence and perceived control scores increased initially and then leveled off at the ends of the recording intervals (i.e., toward Day 7 at pre-treatment, and toward Day 14 at post-treatment). Significant follow-up period × treatment condition interaction effects emerged for both self-efficacy [$F_{\text{interaction}}(1, 3138) = 40.03$, $p < 0.05$] and perceived control over pain [$F_{\text{interaction}}(1, 3165) = 12.44$, $p < 0.05$], such that increases in both variables from pre- to post-treatment were significantly greater among the STD + CBT patients than among the STD patients.

3.5. Prediction of momentary pain at post-treatment

Table 2 shows the results of the analysis in which concurrent and lagged coping scores were used to predict momentary pain reports at the post-treatment time point. Results in the table depict main effects of concurrent and lagged coping scores, controlling for treatment condition, number of records recorded, and time of recording (by time of day, recording day, and the interaction of

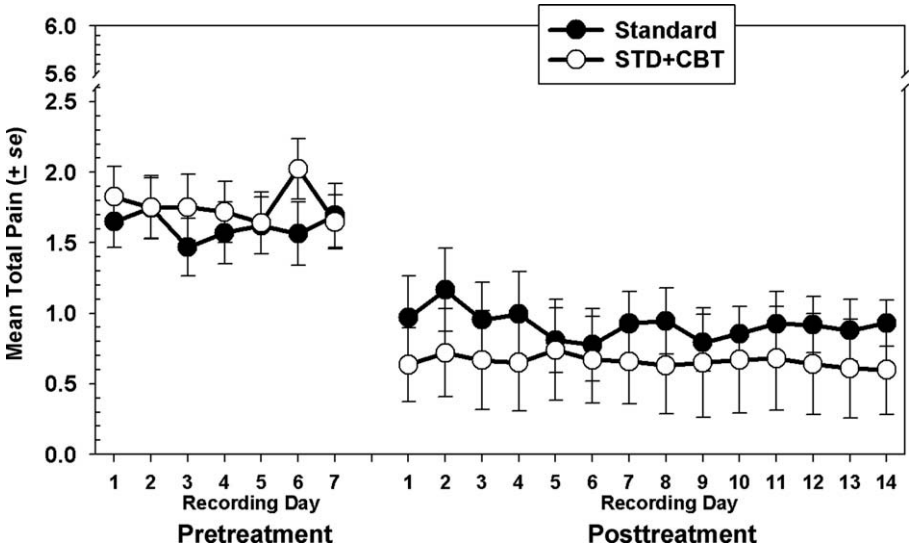

Fig. 1. Means of momentary pain ratings from experience sampling recordings, aggregated over each day of the baseline or post-treatment experience sampling recording period, by treatment condition.

