Examining the Impact of a Resilience-Based Hope Intervention on Pain-Evoked Cortisol Response

Nadia I. Hossain, Michael E. Robinson, Roger B. Fillingim, & Emily J. Bartley

Temperomandibular disorder is an orofacial pain condition often resulting in functional impairment and pain-related disability. Given the relationship between stress and pain in Temperomandibular disorder, it has been suggested that dysregulation of the hypothalamic-pituitary-adrenal axis (e.g., cortisol responsivity) could contribute to the onset and maintenance of the condition. Research has shown that therapies to control pain and stress can improve quality of life in patients with persistent pain, with recent evidence supporting resilience as a potential target of intervention. However, no studies have systematically examined whether a resilience intervention has efficacy in modulating neuroendocrine functioning in Temperomandibular disorder. Therefore, the primary objective of this pilot study was to investigate the effects of a resilience-based hope intervention on pain-evoked cortisol levels in individuals with Temperomandibular disorder. Twenty-nine participants were randomized to a 3-session intervention intended to increase hope or a control intervention targeting pain and stress education. Prior to and after the intervention, participants attended two experimental sessions whereby salivary cortisol was obtained after the induction of a painful, cold-water procedure. While there were no intervention group differences in pain-evoked cortisol response, greater situational and dispositional hope were associated with lower levels of cortisol. Overall, findings suggest that positive emotional resources may attenuate heightened neuroendocrine activity; however, further research is needed to determine the physiological benefits of resilience-oriented therapies.

INTRODUCTION

Temporomandibular disorders (TMD) are a group of orofacial pain conditions primarily affecting the temporomandibular joint and muscles of mastication. TMD often results in reduced work-related productivity and decreased quality of life (Sherman et al., 2005), and patients are at increased risk for other health-related conditions such as irritable bowel syndrome, interstitial cystitis, and mood disorders (Furquim, Flamengui, & Conti, 2015). Causes of TMD are complex and multifactorial but can include oral parafunctional behaviors (i.e., bruxism, teeth clenching), misalignment of the teeth/jaw, and/or emotional factors such as depression or anxiety (Sharma, Gupta, Pal, & Jurel, 2011; Slade et al., 2016).

Alterations in basal and stress-induced hypothalamic-pituitary-adrenal (HPA) activity have been implicated in TMD pathogenesis, with evidence supporting dysregulated stress and cortisol responses in individuals with TMD (Lambert et al., 2013; Ulrich-Lai et al., 2006). Given the multi-systemic effects of the HPA axis, it has been suggested that disruptions in HPA activity may influence central and neural pathways responsible for the transmission and modulation of pain (Ulrich-Lai et al., 2006). Supporting the relationship between stress and pain, Jones and colleagues found that TMD patients secreted higher levels of cortisol in response to experimental stress in comparison to healthy pain-free individuals (Jones, Rollman, & Brooke, 1997), signifying an exaggerated physiological response to stress in this population. Lambert et al. also reported that TMD participants perceive higher amounts of stress than healthy, pain-free individuals (Lambert et al., 2013). Because TMD symptoms often increase during stress, mechanisms associated with the dysregulation of cortisol reactivity in this population could contribute to the development and/or maintenance of TMD symptoms and pain.

Treatments for TMD have historically focused on invasive medical and dental procedures, intraoral appliances, and medications; however, these approaches show modest efficacy and provide insufficient long-term improvement in pain (Sherman & Turk, 2001). As a result, psychosocially-based interventions to ease pain-related suffering have been supported, with recent efforts directed towards examining resilience in the context of pain coping. Resilience is the process of successful adaptation after trauma, adversity, or severe stress, and evidence supports the positive role that resilience has on mental well-being, pain acceptance, and physical health (Sturgeon & Zautra, 2010). While scant, there is a growing body of literature investigating the effects of therapeutic approaches that foster resilience and positive mental health. Resilience-oriented treatments work toward enhancing personal
strengths and coping resources to increase goal-directed behavior and hopeful thinking in the face of adversity. For instance, Hanssen and colleagues examined the influence of optimism on experimental pain in healthy adults via the Best Possible Self (BPS) exercise. The authors found that participants in this optimism intervention reported lower pain intensity ratings compared to the control group (Hanssen, Peters, Vlaeyen, Meevissen, & Vancleef, 2013). Using a similar paradigm, Boselie and colleagues examined whether an optimism manipulation eliminated pain-induced interference with cognitive performance. While experimentally-induced pain (i.e., cold pressor) reduced performance on the memory task, generating an optimistic state abolished these adverse effects (Boselie, Vancleef, Smeets, & Peters, 2014). In addition, Howell conducted hope-based group therapy with 24 individuals with chronic pain. After a six-week intervention, the authors found that participants experienced significant improvements in well-being and pain acceptance (Howell, Jacobson, & Larsen, 2014).

