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RANDOMIZED CONTROLLED COMPARATIVE STUDY

The immediate effects of traditional Thai massage on heart rate variability and stress-related parameters in patients with back pain associated with myofascial trigger points

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Summary The purpose of this study was to investigate the immediate effects of traditional Thai massage (TTM) on stress-related parameters including heart rate variability (HRV), anxiety, muscle tension, pain intensity, pressure pain threshold, and body flexibility in patients with back pain associated with myofascial trigger points. Thirty-six patients were randomly allocated to receive a 30-min session of either TTM or control (rest on bed) for one session. Results indicated that TTM was associated with significant increases in HRV (increased total power frequency (TPF) and high frequency (HF)), pressure pain threshold (PPT) and body flexibility ($p < 0.05$) and significant decreases in self-reported pain intensity, anxiety and muscle tension ($p < 0.001$). For all outcomes, similar changes were not observed in the control group. The adjusted post-test mean values for TPF, HF, PPT and body flexibility were significantly higher in the TTM group when compared with the control group ($p < 0.01$) and the values for pain intensity, anxiety and muscle tension were significantly lower. We conclude that TTM can increase HRV and improve stress-related parameters in this patient population.

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Background

Myofascial pain syndrome (MPS) has been defined as musculoskeletal pain arising from one or several hyperirritable spots within the belly of muscle(s) called myofascial trigger points (MTrPs) (Fricton and Awad, 1989). MPS is associated with many musculoskeletal conditions. A Thai study found that MPS was the primary diagnosis in 36% of 431 patients with musculoskeletal disorders (Chaiamnuay et al., 1998) and a study at a pain clinic reported that MPS was cited as the most common cause of pain; occurring in 85% of people with back pain (Fishbain et al., 1986).

The pathophysiology of MPS is largely unknown making it difficult to design effective approaches for its treatment, although numerous therapeutic approaches, both pharmological and non-pharmalogical, have been tried with varying success rates.

Massage therapy is now one of the most frequently used alternative treatments for back pain (Eisenberg et al., 1998). Traditional Thai massage (TTM) is a form of deep massage with brief sustained pressure on the muscles. Pressure point massage along the body's hypothesised 10 major energy channels or ''Sen Sib'' is believed to release blocked energy and to increase awareness and vitality. Gentle stretching of the muscles relieves tension, enhances flexibility, and induces a deep state of tranquility (Tapanya, 1993). The report by Chaithavuthi and Muangsiri (2005) suggests that TTM also increases blood circulation, lowers heart rate, reduces pain, improves the depth of breathing and promotes relaxation. However, controlled studies to support the effectiveness of TTM for the treatment of different conditions are limited (Chatchawan et al., 2005). There is no published research that objectively assesses the physiological changes involved with the reported relaxation response following TTM, which could be done using methods such as evaluation of heart rate variability.

Heart rate variability (HRV) is controlled by the autonomic nervous system. Generally, sympathetic nervous system (SNS) activity increases heart rate (decreases HRV) and parasympathetic nervous system (PNS) activity decreases heart rate (increases HRV). Observed HRV is believed to be an indicator of the dynamic interaction and balance between the SNS and the PNS (Terathongkum and Pickler, 2004; Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996).

There is evidence to suggest that the balance between SNS and PNS is affected by MPS. This is supported by Perry et al. (1989) who report patients with chronic MPS and with arthritis had decreased parasympathetic activity and increased sympathetic activity, and by Delaney et al. (2002) who found that myofascial trigger point massage therapy (MTPT) decreased heart rate, systolic blood pressure and diastolic blood pressure and increased parasympathetic activity. The later study also found a related self-perceived reduction in muscle tension when compared to the baseline. Regional and/or referred pain are characteristic of MPS, which can lead to anxiety and depression and reduced HRV if not effectively treated (Carney et al., 1995; Stauss, 2003; Terathongkum and Pickler, 2004; Tousignant-Laflamme and Marchand, 2006; Hummel and van Dijk, 2006).