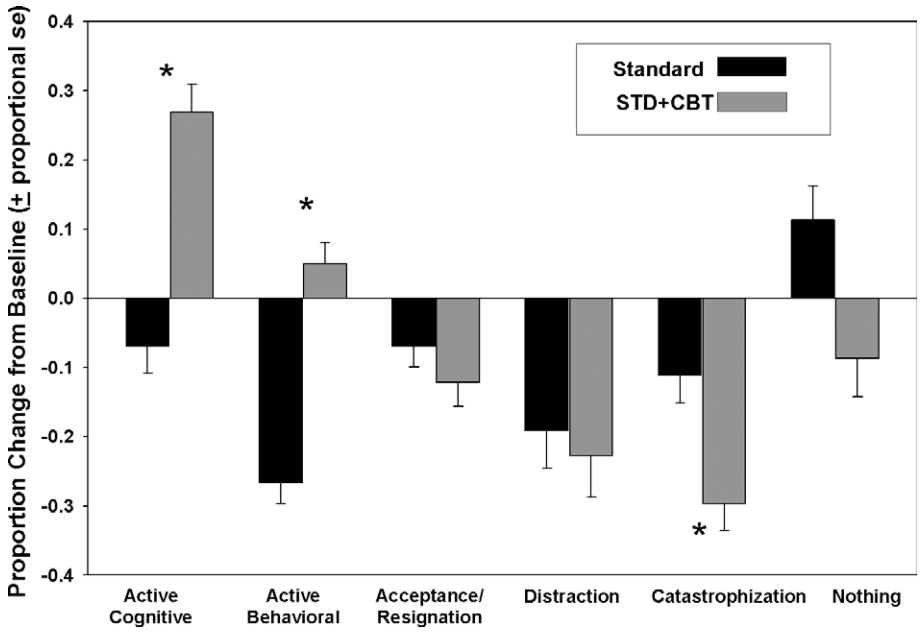

Fig. 2. Proportion changes in coping scale score responses from pre-treatment to post-treatment experience sampling. Scores were aggregated over all time periods and over all days. Stars indicate those pre–post differences that differed significantly by treatment condition in mixed models.

recording time × recording day). As seen in the table, a main effect for treatment condition emerged, such that STD condition (coded −1) was significantly associated with momentary pain. Concurrent reporting of active cognitive coping was protective against pain, and concurrent "acceptance" and catastrophization were predictive of pain. Among the coping scores recorded in the time period immediately prior to the pain rating, active behavioral coping was protective and catastrophization was predictive of pain, even when concurrent scores were controlled for.

Results for affect scale scores are shown in Table 3. Results in the table depict main effects of concurrent and lagged affect scores, controlling for treatment condition, number of records recorded, and time of recording (by time of day, recording day, and the interaction of recording time × recording day). Of the concurrent affect scores, greater high arousal positive affect was significantly associated with less pain. Negative-high arousal mood was a significant predictor of higher pain ratings in the next time period.

The effects of momentary reports of self-efficacy for pain control and perceived control over pain are reported in Table 4. Results in the table depict main effects of concurrent and lagged control and self-efficacy scores, controlling for treatment condition, number of records recorded and time of recording (by time of day, recording day, and the interaction of recording time × recording

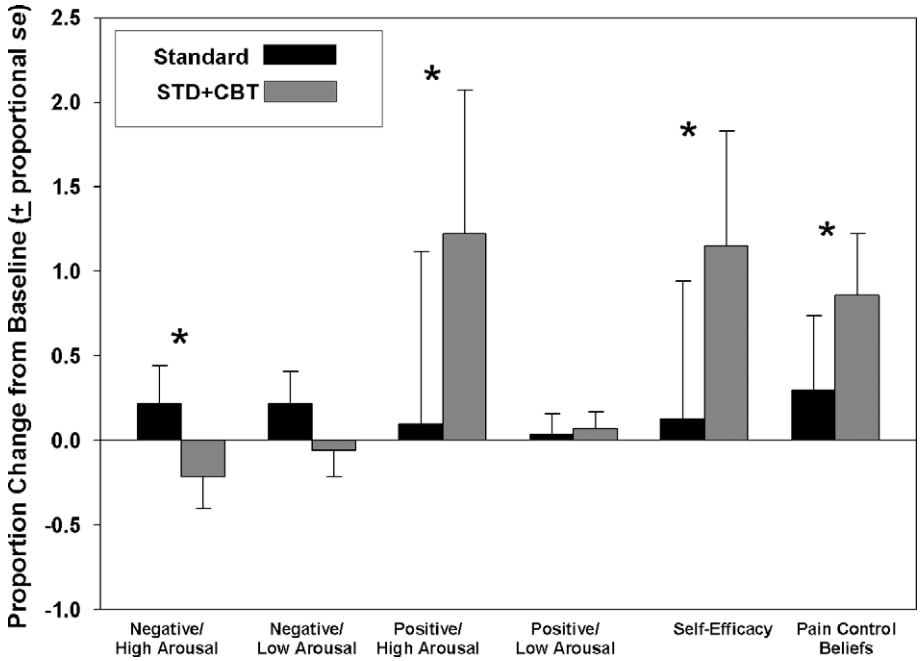

Fig. 3. Proportion changes in affect and cognition scale score responses from pre-treatment to post-treatment experience sampling. Scores were aggregated over all time periods and over all days. Stars indicate those pre–post differences that differed significantly by treatment condition in mixed models.

