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Acute effects of traditional Thai massage on electroencephalogram in patients with scapulocostal syndrome☆

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KEYWORDS
Traditional Thai massage;
Physical therapy;
Scapulocostal syndrome;
Electroencephalogram

Summary

Objective: To investigate acute effects of traditional Thai massage (TTM) on brain electrical activity (electroencephalogram (EEG) signals), anxiety and pain in patients with scapulocostal syndrome (SCS).

Design: A single-blind, randomized clinical trial.

Setting: The School of Physical Therapy, Faculty of Associated Medical Sciences, Khon Kaen University, Thailand.

Intervention: Forty patients, who were diagnosed with SCS, were randomly allocated to receive a 30-min session of either TTM or physical therapy (PT) using ultrasound therapy and hot packs.

Outcomes: Electroencephalogram (EEG), State Anxiety Inventory (STAI), and pain intensity rating.

Results: Results showed that both TTM and PT were associated with significant decreases in anxiety and pain intensity ($p < 0.01$). However, there was a significantly greater reduction in anxiety and pain intensity for the TTM group when compared with the PT group. Analysis of EEG in the TTM group showed a significant increase in relaxation, manifested as an increase in delta activity ($p < 0.05$) and a decrease in theta, alpha and beta activity ($p < 0.01$). Similar changes were not found in the PT group. The EEG measures were also significantly different when compared between the groups ($p < 0.01$), except for delta activity ($p = 0.051$), indicating lower states of arousal with the TTM treatment.

Conclusion: It is suggested that TTM provides acute neural effects that increase relaxation and decrease anxiety and pain intensity in patients with SCS.

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Introduction

Scapulocostal syndrome (SCS) is a chronic type of myofascial pain syndrome (MPS) affecting the posterior shoulder area.[1–6] These include muscles surrounding the scapula, such as the serratus posterior superior, rhomboid and levator scapulae. Myofascial pain trigger points (MTrPs) associated with SCS are actually pathologic lesions resulting from the syndrome.[1,3] These points can be found through physical examination.[1] The pain due to SCS can be referred to other areas such as the shoulder joint.[2] Grachev et al.[7] reported that chronic pain and anxiety are interrelated and can lead to anxiety. Consequently, anxiety should also be considered as a SCS health problem and should be treated.

The pathophysiology of MPS, like SCS, remains unclear.[8,9] However, there are two widely accepted theories; the energy crisis theory and motor endplate hypothesis.[8,10,11] The energy crisis theory is most closely related to the present work. It postulates increased demand on a muscle or macrotrauma leading to increased calcium release from the sarcolemma and prolonged shortening of the sarcomeres. This compromises circulation and with reduced oxygen, muscle cells are unable to produce enough ATP to initiate the process of relaxation. The ischemia also causes by-products of metabolism to accumulate,[10] which are partly responsible for pain. SCS pain results from sensitization of the area surrounding the muscle and direct stimulation of sensory nerves.

Various interventions have been suggested to treat SCS, including rest of the involved anatomical structure,[12] therapeutic heat, activity modification[2] and traditional Thai massage (TTM).[13] However, there remains a lack of evidence of the effectiveness of such methods. In a recent study, Buttagat et al.[14] found that TTM decreased SCS pain intensity and anxiety compared to physical therapy methods (ultrasound therapy and hot pack).

TTM is a type of deep tissue massage focused at the muscle to release tension. It is a branch of traditional Thai medicine and one of the methods used in the Primary Health Care system in Thailand.[15] A massage therapist uses the thumbs to apply pressure to a patient's body along so-called meridian lines (imaginary lines) and focuses pressure at specific points on the lines. Meridian lines have been described as hypothesized lines of energy running through the body.[16] The idea is that if these lines are unblocked, then energy can flow through the body in a balanced manner, increase awareness, vitality, etc.[17] Prior research has revealed that the majority of MTrPs throughout the body fall along the hypothesized meridian lines.[18] Therefore, the trigger points for the muscles surrounding the scapula represent pressure points for TTM. The pressure release at muscles is typically followed by passive stretching.[17,19,20]