Measurement of HRV to investigate autonomic influence on the cardiovascular system can be done using a simple, sensitive and non-invasive technique. This technique is increasingly being used as a powerful predictor of hypertension in patients (Terathongkum and Pickler, 2004; Delaney et al., 2002). One of the conventional methods for analyzing HRV is the frequency domain method that uses spectral analysis to quantify the frequency content of the ECG signals. This analysis has been used to determine the total power frequency and power of high and low frequencies, data that can then be used to determine the contribution of the sympathetic and parasympathetic nervous system to the variability in heart rate. It is generally accepted that vagal activity is the major contributor to the high frequency (HF) component of the spectral analysis, thus an increase in HF power (as well as an increase in total power) reflects increased parasympathetic activity.

Interpretation of increased LF power is still unclear and depends to some extent on the unit of measure used. An increase in absolute value of power (ms^2) of the LF component may reflect both sympathetic and parasympathetic activity. The LF/HF ratio is considered to be an index of sympathetic/vagal balance with an increase in the ratio suggesting either an increase in sympathetic cardiac modulation or a decrease in parasympathetic modulation, or both (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996; Terathongkum and Pickler, 2004).

HRV analysis has also been used to evaluate changes in sympathovagal tone during various emotional states (such as stress and anxiety) and pain (Carney et al., 1995; Stauss, 2003; Terathongkum and Pickler, 2004; Tousignant-Laflamme and Marchand, 2006; Hummel and van Dijk, 2006). Current literature suggests that the relaxation response, meditation, prayer, yoga and therapeutic touch have each been associated with physiologic changes indicating decreased emotional stress and increased parasympathetic activity, which were measurable by HRV (Terathongkum and Pickler, 2004; Benson et al., 1974). In addition, Diego et al. (2005) reported that massage therapy increased the cardiac vagal index (CVI), vagal tone, gastric motility and decreased tachygastria in a group of preterm neonates when compared with sham massage in a control group.

Given the value of HRV as a measure of PNS activity and the lack of evidence about the effect of TTM on the autonomic nervous system we investigated the effects of TTM on HRV and other stress-related parameters in patients with back pain associated with MTrPs.

Methods

Design and setting

A randomized control trial was conducted in the Division of Physical Therapy, Faculty of Associated Medical Sciences, Khon Kaen University, Thailand. The study was approved by the ethical committee of Khon Kaen University.

Participants

Patients with back pain associated with MTrPs were recruited from Khon Kaen province using bulletin boards and oral requests for participants during a 7-month period between September 2007 and March 2008.

The clinical criteria for the diagnosis of MTrPs in this study were adapted from those specified by Travell and Simons (1983). Participants were included if they presented with chronic back pain, which had lasted longer than 12 weeks, and had at least one trigger point in the upper and/or lower back region. Trigger points were diagnosed as the presence of spot tenderness in areas that the patient identified as painful.

The criteria for exclusion from the study was based on any history of disease or other disorder, which may affect heart rate variability (HRV); such as myocardial infarction, hypertension, neuropathy diabetes mellitus, fever, a history of acute trauma, spinal fracture, inflammatory arthritis (rheumatoid arthritis or gout), muscle diseases, evidence of neurological deficits, and/or skin diseases.

Each patient signed an informed consent form prior to the baseline examination. Estimation of the sample size was based on a pilot study ($n = 7$) that compared the immediate effect of TTM (four patients) with that of control treatment (three patients) for subjects with back pain associated with MTrPs. Based on data of the pilot study, a standard deviation (of HF power) of 919.7 was used to calculate the sample size needed to detect a 866.1 ms^2 change in HF power (based on the post-test mean differences between groups) which was considered as the level to accept clinical significance of the results with 80% power and 5% significance. In addition, a drop-out rate of 20% was allowed for in estimating the total sample size. According to these criteria, 36 patients were recruited.

Procedure

Randomization

The 36 patients who met the above inclusion criteria were randomly assigned to either the treatment (TTM) group or the control group using block randomized allocation with block sizes of 2, 4, and 6. Groups were assigned using a pre-generated random assignment scheme enclosed in envelopes (STATA Version 9), which resulted in a total of 18 patients per group.

Treatment

Treatment group (traditional Thai massage — TTM)

Participants received one 30-min session of TTM onto the back muscles while lying in the prone position during the period between 10.00 and 13.00 h on the day of the study. Based on the experience of the first three authors who work as both physiotherapists and massage therapists, plus the outcome of the pilot study, a 30-min session was considered appropriate for an effective impact of massage when confined to the back area only.