Table 2
Prediction of momentary pain at post-treatment: effects of coping strategies.

Variable	Num DF	Den DF	Estimate	*F*
Number of records	1	264	−0.00	0.02
Time period during day	2	264		1.98
Day of recording	8	264		1.10
Time period during day × recording day	16	264		0.92
Treatment condition	1	264	−0.32	3.51*
Concurrent coping				
Active cognitive	1	264	−0.25	3.03*
Active behavioral	1	264	0.05	2.17
Acceptance	1	264	0.46	17.51***
Distraction	1	264	0.10	0.01
Catastrophization	1	264	1.23	18.91***
Nothing	1	264	0.07	0.00
Coping immediately prior				
Active cognitive	1	264	−0.13	0.97
Active behavioral	1	264	−1.09	12.79***
Acceptance	1	264	−0.04	0.17
Distraction	1	264	0.24	0.06
Catastrophization	1	264	0.93	12.25***
Nothing	1	264	0.01	0.00

* $p < 0.05$.
*** $p < 0.001$.

day). Both concurrent self-efficacy and perceived control scores were associated with less momentary pain. Self-efficacy was also a significant negative predictor of pain at the next time period.

Table 5 shows the results of the hierarchical linear analysis of momentary pain report in which all variables that had shown predictive ability in the previous analyses were employed as predictors. As in the preceding tables results in the table depict main effects of concurrent and lagged coping scores, controlling for treatment condition, number of records recorded and time of recording (by time of day, recording day, and the interaction of recording time × recording day). As seen in the table, with all predictors in the model the parameter estimate for treatment condition shrinks to 0.13, suggesting that the predictors in the model are accounting for some of the variance previously accounted for by the treatment condition variable. Neither number of records made, time of day, nor day of recording were significantly associated with momentary pain when all other variables were in the model. A number of concurrent coping variables were associated with pain, particularly acceptance and catastrophization, which were both predictive of pain, and active cognitive coping, which was protective. Self-efficacy cognitions were also strongly protective against pain, as was positive, high arousal affect. Catastrophization and negative, high arousal affect were strong predictors of pain in the next time period, whereas self-efficacy and active behavioral coping were protective against pain in the near future.

Table 3
Prediction of momentary pain at post-treatment: effects of affects.

Variable	Num DF	Den DF	Estimate	*F*
Number of records	1	273	−0.01	0.12
Time period during day (1–4)	2	273		0.75
Day of recording (1–14)	8	273		1.29
Time period during day × recording day	16	273		0.56
Treatment condition	1	273	−0.32	0.81
Concurrent affects				
Negative-high arousal	1	273	0.05	1.35
Negative-low arousal	1	273	0.01	0.01
Positive-high arousal	1	273	−0.01	9.05***
Positive-low arousal	1	273	−0.04	1.99
Affects immediately prior				
Negative-high arousal	1	273	0.15	11.60***
Negative-low arousal	1	273	0.08	1.55
Positive-high arousal	1	273	0.01	0.09
Positive-low arousal	1	273	0.02	0.51

*** $p < 0.001$.

Table 4
Prediction of momentary pain at post-treatment with adaptive cognitions: effects of self-efficacy and perceived control.

Variable	Num DF	Den DF	Estimate	*F*
Number of records	1	286	0.00	0.00
Time period during day (1–4)	2	286		2.26
Day of recording	8	286		1.73
Time period during day × recording day	14	286		0.69
Treatment condition	1	286	−0.15	0.15
Concurrent cognitions				
Self-efficacy	1	286	−0.14	25.76***
Perceived control	1	286	−0.09	5.49*
Cognitions immediately prior				
Self-efficacy	1	286	−0.03	4.46*
Perceived control	1	286	−0.05	2.61

* $p < 0.05$.
*** $p < 0.001$.