Several neuroimaging studies have found that pain stimulation in chronic pain patients (e.g., persons with fibromyalgia and MPS) can induce central nervous system (CNS) disturbances.[21–26] This can lead to changes in brain activity and loss of the ability to modulate stress responses.[25–27] Accordingly, such changes or disturbances in the CNS may also occur in patients with SCS. If patients are effectively treated, pain intensity could be reduced and this may be reflected in brain activity. Hence, such outcomes were observed as a basis to assess the hypotheses in the present study. Recently, electroencephalograms (EEGs) have become an increasingly popular measurement tool[28] in the field of massage therapy research for demonstrating the efficacy of techniques from a neurophysiological perspective. Some studies have shown massage to be associated with an increase in EEG delta activity[29,30] and a decrease in EEG alpha,[29–33] EEG beta[29–31,34] and EEG theta activity[30]; all indices of arousal. However, there is no evidence of the effects of TTM on EEG and acute CNS responses to TTM in chronic pain patients, such as SCS. The present study investigated the acute effects of TTM on EEG, anxiety and pain in patients with SCS.

Methods

Design

The study was a clinical trial conducted at a health care center. Patients with SCS were randomly assigned to either a TTM or a PT group in blocks of 2, 4 and 6 subjects. (The permuted-block randomization was determined with the STATA software in order to ensure balanced samples across groups.) A list was generated by one of the authors and used by a research assistant. Subject assignment to the treatment groups occurred through sealed envelope distribution and investigators were blinded. Dependent variables included EEG and subjective ratings of anxiety and pain intensity measured immediately before and after the treatment sessions. The Ethics Committee of Khon Kaen University approved the research. All patients provided written informed consent prior to baseline examination.

Participants

Participants with scapular pain were recruited from Khon Kaen Province, Thailand through advertisement on bulletin boards and verbal requests. Each participant underwent subjective and objective examinations for SCS diagnosis by a Physiatrist. Inclusion criteria consisted of patients aged between 18 and 50 years with spontaneous scapular pain more than 12 weeks, and had at least one trigger point on muscles of the scapular region (serratus posterior superior, rhomboids, and levator scapulae). Participants were excluded if at least one of the following conditions was reported:

(1) a diagnosis of conditions that could be contraindicated for TTM, such as fever;
(2) a diagnosis of disease or disorder of cervical and thoracic vertebra or the shoulder joint;
(3) a history or diagnosis of conditions that could contribute to pain around the scapular;
(4) a history of neurological disorders; and
(5) current use of CNS-acting medications.

Sample size was calculated using an analysis of covariance (ANCOVA) formula.[35] The calculation was based on pilot study data that compared the immediate effect of TTM ($n = 5$) with that of PT ($n = 5$) for SCS patients. A standard deviation (of delta power) of 1.4 μV^2 for the TTM group and of 0.97 μV^2 for the PT group was observed. These variances

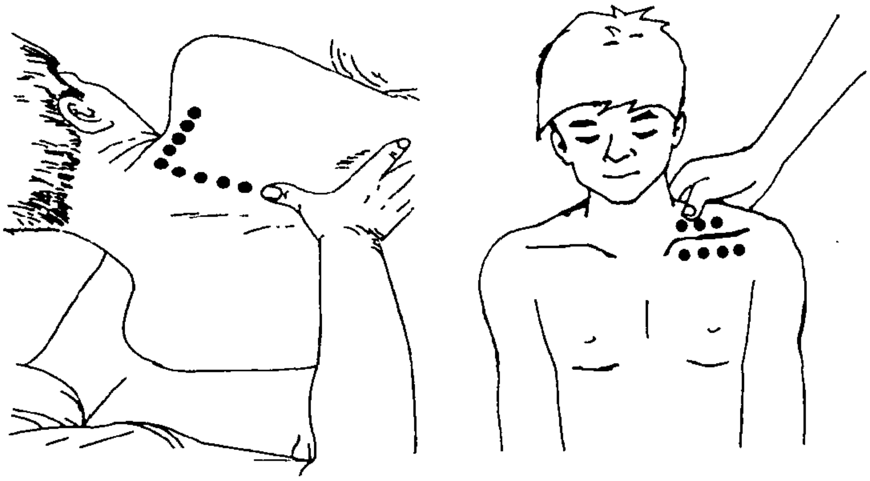

Figure 1 The massage points are located along four lines on each side of the body.

were used to calculate the sample size needed to detect a 1 μV^2 change in delta power with 90% power and 5% significance. According to these criteria, 40 patients were recruited.