All TTM in this study was conducted by a well-trained massage therapist, according to the system of royal Thai massage, which applies the theory of ''Sen Sib'' or the 10 meridian lines. Massage points included in this method are located along two lines and at an additional, single, point along the paravertebral muscles on each side of the spine (Chatchawan et al., 2005). The two lines on the left side of participants are called Ittha and the two lines on the right side of participants are called Pingkhala (Figure 1). The pressing technique employed in TTM uses the body weight of the massage therapist to apply gentle, gradually increasing, pressure through the therapist's thumb, fingers, or palm. Pressure is applied until the patient starts to feel slight discomfort after which this pressure is maintained for 5—10 s at a time. This sequence can be repeated several times for each massage point (Chatchawan et al., 2005).

Control group

The control group relaxed by lying prone quietly in the same environment and for the same period of time as the treatment group. After the study period had ended and all data were collected, the control group were offered a session of TTM for their back. The same pre- and post-treatment assessments were conducted on both groups.

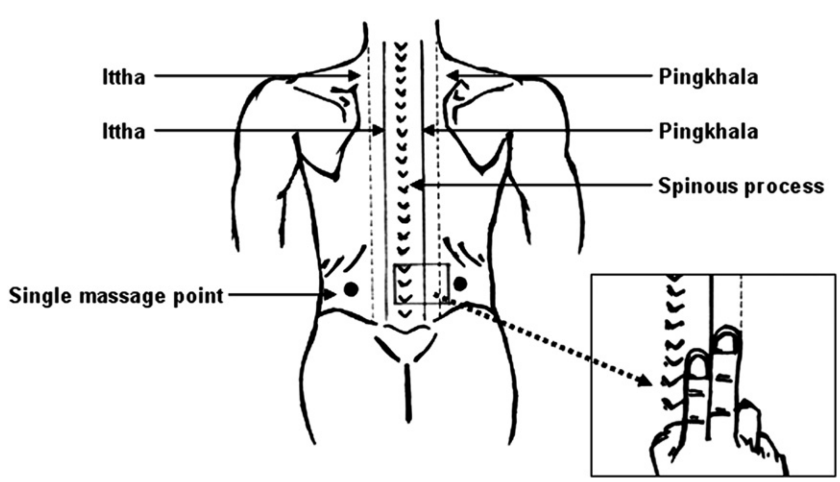

Figure 1 The massage points, along the two meridian lines running from thoraco-cervical junction or C7 to posterior superior iliac spine (PSIS).

At the end of the study, all participants in both groups were given the opportunity for instruction in a series of back exercises to conduct at home.

Outcome measures

All outcome measures were assessed before and after the TTM and control sessions. Details of outcome measures and how they were assessed is described below.

Heart rate variability (HRV)

Participants were requested not to eat, drink or smoke for 4 h before the measurements and during the measurement they were asked to refrain from talking, falling asleep, making exaggerated body movements, and/or intentionally altering their respiration. Before HRV measurement, participants rested in a prone position at room temperature (25 °C) for 20 min. HRV was assessed before and immediately after the treatment/control period. Analysis was based on a 10 min period of ECG signal acquisition, followed by computerized Fourier analysis of the ECG waves, using the BIOPAC system. Participants were carefully monitored using the BIOPAC Respiratory Transducer SS5LB to ensure there were no significant respiratory pattern changes during the ECG measurement. HRV was then calculated manually using the power spectral analysis method (frequency domain method). The parameters used were set as follows: total power frequency (TPF) (0.00–0.40 Hz), low frequency (LF) power (0.04–0.15 Hz), high frequency (HF) power (0.15–0.40 Hz). The low frequency to high frequency ratio (LF/HF ratio) was calculated based on the outcome of the power spectral analysis. HF power was the main parameter of interest in this study.

Pain intensity and muscle tension

Pain intensity and muscle tension were assessed using separate 10-cm visual analogue scales (VAS). The intensity of pain and feeling of muscle tension were reported by the participants using numerical analog scales ranging from 0 to 10 on which 0 indicated no pain or no muscle tension, respectively, and 10 indicated the most pain ever and the tensest ever experienced. Reliability of data obtained with these VAS is reported to be high ($r = 0.99$) (Scott and Huskisson, 1979), with high construct validity (Wilkie et al., 1990).