4. Discussion

Despite some advantage in terms of reducing pain and, to a lesser extent, depressive symptoms, the addition of cognitive–behavioral skills training to a standard conservative treatment for TMD pain did not result in statistically significant benefits on general retrospective measures of pain, depression, and interference at post-treatment. The STD treatment, in fact, produced quite respectable decreases in recalled pain without any skills training added. Overall, mean pain scores were reduced by about 50%, which is typically considered a clinically significant reduction.

When evaluated on a momentary basis, however, experience sampling data indicated that the STD + CBT condition did result in greater decreases in pain scores at post-treatment than those reported by STD patients. Pain scores recorded multiple times per day dropped to less than one-third of their pre-treatment levels in the STD + CBT condition, and to about two-thirds of their pre-treatment levels in the STD condition. Momentary pain scores in

Table 5
Prediction of momentary pain at post-treatment: combined model.

Variable	Num DF	Den DF	Estimate	*F*
Number of records	1	258	0.00	0.01
Time period during day (1–4)	2	258		1.74
Day of recording	2	258		0.81
Time period during day × recording day	8	258		0.94
Treatment condition	16	258	−0.13	0.27
Concurrent predictors				
Active cognitive coping	1	258	−0.11	6.67*
Active behavioral coping	1	258	0.32	0.80
Acceptance	1	258	0.36	12.19***
Catastrophization	1	258	0.86	10.17***
Self-efficacy	1	258	−0.08	7.44**
Perceived control	1	258	−0.09	5.96*
Negative-high arousal affect	1	258	0.02	0.15
Positive-high arousal affect	1	258	−0.08	6.80**
Predictors immediately prior				
Active cognitive coping	1	258	−0.01	0.00
Active behavioral coping	1	258	−0.78	7.64**
Acceptance	1	258	0.04	0.13
Catastrophization	1	258	0.76	8.63**
Self-efficacy	1	258	−0.02	8.59**
Perceived control	1	258	−0.01	0.00
Negative-high arousal affect	1	258	0.13	12.55***
Positive-high arousal affect	1	258	0.02	0.56

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

both of the conditions at both the pre-treatment and post-treatment periods were noticeably lower than the retrospective general pain scores recorded on the MPI. These differences between the retrospective and momentary recording, especially in pain reports, highlight the utility and theoretical importance of the momentary recording procedure.

This discrepancy between recalled pain and averaged momentary pain is an increasingly common finding in the pain literature (e.g., [17]). Stone et al. [18] examined this phenomenon and found that the degree of discrepancy between recalled and momentary pain was a function of the variability of the pain scores recorded in real-time. Recalled pain is a function of a variety of stimuli in addition to pain, and is often influenced by the worst pain of the recall period. Although recalled pain and momentarily recorded pain are related constructs, they are not the same. In this study the correlation between aggregated Day 1 momentary pain and the MPI recalled pain score at baseline was $r = 0.56$. We suggest that variability in pain experience not only alters pain recall, but may also obscure small but real differences in the recalled pain experience, making it difficult to detect post-treatment differences between treatment groups.

It is also possible that a more severely affected sample would have shown clearer treatment differences on the general retrospective measure, in that they would have likely experienced greater overall improvements (that is, a greater pre–post effect size for pain would have been possible). Given the treatment effect size found in this study of $d = 0.2$, an N of 50 per cell would have been required to see treatment differences in the MPI pain measure.

