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Published in:
Complementary Therapies in Clinical Practice

DOI:
10.1016/j.ctcp.2022.101653

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Declarations

Funding: The research leading to these results received funding from the Bond University Infrastructure Grant.

Competing interests: Author A may receive speaking fees for the topic based on clinical expertise. The remaining authors have no relevant financial or non-financial interests to disclose.

Ethics approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Bond University (Date 17/6/2020. No. PS00147).

Consent: Informed consent was obtained from all individual participants included in the study.

Data, Materials and/or Code availability: The datasets for this study can be found at this link https://osf.io/

Authors' contribution: Material preparation, data collection and analysis were performed by Peta Stapleton and Oliver Baumann. The first draft of the manuscript was written by Peta Stapleton and Tom O'Keefe and all authors commented on versions of the manuscript. All authors read and approved the final manuscript.

Acknowledgements: Gold Coast University Hospital Imaging Service; Michele Stewart and Michelle McCosker for facilitating the trial and the emotional assistants who supported the participants.

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Abstract

This clinical trial investigated the effect of an Emotional Freedom Techniques (EFT) intervention on brain activation in chronic pain sufferers using functional magnetic resonance imaging (fMRI). EFT is a brief stress reduction technique which combines a cognitive statement with somatic tapping on acupressure points. Twenty-four adults were allocated to a six-week online group EFT treatment and underwent resting-state fMRI pre and post the intervention. A repeated measures MANOVA indicated significant differences in the levels of pain severity (-21%), pain interference (-26%), quality of life (+7%), somatic symptoms (-28%), depression (-13.5%), anxiety (-37.1%), happiness (+17%), and satisfaction with life (+8.8%) from pre- to post-test. Cohen's effect sizes ranged from small (0.2) to large (0.75) values suggesting significance for the intervention. fMRI analysis showed post-EFT treatment significantly decreased connectivity between the medial prefrontal cortex (a pain modulating area) and bilateral grey matter areas in the posterior cingulate cortex and thalamus, both areas being related to modulating and catastrophizing of pain. There were no brain areas that showed significantly increased connectivity post-EFT treatment. Coupled with the psychological measures the findings support the effects of the EFT intervention in reducing chronic pain and its impacts. Recommendations for future research are discussed.

Keywords: chronic pain, stress, emotional freedom techniques, resting-state fMRI

Highlights

- A radical re-imagining of therapy for chronic pain is needed
- Interventions with a strong somatic component may be effective
- Emotional Freedom Techniques resulted in significant differences in pain
- Emotional Freedom Techniques decreased connectivity in pain brain areas

Neural Changes after Emotional Freedom Techniques Treatment for Chronic Pain Sufferers

Chronic pain (CP) affects one-third to 50% of the population (Katz, et al., 2015) with a higher prevalence among females and affecting 62% of adults 75 years and older (Fayaz et al., 2016; Lynch, 2015). CP is a major health care crisis due to its high prevalence and associated physical and emotional incapacity (Sheng et al., 2017). Current treatment options for CP, which include physical therapy and pharmaceutical approaches, including opioids, are now recognized as inadequate (Abdel Shaheed et al., 2016; Kenan et al., 2012; van Middelkoop et al., 2011). Similarly, cognitive behavioral therapies (CBT) show only moderate-effect sizes of benefit over waiting lists and small or no effects over active comparators for outcomes in pain, disability, and mood (Hajihasani et al., 2019). Although there have been over 100 randomized clinical trials, there is still only low-quality evidence of small to moderate effects of CBT for CP. In the context of this treatment dilemma, body-based somatic approaches have emerged as potential treatments for CP. These approaches share several common features: direct interventions at the body level, potential ability to change brain activity very rapidly, and presumed capacity to shift outdated emotional learning (Feinstein, 2022). We propose a radical re-imagining of therapy for CP is needed - toward approaches with a strong somatic component in their actual treatment delivery (i.e., in contrast to emphasis on cognition), to capitalize on the well-established relationships between mind and body.