Taken together, therapies aimed at enhancing resilience may serve as a potential target for pain management. Despite this possibility, few studies have examined the impact of resilience interventions in individuals with persistent pain, and there have been none to our knowledge that have examined these relationships in TMD. Therefore, the primary objectives of this pilot study were to investigate the association between hope and cortisol and examine differences in pain-evoked cortisol levels between TMD participants receiving a resilience-based hope intervention compared to participants in a pain education control group. Given evidence of heightened stress-evoked cortisol levels in TMD, as well as the protective effects of positive psychological states, it was hypothesized that cortisol would be lower in the Hope group (when compared to Pain Education) after the induction of a pain stressor (i.e., cold water task).

**METHODS**

**Participants**

Individuals with TMD were selected through flyers and radio advertisements placed in the community. Participants were included if they: 1) reported moderate orofacial pain (≥3/10 on a pain rating scale) during the past six months, 2) experienced pain on at least 15 days during the past month, and 3) met diagnostic criteria for TMD. Exclusionary criteria included age <18 or >65 years, current use of opioid analgesics, and diagnosis of neurological, neuroendocrine, and/or cardiovascular disorders.

**Procedures**

The University of Florida Institutional Review Board approved of all procedures and participants provided informed consent before enrolling into the study. Due to diurnal variation in cortisol, all testing sessions were scheduled at approximately the same time of the day within participants (between 08:00 and 10:00 am). Study procedures involved attendance at three intervention sessions and two experimental sensory pain testing sessions (pre- and post-intervention), for a total of five visits. At the first visit, health history and demographic information were collected, questionnaires were completed, and a diagnostic examination (DC/TMD) was carried out for assessment of TMD symptoms.

Classification of TMD involved applying pressure to the orofacial region (i.e., temporomandibular joint and muscles of the temporalis, masseter, and posterior mandibular sites). For study inclusion, participants were required to report pain either in the joint or one orofacial muscle in response to palpation. Participants then underwent the following sensory pain procedures: heat pain tolerance, heat temporal summation, mechanical pressure pain threshold, cutaneous pressure pain, and cold pain threshold/tolerance. Cortisol saliva samples were taken a total of two times during the experimental sessions: before the start of sensory testing and 30-minutes after the cold pressor task. After the initial laboratory session, participants were randomized to either a Hope-based resilience intervention or Pain Education, whereby they received 3 weekly 1-hour sessions (Visits 2-4). During the final visit (Visit 5), sensory pain testing was repeated. After study completion, participants were provided an honorarium up to $200.

**Psychosocial Intervention Protocols**

**Hope Intervention.** The development of the Hope intervention protocol was based upon a theoretical model of hope posited by Charles Snyder (Snyder et al., 1991). Hope consists of one’s ability to cultivate goals, develop routes to achieve goals (pathways thinking), and sustain focused energy toward successful attainment of goals (agency). A general outline of each Hope intervention session is as follows: Session 1) discuss personal history of TMD, overview of conceptual framework of hope: cultivating goal-directed thinking, developing routes to achieve goals (pathways thinking), enhancing motivation for successful goal attainment (agency); Session 2) discussion of pathways thinking, fostering positive thinking, identification of personal strengths; Session 3) discussion of agency thinking, goal-focused imagery exercise, review concepts and skills learned, provide feedback on the use of hope concepts for pain management.
Skills-building activities were conducted during the session and at home to facilitate hopeful thinking and goal-directed behavior.

**Pain Education Intervention.** A general outline of each Pain Education intervention session is as follows: Session 1) discuss personal history of TMD, instruction on TMD symptoms, etiology, and treatments, information on Gate-Control theory of pain; Session 2) education on the influence of stress on TMD pain; Session 3) discuss lifestyle management of pain (i.e., sleep hygiene, exercise), review concepts and skills learned.