Interventions

The TTM patients received one 30 min session of TTM administered by a certified Thai massage therapist at both sides of the scapular region while lying on one side. Massage points used in this study were located along four meridian lines on each side of the body (Fig. 1). These four lines fell along the most affected muscles, including the serratus posterior superior, rhomboids, levator scapulae and scalenei. The pressing technique employed in TTM used the body weight of the therapist to apply gentle and gradually increasing pressure through the thumbs. Pressure was applied until the patient started to feel slight discomfort after 5–10 s. This sequence was repeated several times for each massage point.[19] The TTM technique for SCS has been previously described in detail.[14]

The PT patients received one 30-min session including ultrasound therapy and a hot pack (in the same environment as the TTM group) administered by an experienced licensed physical therapist. The ultrasound therapy (Sonostat 833; CAmed Medical Systems GmbH, Germany) was administered for 10 min per session to both sides of the scapular region while a patient lay on their side. A continuous mode of operation of the ultrasound was used with a frequency of 1 MHz and an intensity of 1 W/cm^2. Subsequently, the hot pack (60 °C) was applied to the same area for 20 min.

The patients in both groups did not receive any concomitant treatment. Each of the groups was treated in separate rooms and scheduled so as to reduce any confounding effects.

Outcome measures

All outcome measures were determined and analyzed by an investigator who was blinded and was not obligated to provide any intervention for patients.

In preparation for EEG recording, participants rested in a supine position at room temperature (25 °C) for 10 min before EEG recording in order to ensure that a resting state was achieved. Bipolar EEG was recorded with Ag–AgCl electrodes at temporal (T6) and parietal (P4) locations; a reference electrode was placed on the right earlobe.[36] The EEG was recorded before and immediately after the treatment. Participants were asked to close their eyes and refrain from talking, falling asleep, or making exaggerated body movements during EEG measurement. Analysis was based on a 5-min period of EEG signal acquisition, followed by computerized Fourier analysis of the EEG waves, using a BIOPAC system (BIOPAC Systems, Inc., Goleta, California). The signal was sampled at a rate of 500 Hz and was digitally filtered using 1–50 Hz band pass filter. The signal was filtered to yield categories of EEG, including delta (1–5 Hz), theta (5–8 Hz), alpha (8–13 Hz) and beta (13–30 Hz).

The State Anxiety Inventory (STAI) (Thai version)[37] was administered with 20 items concerning how the participant felt. Characteristic items included ''I feel rested'' or ''I feel anxious''.[38] Responses were provided on a severity rating scale from ''not at all'', to ''a little'', to ''somewhat'' and to ''very much so''. Overall STAI scores range from 20 to 80; where higher scores indicate greater levels of anxiety. A difference of 10% (6 points) in STAI scores is considered to be a minimal clinically significant difference (MCSD).[39–41]

Pain intensity was evaluated using a 10-cm visual analog scale (VAS). The scale ranged from 0 to 10, where 0 indicated ''no pain'', and 10 indicated the ''most pain ever'' experienced. Participants were instructed to mark the scale indicating their level of pain intensity. The MCSD in pain score was 1.8 cm.[42,43] Reliability of data obtained with such a VAS has been reported to be high ($r = 0.99$)[44] along with high construct validity.[45]

Data analysis

Data were analyzed with the STATA Version 10 software (StataCorp LP, College Station, Texas). Mean and standard deviations were calculated for each response variable. Paired t-tests were used to compare the outcome variables