In this regard, an innovative answer may be in altering pain through a consideration of embodied perception—meaning an embodied pain approach. Emotional Freedom Techniques (EFT) is one such body-based approach, an evidence-based brief intervention for anxiety, depression, phobias and posttraumatic stress disorder (PTSD). EFT combines elements of cognitive and exposure therapy with physical stimulation of acupressure points, and is a manualized evidence-based stress reduction technique. It has been validated in more than 100 clinical studies, and meta-analyses of

EFT for anxiety (Clond, 2016), depression (Nelms & Castel, 2016), and PTSD (Sebastian & Nelms, 2017) indicate treatment effects that exceed those of psychopharmacology and conventional psychotherapy (Cohen's d or Hedge's g above 0.8). The impact of EFT on physical symptoms has been examined in diverse samples, including veterans (Church et al., 2013), hospital patients with tension headaches (Bougea et al., 2013), cancer patients (Baker & Hoffman, 2014), chronic pain (Stapleton et al., 2017), fibromyalgia (Brattberg, 2008), healthcare workers (Church & Brooks, 2010), frozen shoulder (Church & Nelms, 2016), psoriasis (Hodge, 2011), seizure disorders (Swingle, 2010), and traumatic brain injury (Church & Brooks, 2014). The delivery of EFT has also been examined across a range of options outside of in person trials, including online for weight loss (Church et al., 2018), relationship skills training (Church & Clond, 2019), food cravings (Stapleton, et al., 2019a, 2019b), fibromyalgia (Brattberg, 2008) and via an app for stress and anxiety (Church et al., 2020). All studies indicate effectiveness and longevity for the intervention delivered as such.

Six comparative studies and a meta-analysis have addressed whether acupoint tapping is an essential ingredient for the favorable outcomes reported following EFT treatments, or whether the cognitive, exposure, and non-specific therapeutic elements of the protocol are the primary active ingredients (Church et al., 2018). Otherwise identical protocols with and without the acupoint tapping component were compared, and those which included tapping produced a larger effect size than those with the other components but without tapping. Finally, clinically favorable shifts after acupoint tapping sessions have also been reported for a number of biomarkers (Church, 2013; Church et al., 2012) and include reductions in cortisol production, normalization of brain-wave patterns, shifts in blood flow within the brain, and changes in gene expression (Church et al., 2018; Maharaj, 2016; Stapleton et al., 2019a).

Research on the efficacy of EFT directly for CP is in its infancy, however intervention trials to date indicate significant reductions in a range of psychological and physical conditions. A trial offered as a 3-day workshop for CP sufferers resulted in significant reductions for Pain Catastrophizing Scale items (rumination, magnification, and helplessness) as well as significant improvements in pain severity, interference, life control, affective distress, and dysfunctional composite (Ortner et al., 2014). A brief 4-hour intensive EFT program for CP (Stapleton et al., 2017) revealed a significant decrease in the severity (–12.04%, $p = 0.044$) and impact (–17.62%, $p = 0.008$) of participants' pain from pretest to posttest, and a significant improvement in their overall psychological distress from pretest to posttest (–36.67%, $p < 0.001$). There was also a significant improvement in participants' depression (–29.86%, $p = 0.007$), anxiety (–41.69%, $p < 0.001$), and stress (–38.48%, $p = 0.001$) from pretest to posttest. The main effect was still present after 6-month follow-up. Similarly, significant reductions in pain catastrophizing thoughts (rumination, magnification and helplessness), anxiety, and depression in a sample of women diagnosed with fibromyalgia, have been found following EFT treatment delivered online (Brattberg, 2008).

Outside of this direct targeting of EFT for chronic pain, at least 20 other EFT trials have measured the impact of the intervention on pain as a variable. This has included PTSD symptom remediation in veterans (Church & Brooks, 2014), in relationship to anxiety, depression and food cravings in healthcare workers (Church & Brooks, 2010), dismenorrhea pain in adolescents (Sastra & Sari, 2016), and post operation pain related to caesarian section (Latifah & Ramawati, 2014). The majority reported significant statistically improvement in pain even when not being directly targeted.

Though the mechanisms supporting EFT's benefits have not been fully elucidated, it is proposed the manual stimulation of acupuncture points sends, to specific brain areas, activating and deactivating signals that are beneficial in relation to the psychological issues being addressed

(Feinstein, 2022). Harvard Medical School initially investigated the effects of stimulating acupuncture points via fMRI and other imaging across a 10-year study and indicated the amygdala and other areas of the limbic system were reduced in arousal, almost immediately after stimulation (Fang et al., 2009). To date only one fMRI study exists for EFT that showed after a 4-week (8-hour) intervention for food cravings and emotional eating in obese adults, blood flow to brain regions involved with craving (the superior temporal gyrus, associated with cognition, and the lateral orbito-frontal cortex, associated with reward) was significantly reduced when images of desired foods were presented (Stapleton et al., 2019a). Finally, there is also speculation tapping on acupoints generates signals known as "mechanosensory transduction" (Bagriantsev et al., 2014). Piezoelectricity occurs after pressure on a class of large proteins in skin cells converting mechanical stimulation into electrical impulses (Langevin & Yandow, 2002). The signals are believed to carry to other areas of the body via connective tissue. Current research (Li et al., 2021) has shown tracer dyes, injected at acupuncture points, generated linear migrations at these points, pointing to an anatomical basis for the acupoints.