**Questionnaires**

**Adult Dispositional Hope Scale (ADHS):** The Adult Dispositional Hope Scale (Snyder et al., 1991) is a self-report, 12-item inventory designed to tap dispositional (trait) hope in adults, ages 15 and older. It consists of 4 agency, 4 pathway, and 4 distracter items. Responses to items are on a scale from 1 (definitely false) to 8 (definitely true). Agency and pathways subscale scores are derived, as well as a total score consisting of a sum of these two subscales (Range: 8 to 64). The ADHS was administered at the beginning of the baseline visit.

**Adult State Hope Scale (ASHS):** The Adult State Hope Scale (Snyder et al., 1996) is a self-report, 6-item inventory used to assess goal-directed thinking at a given moment in time. It consists of 3 agency and 3 pathway items. Responses to items are on a scale from 1 (definitely false) to 8 (definitely true). Agency and pathways subscale scores are obtained, as well as a total score consisting of a sum of these two subscales (Range: 6 to 48). The ASHS was administered to participants during baseline and Visit 5 sessions immediately prior to sensory pain testing.

**Pain Induction**

**Cold Pressor (CP).** During the pre- and post-intervention experimental sessions, participants submerged their dominant hand up to their wrist in 5 °C water until they were no longer able to tolerate the cold water pain (for a maximum immersion of three minutes). Participants’ pain intensity ratings at threshold and tolerance and the time participants first reported pain and withdrew their hand was recorded (data reported elsewhere). The CP task is a widely-used procedure to assess pain sensitivity (Herbert et al., 2014).

**Cortisol Assessment**

Cortisol was measured through saliva samples as salivary assessment is non-invasive, cost-effective, reliable, and easy to collect (Gann, Giovanazzi, Van Horn, Branning, & Chatterton, 2001). Participants had to refrain from alcohol use 12 hours before collection, eating one hour prior to collection, and brushing their teeth 45 minutes before collection to prevent salivary contamination. Participants first pooled saliva in their mouth and then passively salivated into a 2-inch straw attached to a plastic test tube until 2 mL of saliva was obtained. Samples were refrigerated within two hours after collection and then later kept in a -80 °C freezer. Samples were shipped overnight on dry ice to Salimetrics LLC for testing of cortisol levels (Salimetrics, 2015).

On the day the samples were to be assayed, they were thawed to room temperature, vortexed, and then centrifuged for 15 minutes at approximately 3,000 RPM (1,500 x g). Samples were tested for salivary cortisol (Cat. No. 1-3002) using high-sensitivity enzyme immunoassays. The test used 25 μL of saliva per determination and had an assay range of 0.012-3.0 ug/dL. The average intra-assay coefficient of variation was 7.0%, the inter-assay coefficient of variation was 8.0%, and the assay sensitivity was 0.007 ug/dL. Per Salimetrics, acceptance criteria for duplicate results was a coefficient of variation < 15% between samples 1 and 2.

**Statistical Analysis**

Statistical analyses were completed using SPSS 23.0 (SPSS Inc, Chicago, IL). Before conducting analyses, distributions of the variables were examined and extreme cortisol outliers (3 SD above or below the mean) were eliminated. Bivariate correlations were conducted to examine associations between state and trait hope (using total scores and subscale scores) with baseline and pain-evoked cortisol levels. The following guidelines were implemented to assess the strength of the correlation coefficient: small ($r_\text{state} = .10$ to .29), medium ($r_\text{state} = .30$ to .49), large ($r_\text{state} = .50$ to 1.0). To examine the effect of intervention group on pain-evoked cortisol levels, a 2 (Intervention Group) x 2 (Time: Pre- vs. Post-Intervention) repeated measures ANOVA was conducted. Follow-up mean comparisons to significant F tests were conducted using Fisher Least Significant Difference tests. To obtain effect size estimates associated with F-tests, partial eta-squared ($\eta^2_p$) was calculated from GLM analyses ($\text{small}=.01$, medium=.06, large=.14). Significance was set at $p \leq .05$ (two-tailed).

**RESULTS**

**Participant Characteristics**

Demographic and clinical characteristics of the participant sample are shown in Table 1. The majority of the participants were female, not married, non-Hispanic, white/Caucasian, and either employed full- or part-time with a college education. Ages ranged from 19-62 years.
Thirty-six participants signed consent to participate during Visit 1, but 1 subject was excluded due to hypertension. Before randomization, 2 more participants withdrew consent due to time commitments and exacerbation of TMD pain. From the remaining 33 randomized participants, 1 participant discontinued from the Hope group (i.e., moved) and 3 participants withdrew from the Pain Education group (i.e., 1 moved, 2 lost to follow-up) before the completion of the study. Thus, 29 participants completed all five sessions of the study (Hope: N=15). Baseline saliva samples from 1 participant had blood contamination, and 2 participants experienced xerostomia during saliva collection; therefore, these samples were excluded from analysis. Further, 1 participant (Hope Group) had a hormone value that was an extreme outlier at pre-intervention resulting in the exclusion of this observation.