Pressure pain threshold (PPT)

The pressure pain threshold was measured using the pressure algometry technique recommend by Fisher (1986, 1988) and evaluated by Reeves et al. (1986). The participant was asked to signal when he or she began to feel pain or any discomfort, at which point the compression was stopped (Esenyel et al., 2000). Each trigger point was measured three times and the average was taken for analysis. Results of the pressure measurements were expressed in kg/cm^2. The precision of measurement was 0.1 kg/cm^2.

State anxiety inventory (STAI)

The state anxiety inventory (Thai version), is a 20-item inventory on how the participant feels at the moment. Characteristic items, which include 'I feel at ease' and 'I feel confused', are answered in terms of severity (not at all, a little, somewhat and very much so). The STAI score has a high correlation with stress ($r = 0.93$) (Thai version) (Lertluechachai, 1989).

Body flexibility

A sit-and-reach box was used to measure body flexibility. Body flexibility was measured three times and the average was computed for inclusion in the analysis reported here. Reliability of data obtained with the sit-and-reach box is reported to be high ($r = 0.97$) (Chatchawan, 2005).

Statistical analyses

Data were analyzed using STATA Version 9. Descriptive statistics were used to describe the continuous and categorical data including number of participants, age, weight, sex, etc. Mean and standard deviations of the values were calculated for each variable. Paired t-tests were used to compare outcome variables at baseline with outcome measures immediately after the treatment or control period within each respective group. An analysis of covariance (ANCOVA) was used to compare the difference in post-test values between the control and treatment groups after adjusting for differences in baseline values, for each outcome measure. A difference at the level of $p < 0.05$ was considered statistically significant.

Results

Demographic and baseline clinical characteristic

Demographic data and baseline clinical characteristics of the patients are presented in Table 1. Of the 36 patients enrolled in this study, 20 were female and 16 were male. Their mean age was 22.6 ± 2.9 years. Eighty-three percent of the patients were students. In more than 88% of all cases, the most painful trigger point of each patient was found in the lower part of the back. Baseline results for HRV and other outcomes measured pre- and post-treatment are shown in Table 2. Most baseline characteristics were equally balanced between the two groups except that the TTM group had a higher high frequency (HF) heart rate variability measurement and had greater body flexibility.

Immediate effects of traditional Thai massage on heart rate variability

Table 2 shows that immediately after receiving TTM; the TPF, LF power and HF power components of HRV were significantly increased when compared with pre-treatment values ($t = -4.2$, $p < 0.001$; $t = -3.7$, $p = 0.002$; and $t = -4.7$, $p < 0.001$, respectively) and the LF/HF ratio was significantly decreased ($t = 2.3$, $p = 0.032$). In contrast, no statistically significant difference was found in the control group except for LF/HF ratio, which increased following the control period. When comparing between the two groups (Table 3), it was found that, after adjustment for baseline levels, the post-test values for TPF and HF power among the TTM group were significantly higher than those found

Table 1 Demographic and baseline clinical characteristics of patients with back pain associated with MTrP.

Characteristics	TTM	Control	Total
Number of patients	18	18	36
Demographic data			
Age (years); mean (SD)	22.9 (3.4)	22.3 (2.6)	22.64 (2.9)
Gender; *n* (%) of female	11 (61.1)	9 (50.0)	20 (55.6)
Weight (kg); mean (SD)	54.72 (7.7)	54.89 (10.3)	54.81 (8.9)
Height (cm); mean (SD)	164.28 (7.7)	163.44 (7.6)	163.86 (7.6)
Body mass index; *n* (%)			
<18.5	4 (2.2)	6 (33.3)	10 (27.8)
18.5–22.9	12 (66.7)	10 (55.6)	22 (61.1)
23–24.9	2 (11.1)	1 (5.6)	3 (8.3)
25–29.9	0 (0.0)	1 (5.6)	1 (2.8)
Occupation or study, *n* (%)			
Student	16 (88.9)	14 (77.8)	30 (83.3)
Physical therapist	1 (5.6)	3 (16.7)	4 (11.1)
Teacher	0 (0.0)	1 (5.6)	1 (2.8)
Police inspector	1 (5.6)	0 (0.0)	1 (2.8)
Back pain with MTrP area; *n* (%)			
Upper part of the back	1 (5.6)	2 (11.1)	3 (8.3)
Lower part of the back	17 (94.4)	16 (88.9)	33 (91.7)
Severity of back pain: by pain scale; mean (SD)	5.2 (2.0)	4.6 (1.4)	4.9 (1.7)
Severity of back pain: by muscle tension scale; mean (SD)	4.7 (1.7)	4.1 (1.8)	4.4 (1.8)
Duration of back pain episode (month)	19.1 (16.1)	14.1 (16.6)	17.0 (16.2)

Note: TTM is traditional Thai massage.

among the control group ($F = 23.55$, $p = 0.006$ and $F = 36.24$, $p < 0.001$, respectively) whereas the post-test LF/HF ratio was lower in the treatment group than the control group ($F = 25.89$, $p < 0.001$). There was no significant difference in the post-test LF power values between the two groups.