Specifically, EFT combines elements of two other evidence-based psychotherapeutic techniques, exposure therapy and cognitive therapy, with acupoint stimulation in the form of pressure or tapping with the fingertips. It is principally a body-centric approach. As might be expected from a therapy that includes a strong somatic component, physiological shifts appear to follow EFT treatments. Our aim in the present trial was to assess EFT's effects on pain-related brain circuitry underlying CP and evaluate the treatment related changes. Our primary hypothesis centred on CP being a multidimensional experience comprised of sensory, affective, and cognitive components, therefore EFT would reduce psychological symptoms related to CP, as well as functional connectivity in catastrophizing regions of the brain.

Method

Participants and Procedure

Participants (N=24) were called for through community advertising, and were over 18 years, not suffering any severe psychological impairment, not currently receiving treatment (psychological or medical) for their chronic pain, and all genders were eligible. Ethical approval was provided by the Bond University Human Research Ethics Committee. Inclusion criteria included: being English-speaking; having an endorsement of chronic pain for at least 6 months out of the past 12 months that negatively impacted overall functioning and quality of life; having chronic pain without clear organic etiology determined by primary care physician or subspecialist; and having a current pain rating of 4 or higher on 0 to 10 visual analog pain index. Exclusion criteria included: not currently being engaged in another psychotherapy treatment intervention for chronic pain (e.g. cognitive behavioural therapy); having a major psychiatric disorder (e.g. bipolar disorder) concomitant to symptoms of chronic pain and deemed likely to interfere with treatment delivery of EFT; not currently in high-intensity substance use disorder treatment program; not in current or planned cancer treatment with radiation and/or chemotherapy; having no malignant pain caused by cancer pain syndrome; having no referred pain such as back pain caused by pancreatitis; having no co-morbid autoimmune disorders, including rheumatoid arthritis and systemic lupus erythematosus; and no planned major surgical procedure within the proceeding 90 days. Because of the fMRI aspect of the study, participants could not have any metal implants (e.g., pacemaker) and completed a MRI head safety questionnaire prior to the scan.

All participants completed a pre-survey battery of measures via an electronic link (PsychData) and attended a brain scan (fMRI) at a local hospital radiology facility twice (pre-and post EFT intervention). Most of the sample was female (N = 19, 79%) and the ages of the participants ranged between 18 to 77 (M = 50.0, SD = 14.95). The most common level of education was a Bachelor's degree (41.7%), and the modal household income was between $70,000 to $90,000. Consent was received from all participants before the collection of data. A further breakdown of the demographics is provided in Table 1.

Table 1

Frequencies of the Demographic Variables of Participants (n = 24)

Variable	Category	*n* (%)
Marital Status	Divorced	12 (50.0)
	Living with another	1 (4.2)
	Married	2 (8.3)
	Separated	6 (25.0)
	Single	2 (8.3)
	Widowed	1 (4.2)
People in Household	One	6 (25.0)
	Two	7 (29.2)
	Three	4 (16.7)
	Four or more	7 (29.2)
Education	High School or Equivalent	3 (12.5)
	Vocational/Technical College	6 (25.0)
	Bachelor's Degree	10 (41.7)
	Master's Degree	1 (4.2)
	Doctoral Degree	0 (0)
	Other	4 (16.7)
Annual Income	$10,000 or less	2 (8.3)
	$10,001 - $30,000	4 (16.7)
	$30,001 - $50,000	2 (8.3)
	$50,001 - $70,000	2 (8.3)
	$70,001 - $90,000	3 (12.5)
	$90,001 - $110,000	2 (8.3)
	$110,001 or more	9 (37.5)
Profession	Homemaker	3 (12.5)
	Retired	3 (12.5)
	Student	3 (12.5)
	Unemployed	1 (4.2)
	Education – Primary/Secondary, University, or Adult	5 (20.8)
	Finance and Insurance	1 (4.2)

Variable	Category	*n* (%)
	Government	1 (4.2)
	Health Care	6 (25.0)
	Manufacturing	1 (4.2)

Note. n = Total no. of participants, % = Percentage of participants.