Table 1. Demographic and Clinical Characteristics across Intervention Group

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hope N=15</th>
<th>Pain Education N=14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>38.1 ± 14.3</td>
<td>39.7 ± 14.0</td>
</tr>
<tr>
<td>Sex (% Female)</td>
<td>12 ± 80</td>
<td>10 ± 67</td>
</tr>
<tr>
<td>Race (% Caucasian)</td>
<td>11 ± 73</td>
<td>10 ± 67</td>
</tr>
<tr>
<td>Ethnicity (% Non-Hispanic)</td>
<td>14 ± 93</td>
<td>14 ± 93</td>
</tr>
<tr>
<td>Education (% College Degree)</td>
<td>11 ± 73</td>
<td>9 ± 60</td>
</tr>
<tr>
<td>Marital Status (% Not Married)</td>
<td>11 ± 73</td>
<td>7 ± 47</td>
</tr>
<tr>
<td>Employment Status (% Employed)</td>
<td>8 ± 53</td>
<td>9 ± 60</td>
</tr>
<tr>
<td>Income (% ≥ $30,000)</td>
<td>10 ± 67</td>
<td>7 ± 47</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>25.0 ± 5.4</td>
<td>25.4 ± 3.6</td>
</tr>
<tr>
<td>TMD Duration (years)</td>
<td>10.2 ± 10.8</td>
<td>9.1 ± 11.1</td>
</tr>
</tbody>
</table>

**Associations between Hope and Cortisol**

The relationship between hope (as measured by the dispositional and state hope scales) and cortisol levels (measured at baseline and pain-evoked) was investigated using Pearson product-moment correlation coefficients. There were strong, negative correlations between dispositional pathways thinking (r = -.51, p = .006), dispositional agency (r = -.43, p = .02), and dispositional hope (total scale) (r = -.57, p = .001) with baseline cortisol at post-intervention, contributing 19-33% of the variance in cortisol levels. Further, greater situational pathways thinking during pre-intervention was associated with lower baseline cortisol at post-intervention. All other correlations were non-significant (r's < -.36, p's > .05). Findings for the total dispositional scale and situational pathways scale are provided in Figures 1 and 2.

**Differences in Cortisol across Intervention Group and Time**

Descriptive data for cortisol levels are presented in Table 2. There were no significant differences across group (Hope vs. Pain Education) in mean levels of baseline cortisol either before or after the intervention period [F(1, 25) = .76, p = .39, ηp² = .03], suggesting that the two groups had similar cortisol levels prior to the cold pressor test. For pain-evoked cortisol levels, the main effects of intervention group [F(1, 21) = .34, p = .56, ηp² = .02] and time [F(1, 21) = .01, p = .91, ηp² = .00] were not significant. Further, the Group X Time interaction was non-significant [F(1, 21) = .58, p = .45, ηp² = .03], indicating that there were no intervention group differences from pre- to post-intervention in pain-evoked cortisol levels.
Table 2: Descriptive Statistics for Cortisol Levels (μg/dL) across Intervention Group and Time

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Intervention</th>
<th></th>
<th>Post-Intervention</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>Range</td>
<td>M</td>
</tr>
<tr>
<td>Hope Baseline</td>
<td>.23</td>
<td>.16</td>
<td>.07-61</td>
<td>.38</td>
</tr>
<tr>
<td>Hope Pain-Evoked</td>
<td>.14</td>
<td>.05</td>
<td>.06-27</td>
<td>.21</td>
</tr>
<tr>
<td>Pain Education Baseline</td>
<td>.17</td>
<td>.14</td>
<td>.05-58</td>
<td>.33</td>
</tr>
<tr>
<td>Pain Education Pain-Evoked</td>
<td>.19</td>
<td>.15</td>
<td>.05-53</td>
<td>.22</td>
</tr>
</tbody>
</table>

**DISCUSSION**

While evidence supports the relationship between resilience and adaptive pain functioning, there have been no studies examining the therapeutic efficacy of resilience on pain-related physiological activity. Therefore, the primary objectives of this pilot study were to examine the association between cortisol and hope (a measure of resilience), and assess whether individuals undergoing a resilience-based hope intervention exhibit a stronger change in pain-evoked cortisol response, compared to participants undergoing pain education.