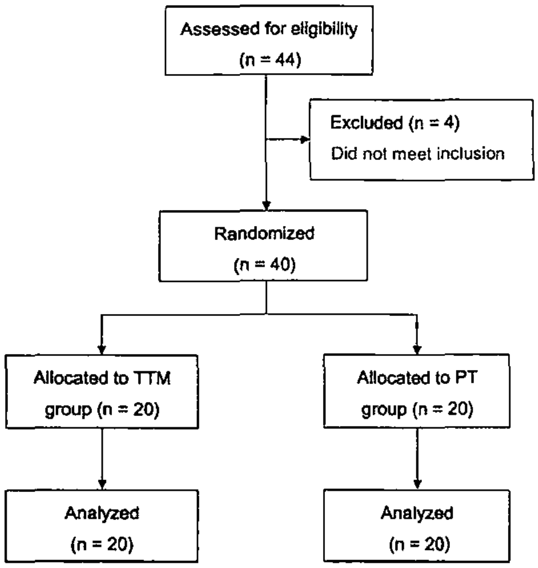

Figure 2 Participants flowchart.

immediately before and after the treatment period within each respective group. An ANCOVA was used to compare the difference in post-test values between groups after adjusting for differences in pre-test values, for each outcome measure. Pearson product—moment correlation coefficients (r) were used to analyze the linear association of the change in EEG signals with STAI scores and pain intensity ratings (from pre- to post-test). p-Values less than 0.05 were considered to be statistically significant.

Results

Forty-four patients were screened for eligibility for the study. Forty of these patients met the inclusion/exclusion criteria and were recruited. Twenty patients were randomly allocated to receive TTM and the remaining participants received PT (see Fig. 2). Demographic data and baseline clinical characteristics of the patients are presented in Table 1. The majority of baseline characteristics were equally balanced between the two groups.

Acute effects of TTM vs. PT on EEG

Table 2 shows that immediately after receiving TTM, the delta power of EEG significantly increased compared with pre-treatment values ($p = 0.042$), and theta, alpha and beta power were significantly decreased ($p < 0.01$). In contrast, no statistically significant difference was found for the PT group except for alpha and beta power, which increased after receiving PT (i.e., increased arousal). When making comparison between the two groups (Table 3), after adjustment for pre-test levels, the post-test values for theta, alpha and beta power were significantly different ($p < 0.01$). However, there was no significant difference in post-test delta power values between groups ($p = 0.051$).

Acute effects of TTM vs. PT on STAI and pain intensity

Both groups showed a significant decrease in STAI scores and pain intensity after treatment periods ($p < 0.001$; see Table 2). A comparison of the adjusted post-test values for STAI and pain intensity between groups indicated a significantly greater reduction in anxiety and pain intensity for the TTM group compared with the PT group ($p < 0.05$) (see Table 3).

Correlation analyses on EEG signals, STAI scores, and pain intensity ratings

Correlation analysis on the change in delta power and STAI ratings (from pre- to post-test) revealed a negative association ($r = -0.32$). The change in theta power was positively related to STAI scores ($r = 0.23$) and the same correlation was observed for the change in alpha power and STAI scores ($r = 0.23$). A slightly weaker relation was observed for the change in beta power and STAI scores ($r = 0.21$).

With respect to the correlation of change in EEG signals and pain intensity, the change in delta power was negatively related to pain intensity ($r = -0.27$). Positive correlations of pain intensity were observed with the change in theta power ($r = 0.26$), the change in alpha power ($r = 0.26$) and the change in beta power ($r = 0.33$).

Table 1 Demographic and baseline clinical characteristics of patients with scapulocostal syndrome.

Variable	PT group ($n = 20$)	TTM group ($n = 20$)
Age (years); mean (SD)	27 (6.9)	28 (8.3)
Gender (number of females)	16	16
Weight (kg); mean (SD)	56 (11.9)	54 (9.4)
Height (cm); mean (SD)	163 (7.1)	161 (8.0
Scapular pain with MTrP area; n (%)		
Right side	18 (90)	16 (80)
Left side	2 (10)	4 (20)
Severity of scapular pain: by pain scale; mean (SD)	5.7 (1.5)	5.9 (1.6)
Duration of scapular pain episode (months); mean (SD)	18 (18.4)	15 (16.5)

Table 2 Comparison of outcome measures between pre-test and post-test assessments in the TTM and PT groups (paired *t*-tests).