Psychological Measures

Demographic Questions. Participants were asked to provide information regarding age, gender, marital status, number of people in their household, country of birth, income, and highest level of completed education.

The Brief Pain Inventory Short Form (BPI; Cleeland & Ryan 1994). The BPI is a widely used measure of pain and has been shown to be an appropriate measure for a wide range of clinical conditions. The BPI assesses pain at its “worst,” “least,” “average,” and “now” (current) state. It also measures how much pain has interfered with seven daily activities, including general activity, walking, work, mood, enjoyment of life, relations with others, and sleep pain. Reliability has been established with cancer patients (Daut et al., 1983), outpatients (Radbruch et al., 1999), osteoarthritis (Mendoza et al., 2006), and postsurgery pain (Mendoza et al., 2004).

The Satisfaction with Life Scale (SWLS; Diener et al., 1985). The SWLS is a short 5-item instrument designed to measure global cognitive judgments of satisfaction with one's life. The coefficient alpha for the scale has ranged from .79 to .89, indicating that the scale has high internal consistency. The scale was also found to have good test-retest correlations (.84, .80 over a month interval; Pavot & Diener, 1993). The scores range from five to 35 and higher scores indicated higher satisfaction.

The Quality-of-Life Scale for Pain (Cowan & Kelly, 2003). The QOL scale is a one item measure of function for people with pain, assessed on a 11-point likert scale (0 = non-functioning to 10 = normal quality of life). The QOL scale was developed by the American Chronic Pain Association to evaluate the impact pain has on basic activities of daily life.

The Patient Health Questionnaire (PHQ, Kroenke et al., 2010). The PHQ is a self-administered scale that consists of five modules used to aid in the detection of DSM disorders. These modules can be used together or alone. The current study administered the depression, anxiety and somatoform modules of the PHQ. Somatic complaints, anxiety, and depressive symptoms are often co-occurring [the Somatic-Anxiety-Depressive (SAD) triad] and each has a significant relationship to chronic pain. The SAD modules have good internal reliability (.80 to .92) and criterion validity, ranging from .71 to .94 (Kroenke et al., 2010).

Happiness (Abdel-Khalek, 2006). Happiness was assessed using an 11-item Likert-type scale (SUDS rating).

The Adverse Childhood Experiences. Adverse Childhood Experiences (ACEs) are potentially traumatic events that occur in childhood. ACEs can include violence, abuse, and growing up in a family with mental health or substance use problems. Toxic stress from ACEs can change brain development and affect how the body responds to stress, which is linked to chronic health problems and mental illness in adulthood (Felitti et al., 1998). Because chronic pain and psychological distress are closely related, the ACE scale was included in the current study to examine the association between ACEs and chronic pain (McBeth et al., 2001).

EFT Treatment

The EFT treatment was offered for two hours per week, for the 6-week period, and was delivered live online via a secure platform due to the inability to attend in person because of pandemic restrictions (https://zoom.us/). A trained EFT practitioner counsellor and a clinical psychologist delivered the live intervention, and all sessions were based on standardised protocols (See Craig & Fowlie, 1995). Acupressure points on the eyebrow, side of eye, under eye, under nose, chin, collarbone, under arm, and the top of the head were used (see Figure 1). Full instructions and safeguards are described in Flint et al.(2005).

The procedure of EFT begins by the individual stating a difficulty they are experiencing, followed by an opposing, but positive affirming statement. For example, an individual may state "Even though I have this intense pain in my right shoulder, I accept myself and this problem". Previous research has reported when positive and negative thoughts are combined (such as in Systematic Desensitization, a behaviour modification therapy), the individual experiences a decrease of the negative experience (Kazdin & Wilcoxon, 1976). The somatic component of EFT then involves tapping specific acupressure points while saying a shorter reminder phrase e.g., "this pain". The subject rates their level of the problem at the beginning (pain severity) out of 10 (0 = no pain, 10 = highest level of pain), and re-rates this every time they complete the eight tapping points. The process is repeated until the discomfort score is zero. Participants were encouraged to self-administer EFT outside of treatment sessions in response to pain or stress. An overview of the EFT program is presented in Table 2.