We found that higher dispositional hope and situational pathways thinking (at pre-intervention) were associated with lower baseline cortisol levels at post-intervention. These findings suggest that hope may serve as a protective factor against heightened HPA activity and would align with existing research supporting the biological benefits of resilience. For instance, Lai and colleagues observed that individuals who scored higher in optimism secreted less salivary cortisol (Lai et al., 2005), while another study found that optimism was protective against elevated cortisol secretion on days of high perceived stress (when compared at the within-person level) (Jobin, Wrosch, & Scheier, 2014). Similarly, Polk et al. found divergent effects between positive (PA) and negative affect (NA) – lower cortisol levels were associated with PA while higher cortisol concentrations were related to NA (Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005). Overall, these studies suggest that positive psychological states may modulate adrenocortical functioning.

Following the intervention, both the Hope and Pain Education groups showed similar pain-evoked cortisol activity. Although this is in contrast to existing research observing alterations in cortisol after psychosocial intervention (Matousek, Dobkin, & Pruessner, 2010; Robinson, Garofalo, & Gatchel, 2006; Yoo et al., 2016), our findings are comparable to Goodin and colleagues, who reported that brief (2-session) hypnosis produced negligible effects on cortisol reactivity to experimentally-induced pain (Goodin et al., 2012). While it is unclear why we were unable to detect group differences, it is important to note that our intervention period was relatively brief; thus, a larger therapeutic “dose” may have been necessary to engage HPA activity and observe differential effects at the group level. Findings may have also been due to cortisol decreasing after the baseline period. Indeed, after additional analysis results revealed significant reductions in cortisol from the baseline to pain-evoked period ($p=.02$, $\eta_p^2=.20$), which could have created a floor effect and attenuated group differences. Another possible explanation for the lack of findings across interventions was our assessment of cortisol. Specifically, it has been suggested that measures of recovery (rather than response parameters) may better characterize system functioning, such that faster recovery after the onset of a stressor reflects an adaptive process (Chapman, Tuckett, & Song, 2008). Therefore, it is conceivable that group differences may have emerged in cortisol recovery (e.g., taking multiple cortisol measurements after pain induction) that were not accurately reflected in the single measurement. Future studies would benefit from examining whether resilience-based interventions impact recovery parameters in physiological pathways associated with pain.

**Strengths and Limitations**

Some limitations merit acknowledgement. First, given the pilot nature of this study, our current sample size may have been underpowered to detect small effect group differences. Additionally, only 4 out of 36 correlations were significant when examining the association between hope and cortisol, and it is unclear whether results would replicate in a larger sample. Findings should therefore be interpreted with caution. Second, study participants were primarily Caucasian, female, and college-educated, thus, the generalizability to other demographic groups is unclear. Cortisol was measured 30 minutes after the cold pressor task to remain consistent with previous research (Dickerson & Kemeny, 2004; Goodin et al., 2012). However, other studies have taken samples at later time-points (DeSanitis, Adam, Hawkley, Kudielka, & Cacioppo, 2015; Gaab et al., 2003) after a stressor was administered; therefore, it is possible that cortisol may have peaked at a subsequent time-point and impacted the ability to detect differences. Finally, we delivered a brief (3-session) intervention to participants to reduce the burden associated with longer treatment. As a result, it is uncertain whether a longer intervention duration would have produced more robust effects.

Despite these limitations, the current study is one of few that have evaluated the contributions of a resilience-based treatment for chronic pain, and intervention development was based upon an existing theoretical model of hope (Snyder et al., 1991). Retention rates were high for the study, with a lower dropout rate observed for the Hope group, thus speaking to the feasibility and credibility of the interventions. Furthermore, this is the first randomized controlled trial to assess the physiological effects of a resilience-oriented intervention, and the findings add to the literature on the role of hope on neuroendocrine functioning.
CONCLUSION

Although preliminary, results indicate that individuals higher in hope had lower baseline cortisol levels; however, there were no intervention group differences in pain-evoked cortisol response. Given the limited research in this area, continued investigation is warranted to identify resilience factors associated with adaptive physiological functioning, as well as examine whether larger-scale resilience interventions impact physiological processes associated with pain and stress.

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REFERENCES