Parameter	PT				TTM			
	Baseline (mean (SD))	Post − test (mean (SD))	Difference (95% CI)	*p*-Value	Baseline (mean (SD))	Post-test (mean (SD))	Difference (95% CI)	*p*-Value
EEG								
Delta (μV^2)	3.4 (1.2)	3.2 (1.0)	0.2 (−0.5 to 0.9)	0.198	3.3 (1.0)	4.0 (1.4)	−0.7 (−1.4 to −0.03)	0.042
Theta (μV^2)	3.2 (1.3)	3.9 (2.5)	−0.7 (−1.4 to 0.1)	0.079	3.5 (1.8)	2.7 (1.0)	0.8 (0.3–1.3)	0.006
Alpha (μV^2)	3.8 (1.9)	4.4 (1.8)	−0.6 (−1.1 to −0.1)	0.031	4.4 (2.0)	2.9 (1.3)	1.5 (0.9–2.1)	<0.001
Beta (μV^2)	3.3 (1.2)	3.8 (1.8)	−0.5 (−0.9 to −0.1)	0.028	3.7 (1.7)	2.4 (1.1)	1.3 (0.8–1.8)	<0.001
Other parameters								
STAI	44.0 (7.9)	38.3 (6.0)	5.7 (3.9–7.5)	<0.001	46.5 (9.4)	34.6 (6.6)	11.9 (8.2–15.6)	<0.001
Pain intensity (VAS)	5.66 (1.45)	4.68 (1.81)	0.98 (0.48–1.48)	<0.001	5.94 (1.58)	3.88 (2.39)	2.06 (1.33–2.78)	<0.001

Discussion

The main purpose of the present study was to investigate the acute CNS effects of TTM on SCS patients by using EEG. The STAI and pain intensity were chosen as a secondary outcome measures in order to subjectively quantify participant anxiety and pain intensity. Although the effect of TTM on STAI scores and pain intensity has been previously observed[14,20] in this study, the anxiety and pain measures were useful for confirming the effect of TTM on EEG. This study demonstrates TTM on the scapular area is effective for promoting relaxation and reducing anxiety and pain intensity in SCS patients, manifested as an increase in delta activity ($p = 0.042$) and a decrease in theta, alpha and beta activity, STAI scores and pain intensity ratings ($p < 0.01$) (refer to Tables 2 and 3). Moreover, the magnitude of improvements in anxiety and pain intensity in this study were also considered as clinically meaningful.

The present findings of enhanced EEG and reduced anxiety are similar to other studies despite some differences in the massage techniques and patient populations. Diego et al.[30] showed that after participants received a 10-min session of moderate pressure massage of the back, shoulders and arms, EEG delta activity increased while alpha and beta decreased, indicating relaxation responses. Field et al.[29] found that 15-min of chair massage increased delta activity and decreased alpha and beta activity in healthy adults. Furthermore, Jodo et al.[31] reported that a 20 min session of facial massage significantly decreased alpha and beta activity in female students. These studies also reported lower anxiety immediately after treatments, as measured using subjective rating responses.

Several studies, regarding other physiological effects of massage, also support our findings of increased relaxation. Buttagat et al.[20] found that a 30-min session of TTM of back muscles decreased anxiety and increased parasympathetic nervous system activity in patients with back pain associated with MTrPs. Another study[46] found that healthy adults receiving 20-min of massage at the neck and shoulders exhibited decreased alpha-motoneuron pool excitability for the flexor carpi radialis and decreased normalized electromyography amplitude of the upper trapezius muscle, suggesting increased physical relaxation. Moreover, some studies[29,47–51] revealed that massage can reduce stress-related hormone production in various patients, including depressed subjects. These findings also support our observation of decreased anxiety in the TTM group.

Conversely, the present study showed analysis of EEG in a PT group significantly increased alpha and beta activity. Diego et al.[30] suggested that such increases in EEG are associated with decreased relaxation. This contention is in agreement with our findings of increased arousal in the PT group.

Comparison between the two groups in the present study revealed that patients receiving TTM have significantly lower STAI scores and theta, alpha and beta activity ($p < 0.001$) than those in the PT group. In addition, the TTM group showed a tendency toward higher delta activity compared with the PT group ($p = 0.051$). These findings indicate neurological and psychophysical benefits of TTM over PT for stress and anxiety reduction in SCS patients, due to differences in the PT and TTM treatment techniques. For the

Table 3 Comparison of mean post-test measures between TTM and PT groups after adjustment for differences in baseline values (ANCOVA).