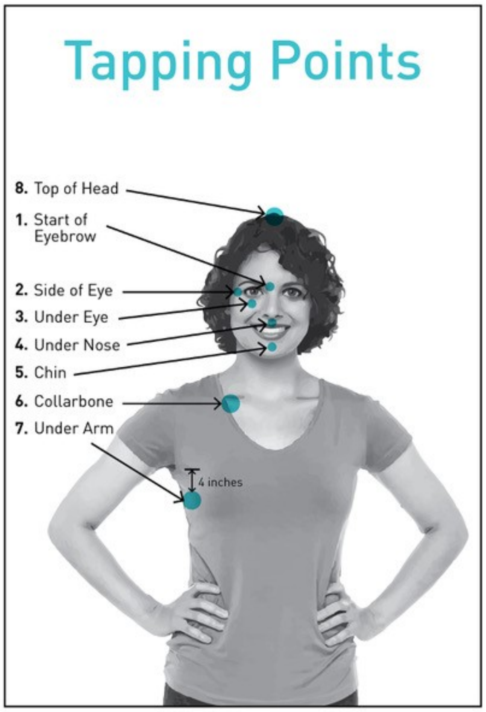

Figure 1 EFT Tapping Points

Table 2

Overview of the EFT Program

Session	Topic	Operationalization	Time Spent
1	Psychoeducation about the EFT technique	Session discussed the nature of EFT, stress and doubt that EFT could be of assistance, and pain management; application of EFT to pain severity and intensity; Boxing Up technique for unfinished EFT	60 minutes psychoeducation 60 minutes in application of EFT
2	Chronic Pain and Feelings I; The Movie Technique	The EFT sessions used statements regarding common feelings related to their pain (e.g. “Even though I feel frustrated when I wake up in pain, I accept this”) while doing the tapping process. Participants were taught how to use EFT if a past memory came to mind (e.g. related to the origin of their pain)	60 minutes psychoeducation 60 minutes in application of EFT
3	Chronic Pain and Feelings II; The Personal Peace Procedure	Session discussed anger and neurochemistry that occurs and relationship to chronic pain; beliefs about pain; application of EFT for anger; The Personal Peace Procedure was overview as a homework activity	30 minutes psychoeducation 90 minutes in application of EFT
4	Pain as Protection	Session discussed possible secondary gain issues in pain; application of EFT for the protective purpose of pain	30 minutes psychoeducation 90 minutes in application of EFT
5	Sleep and Energy	Session involved the application of EFT for insomnia due to pain, and daily activity/energy;	30 minutes psychoeducation 90 minutes in application of EFT
6	Goal Setting and Relapse Prevention	Session discussed living pain-free in the future and their associated identity; goal setting for the future; application of EFT to future goals and preventing relapse	60 minutes psychoeducation 60 minutes in application of EFT

MRI Acquisition

All images were acquired using a 3.0-Simens Skyra scanner. A resting-state echo-planar imaging scan (36 axial slices; 3 × 3 mm in-plane resolution; slice thickness, 3.0 mm (with 25% gap); 280 volumes; TR/TE, 2210/30 ms) was acquired for each participant. Participants were instructed to rest with their eyes open. A high-resolution T1-weighted fast field echo structural scan (192 slices; 1.0-mm isovoxel resolution; TR/TE, 2400/2.26 ms) was also acquired. All participants had an initial (pre) brain scanning session and a second (post) scan 6-weeks later. All scans were completed between 8:00 a.m. and 11:00 a.m. after participants were presented with safety questions.

rsfMRI Processing

rsfMRI preprocessing was completed using MATLAB R2015b (MathWorks Inc., Sherborn, USA), Statistical Parametric Mapping software (SPM12, Wellcome Trust Centre for Neuroimaging, University College London, UK), and functional connectivity toolbox version 17 (CONN). CONN is a MATLAB-based cross-platform application for the computation, display, and analysis of fMRI data. Images were motion corrected using rigid body linear transformation and unwarping. Motion parameters were extracted and used as subject-level regressors. Next the CONN algorithm for outlier detection was applied (i.e., ART-based identification of outlier scans). Subsequently normalization to Montreal Neurological Institute (MNI) space was performed based on the standard SPM MNI-152 T1 template. Finally, the functional data was smoothed using an 8x8x8 FWHM Gaussian kernel.