Momentary recording also yielded interesting results regarding the actions taken by TMD patients in response to pain episodes. As expected, the addition of cognitive behavioral skills training to standard treatment resulted in large increases in cognitive coping and decreases in catastrophization at post-treatment. Both cognitive coping and reducing catastrophization were stressed in the current treatment. However, behavioral coping skills such as relaxation, which was also specifically emphasized, were apparently not widely used at critical times. This finding is at odds with that by Riley et al. [12], who reported that relaxation was among the most frequently used strategies among a sample of myofascial TMD patients. It should be noted, however, that the Riley et al. study was retrospective, required patients to choose from a list of only eight self-care responses, and did not allow non-responses. Our momentary data suggest that our patients did not take the time to engage in relaxation in pain episodes, but did resort to some brief cognitive strategies (e.g., self-talk such as "I told myself it would end"). When patients did engage in active behavioral strategies, however, their pain ratings were lower in subsequent time periods. Thus relaxation, and other active behavioral strategies, appears to be an effective preventive strategy, but more attention might be paid to teaching patients to use it more often to cope with acute episodes.

The momentary coping findings here are consistent with those of Aaron et al. [2], who had patients enrolled in an orofacial pain treatment program record pain and coping activities using an electronic diary three times per day for 14 days. Aaron et al. reported that these patients resorted to a number of coping behaviors, particularly active behavioral and active cognitive strategies, prior to being trained to do so in treatment. The CBT program in the current study appeared to have capitalized on this tendency for self-care, but also served to forestall catastrophization and increase self-efficacy. Again, these differences were only made apparent by the use of momentary recording of experience.

Overall, differences in momentary outcomes by treatment were not entirely accounted for by differences in coping responses (see Table 2). Treatment condition differences in momentary pain persisted even when coping responses were in the model. Changes in other aspects of pain management and pain experience, however, including affects and cognitions, did account for treatment effects. The addition of cognitive behavioral strategies, then, resulted not only in specific improvements in some coping, but also in improvements in affects and cognitions, particularly increases in self-efficacy expectations and decreases in catastrophization, that may have been more important than the coping changes per se.

There are some limitations to this study. One issue that must be considered in this study is the possible reactivity of the ES protocol. It could be argued that the frequent prompts to answer questions about pain and behavior might alter these responses. Reactive effects, if they occurred, do not threaten the internal validity of the study because all subjects were participating in the same ES protocol. The greater threat is to the external validity of the study. However, measurement reactivity is minimized when diaries such as those used here involve recording more than one construct [5]. More to the point is published research indicating that experience sampling does not affect the recording of pain and pain-related affects, cognitions and behaviors [1,20].

Other problems with the methodology are somewhat more serious. Because of limitations in the technology employed when the study started, open-ended coping questions were not used. Instead, subjects responded to a checklist of coping items. This list may have artificially restricted and/or directed the responses endorsed by participants recalling how they reacted to an acute pain situation. Two aspects of the data suggest that the restriction-of-choice-problem may not have been severe. First, the data themselves appeared to be distributed in a way that is consistent with how we believe patients respond in real life. For example, there was relatively little resort to "accepted the pain." Second, participants did record pain episodes, and, more important, recorded when they did "nothing" to try to manage pain. The present dataset, then, is at least valid on its face. Our upcoming work in this area will allow free response to record coping efforts, however.

Another problem involves interpretation of the results. Consistent with the hypotheses, the STD + CBT condition appeared to result in increased coping efforts recorded at post-treatment. The momentary recordings of coping responses were also associated with pain recorded at post-treatment. It is not clear whether pain levels were reflecting coping changes that had occurred as a function of treatment (as hypothesized), or whether coping responses had been altered by changes in pain levels that had already taken place by the time treatment had ended. It will require additional follow-ups to establish a causal chain from coping behaviors to pain control. It is most likely that coping and pain influenced each other over time, in a dynamic relationship.

Despite the limitations the present results are strongly supportive of a cognitive social learning formulation of pain management training. The addition of cognitive behavioral coping skills training to standard treatment resulted in lower pain at post-treatment (at least when measured on a momentary basis), and in increases in momentary coping and decreases in catastrophizing. Finally, treatment differences in post-treatment momentary pain were accounted for by treatment-related changes in cognitions, affects and coping behaviors. The results suggest not only that short cognitive–behavioral treatments have value added, but also that they operate by changing key constructs.

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