Parameter	PT	TTM	Difference (95% CI)	*p*-Value
EEG				
Delta (μV^2)	3.2	4.0	−0.8 (−1.5 to 0.0)	0.051
Theta (μV^2)	4.0	2.6	1.4 (0.5–2.3)	0.003
Alpha (μV^2)	4.6	2.7	1.9 (1.2–2.7)	<0.001
Beta (μV^2)	3.9	2.3	1.7 (1.0–2.3)	<0.001
Other parameters				
STAI	38.9	33.9	5.0 (2.0–8.0)	0.001
Pain intensity (VAS)	3.73	4.83	1.1 (0.24–1.96)	0.014

PT group, ultrasound therapy and hot packs provided local heat. The ultrasound therapy generates light pressure at the treated area while a therapist was moving the transducer head. However, this is not comparable to the deep muscle pressure that TTM provides. Diego et al.[30] found that light pressure massage on the back, shoulders and arms region actually decreased relaxation responses (decreased delta and increased beta activity and heart rate). It is possible that the light pressure generated by the ultrasound therapy may be associated with a similar arousal response, unlike the TTM treatment.

The mechanism by which TTM promotes relaxation and changes in CNS activity may be explained by the findings of Ouchi et al.[51] They reported that a 20-min session of back massage increased cerebral blood flow (rCBF) in the parietal and occipital regions, which may result in changes of brain electrical activity.[52] The other possibility is that the interpersonal attention and perceptions of care experienced by patients in massage therapy may affect higher brain centers and lead to changes in perceptions of pain and stress.[53–56] Our finding of reduced anxiety through TTM may also be explained by the findings of Field et al.[57] They reported that moderate pressure massage contributed to increased dopamine production, which led to decreased norepinephrine levels; thus, anxiety levels were decreased.[58] Since TTM is a kind of pressure massage, it is possible that the same mechanism was partly responsible for the decrease in anxiety observed in this study.

Immediately after treatment, the TTM group also showed a significantly greater reduction in pain intensity when compared to the PT group. A previous study showed that TTM could decrease pain intensity in patients with back pain associated with myofascial trigger points.[19,20] The potential mechanism proposed was that TTM might increase production of pain-relieving neurotransmitters (e.g., serotonin), which leads to reduced pain levels. Serotonin has been noted to increase following massage therapy for several pain syndromes.[57] Furthermore, a reduction in pain resulting from TTM may be explained by gate control theory.[59] Stimulation of large diameter nerve fibers by pressure or touch can interfere in signals from pain fibers (thin diameter nerve fibers), thereby inhibiting pain.[57]

Clinical implication

TTM was found to be an effective intervention for anxiety reduction and pain intensity in patients with SCS. Moreover, the interpretation of brain activity of patients in this study demonstrated greater relaxation after a TTM session compared with PT modalities. The beneficial effects found here could be used as a guide for routine treatment for pain, stress and anxiety decrease in SCS patients and might influence other forms of patient care, such as decreases in dosages of prescribed medications.

Regarding limitations of this study, we did not use a control group for comparison purposes. Further studies should include a no-intervention group in addition to specific treatment groups. Secondly, we only evaluated the acute effects of TTM, and results do not reflect long-term implications of the massage technique. Therefore, longitudinal study of TTM effects on CNS responses would be an interesting direction for future research. Another limitation of this study was the lack of blinding of patients to the type of treatment being received, which can cause potential bias. However, it is difficult to perform such blinding due to the nature of non-pharmacological treatments.

Conclusion

The present study is unique in its report of the effect of TTM on acute CNS responses using EEG. The study provides insight into physiological changes and subjective reports of relaxation associated with TTM. The findings reveal a single 30-min session of TTM at the scapular region produces an immediate decrease in pain intensity and anxiety and an increase in relaxation in SCS patients. It is recommended that TTM be considered as an alternative treatment for stress, anxiety and pain in patients with SCS.

Conflict of interest

The authors have no personal or financial conflicts of interest associated with this work.

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