For the second level statistical analysis we conducted a *seed-to-voxel-voxel* functional connectivity analysis, using anatomical seed-regions of interest definitions of the FSL Harvard-Oxford Atlas as implemented by CONN. Guided by our prediction, we chose the Medial Prefrontal Cortex as our seed region for the analysis, i.e., we tested for changes in connectivity originating in this brain region. The pre vs post treatment comparison was the main regressor of interest. In addition, further nuisance covariates were entered, i.e, motion regressors (from the realignment procedure) and invalid images (from the ART procedure). The data was further band-pass filtered using the default values of 0.008 – 0.09 Hz and corrected for noise components from cerebral white matter and cerebrospinal areas using the CompCor denoising algorithms implanted as a default in CONN (Behzadi et al., 2007). To detect changes due to EFT we performed a two-sided comparison of pre vs. post intervention resting state connectivity. The two-sided test was used to be able to detect both increases as well as decreases in brain connectivity. A voxel threshold of $p < 0.01$ and a cluster-defining threshold $p < 0.05$ (FEW corrected for multiple comparisons) was employed.

Results

Data was analysed though Statistical Package for Social Sciences Version 28 (SPSS; IBM, Armonk, NY, 2014). An alpha level of .05 was used for all statistical analyses unless otherwise stated. Initial analysis was conducted to explore the participants' accounts of their pain before the EFT treatment. The participants ranged in suffering CP from very high intensity to very low (M = 6.05, SD = 2.72), and there was a wide difference in total time suffered and the self-assessed severity (see Table 3). A mean ACE score of 2.38 (SD = 2.93) was indicated among the participants.

Table 3

Pain Levels in the Sample (n = 24)

Variable	*M*	*SD*	Min	Max
Years Of Pain	5.65	6.05	0.30	26.00
Pain Severity	5.45	2.25	1.25	9.25
Pain Interference	6.05	2.72	1.00	9.57
ACE	2.38	2.93	0.00	10.00

Note: *M* = mean, *SD* = standard deviation.

Psychological Measures

A repeated measures MANOVA with two within-subjects factors (pre-test, post-test) was conducted to determine whether significant differences in the levels of pain severity, pain interference, quality of life, somatic symptoms, depression, anxiety, happiness, and satisfaction with life occurred between the pre-test and post-test measures (see Table 4 for descriptive statistics).

Table 4

Descriptive statistics for the dependent variables across pre-test (n = 24) and post-test (n = 24).
Note: *M* = mean, *SD* = standard deviation, Range = minimum & maximum.

Variable	Pre-test			Post-test			Change in Mean	Cohen's d
	M	*SD*	Range	*M*	*SD*	Range		
Pain Severity	5.45	2.25	1.25 - 9.25	4.30	2.44	1 - 8.75	-1.15	0.49
Pain Interference	6.05	2.72	1 - 9.57	4.48	2.70	1 - 9	-1.57	0.58
Quality of Life	7.79	2.59	3 - 11	8.33	2.53	2 - 11	0.54	0.21
Somatic Symptoms	6.71	3.38	1 - 14	4.83	2.99	0 - 11	-1.88	0.59
Depression	8.33	4.98	0 - 16	7.21	4.91	0 - 21	-1.12	0.22
Anxiety	6.30	3.05	0 - 11	3.96	3.13	0 - 9	-2.34	0.75
Happiness	7.62	2.41	2 - 11	8.92	2.00	4 - 11	1.30	0.53
Life Satisfaction	15.92	6.71	6 - 30	17.33	7.06	5 - 30	1.41	0.20

Sensitivity power analysis through G*Power 3.1 indicated that the sample (N = 24) was sufficient to detect an effect size of $f2$ = .34 with a power of 0.8 and an alpha of .05. Prior to the MANOVA, the data was screened for assumptions of normality and multivariate outliers. Shapiro-Wilk tests were carried out on the DVs and found that the assumption of normality was violated in the pre-test and post-test pain interference, post-test happiness and post-test quality of life measures. Visual inspection of the univariate box plots revealed a single outlier among the post-test depression group; however, this was determined to be a genuine difference from the normal distribution, and the outlier was included in the analysis. Pillai's Trace was used due to the small size of the sample and the violation of normality.

The results of the repeated measures MANOVA indicated there was a significant difference in the combined dependent variables between pre-EFT and post-EFT (F (8, 14) = 3.366, p = .023, partial η^2= .658). Analysis of the dependent variables at a univariate level showed that, corrected for multiple comparisons (α = .006), pain severity (F (1, 21) = 8.731, p = .008, partial η^2= .294), pain interference levels (F (1, 21) = 13.337, p = .001, partial η^2= .388)), somatic symptoms (F (1, 21) = 13.275, p = .002, partial η^2= .387), anxiety: (F (1, 21) = 5.538, p = .028, partial η^2= .209) and quality of life: (F (1, 21) = 5.502, p = .029, partial η^2= .208) were significantly different between pre-EFT and post-EFT.

The participants of the trial reported a significant decrease in pain severity from pre to post EFT (M=5.45 to M = 4.30) of 21% and interference (M = 6.05 to M = 4.48) of 26%. Participants also achieved a significant decrease in depression (M = 8.33 to 7.21) of 13.5%, a decrease of 37.1% in anxiety (M=6.3 to 3.96) and a decrease of 28% in somatic symptoms (M = 6.71 to M = 4.83). Increases in life satisfaction of 8.8% (M=15.92 to M = 17.33), happiness (M = 7.62 to 8.92, 17%) and quality of life (M = 7.79 to 8.33, 7%) were also reported.

A correlation analysis was conducted to assess the relationship between ACE scores and the pain markers among the participants in the pre-test phase. Shapiro-Wilk tests were carried out on the dependent and ACE variables and found that the assumption of normality was violated for both ACE and pain interference, therefore Spearman's ρ was used for the analysis. No significant relationships were found between the ACE scores and any of the pain measures.

rsfMRI Outcomes

In total, 19 participants attended the first fMRI scan, of these, 16 participants also completed the second scan session. As shown in Figure 2, the rsfMRI showed post-EFT treatment significantly decreased connectivity between the medial prefrontal cortex and bilateral grey matter areas in the posterior cingulate cortex (-2, -58, 14; 754 voxels, T = -5.8) and thalamus (10, -24, 4; 418 voxels, T = -6.52). There were no brain areas that showed significantly increased connectivity post-EFT treatment.

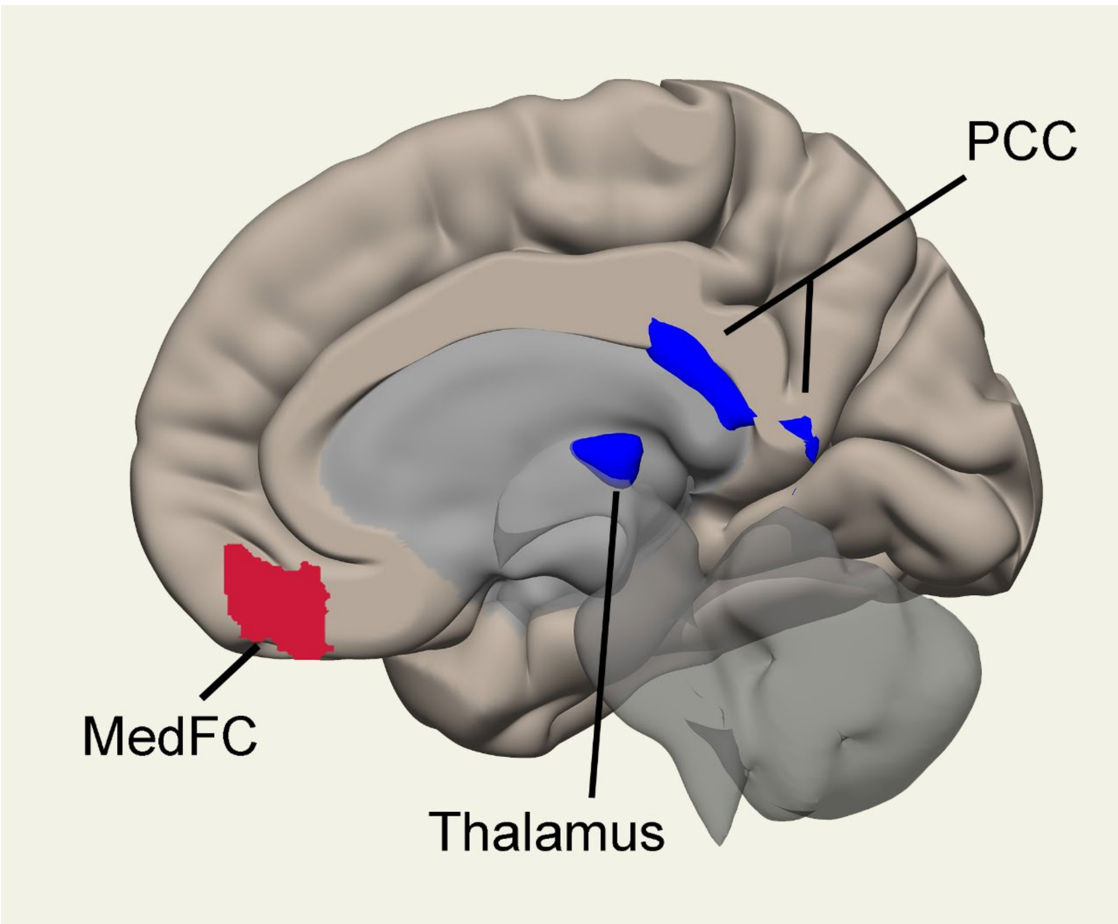

Figure 2. Results for the seed-to-voxel-voxel functional connectivity analysis. Sagittal brain image depicting the seed region in the medial frontal cortex (MedFC) and the brain regions exhibiting statistically significantly decreased patterns of interregional connectivity (i.e. the thalamus and posterior cingulate cortex (PCC)). A two-sided t-test was used at a voxel threshold of $p < 0.01$ and a cluster-defining threshold $p < 0.05$ (FWE corrected for multiple comparisons).

Discussion

The present study supports previous findings that EFT may have the ability to significantly reduce pain symptomology and associated psychological indicators. The neuroimaging results add to this literature suggesting EFT also potentially affects connectivity between the medial prefrontal cortex, bilateral grey matter areas in the posterior cingulate cortex and thalamus in CP sufferers. The prefrontal cortex is recognised as one of the main regions modulating pain (Ong et al., 2019); the changes that occur during acute and chronic pain are altered by neurotransmitters, gene expression, glial cells, and neuroinflammation. The medial frontal cortex connectivity to the thalamus is also related to relay and modulation of pain, and the thalamus is indicated to be part of a network affecting spinal cord activity and modulating nociceptive information (Ab Aziz & Ahmad, 2006). Finally, the posterior cingulate cortex is implicated as a key centre for catastrophizing pain (Lee et al., 2018).

Generally, it has been shown psychotherapeutic interventions can result in structural brain changes, and this ranges from cognitive approaches to behaviour activation, virtual reality as exposure, and psychodynamic therapies (Álvarez-Pérez et al., 2021; Beauregard, 2014; Manthey et al., 2021). Indeed, there is strong evidence that therapy targeting changes in thought patterns, beliefs, feelings, and behaviors can lead to a normalization of functional brain activity at a global level (Beauregard, 2014; Manthey et al., 2021). Specific to pain, psychological interventions such as CBT have demonstrated reduced resting state connectivity between the primary somatosensory cortex and anterior/medial insula after 4-weeks of intervention for Fibromyalgia, and these were associated with concurrent treatment-related reductions in catastrophizing (Lazaridou et al., 2017). Others have indicated abnormal intrinsic connectivity networks related to the orbitofrontal cortex (OFC) and inferior parietal lobule within the dorsal attention network normalize after 12-weeks of CBT

(Yoshino et al., 2018). Functional changes have also been noted in the posterior cingulate cortex, cingulate gyrus, and paracingulate gyrus after CBT for migraine, experimental pain, and mixed pain (Bao et al., 2022). In light of the current study and EFT intervention, this does appear to highlight the complexity of pain and nature of connectivity between brain regions. EFT affected somewhat different areas compared to CBT, although both show positive changes aligned with the psychological outcomes. Pain is considered a multidimensional sensory and emotional experience and this study offers an alternative body-centric intervention to achieve top-down pain control and altered perception of the pain signal.

While the present study has several strengths (comprehensive inclusion and exclusion criteria and moderate power), a number of limitations will need to be addressed in future studies. The sample was not large enough to determine the impact of adverse childhood experiences and their contribution to CP. Previous research (e.g., McBeth et al., 2001) has shown a relationship however the mean ACE score in this sample was low. We did not have a control group nor follow-up period, nor did we isolate certain pain conditions. Future research would benefit from analyzing separate specific types of pain through randomized controlled trials.

Despite this, collectively the results support the potential effectiveness of EFT in reducing catastrophizing and modulating pain in CP sufferers. This is the first EFT study to include objective measures such as fMRI, and the outcomes are consistent with previous studies that have only targeted subjective measures. The acupoint tapping technique may indeed generate activating and deactivating signals which impact brain areas implicated in chronic pain. This may be particularly important in supporting non-pharmacologic treatment protocols, and in stepped care models of pain. As an approach that is effectively delivered both as a self-help modality and in the online space, it has the capacity to support self-management for chronic pain sufferers and as an adjunct to other interventions.

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