Immediate effects of traditional Thai massage on other parameters

The pain intensity (VAS), pressure pain threshold, muscle tension (VAS), body flexibility and state anxiety inventory (STAI) all showed significant improvements with TTM treatment ($t = 9.4$, $p < 0.001$; $t = -10.8$, $p < 0.001$; $t = 7.0$, $p < 0.001$; $t = -4.7$, $p < 0.001$; and $t = 6.6$, $p < 0.001$, respectively). No statistically significant differences were found in these five parameters pre- to post-test among the control group except for a negative change in body flexibility (Table 2). A comparison of the adjusted post-test values for the five non-HRV related outcome measures between the TTM and control groups indicated a significant improvement in these parameters in the TTM group ($F = 45.57$, $p < 0.001$; $F = 106.75$, $p < 0.001$; $F = 20.67$, $p < 0.001$; $F = 250.86$, $p < 0.001$; and $F = 10.19$, $p = 0.026$, respectively) (Table 3).

Discussion

The outcomes of this study support that theory of Moyer et al. (2004) that massage has an effect on the PNS. Findings from this present study suggest that TTM onto the back muscle of patients with back pain associated with MTrP is effective in increasing cardiac parasympathetic activity and decreasing sympathetic activity. The consequences of these changes to the autonomic system manifest as: increased TPF and HF power and a decrease in LF/HF ratio. Associated effects of these changes, as observed in this study, are: decreased pain and related increased pressure pain threshold, and decreased muscle tension and feeling of stress (Tables 1 and 2).

These findings are in accordance with those of Delaney et al. (2002) and Diego et al. (2005), as described in the background section of this paper. However, it should be noted that some aspects of these studies differ from the present study, which include underlying condition, the body area treated, the position of patients during treatment, the massage technique and the duration of treatment.

An increase in LF power after receiving TTM was found in this study (Table 2). This finding of increased LF power is in accordance with the study of Delaney et al. (2002) which showed a trend toward increase of LF power but did not show a statistically significant increase following treatment by MTPT (the LF power in the MTPT group at baseline was 910 ms^2 and this was increased to 1390 ms^2 after treatment). However, interpretation of increased LF power is still unclear.

From comparison of results between the treatment and control groups we can conclude that treatment by TTM among patients with back pain associated with MTrP is superior to the control condition of rest in the prone position.

The mechanisms by which TTM may enhance heart rate variability and cardiac parasympathetic activity and the

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

Parameter	TTM (n = 18)					CONTROL (n = 18)				
	Baseline (mean (SD))	Post-test (mean (SD))	Difference (95% CI)	t value	p value	Baseline (mean (SD))	Post-test (mean (SD))	Difference (95% CI)	t value	p value
Heart rate variability (HRV)										
Total power frequency (TPF): ms^2	1264.4 (910.8)	2066.9 (1346.8)	802.5 (395.1 to 1209.9)	−4.2	<0.001	1211.3 (933.4)	1249.6 (857.5)	38.3 (−328.6 to 405.3)	−0.2	0.828
Low frequency (LF): ms^2	281.3 (253.9)	496.7 (313.1)	215.4 (93.4 to 337.3)	−3.7	0.002	305.2 (276.4)	428.2 (360.6)	123 (−26.5 to 272.5)	−1.7	0.101
High frequency (HF): ms^2	478.7 (520.5)	1012 (763.5)	533.3 (294.9 to 771.7)	−4.7	<0.001	405.1 (220.1)	340.5 (209.1)	−64.6 (−166.5 to 37.2)	1.3	0.198
Low frequency to high frequency (LF/HF)	0.87 (0.53)	0.66 (0.35)	−0.21 (−0.40 to −0.02)	2.3	0.032	0.71 (0.39)	1.2 (0.68)	0.53 (0.33 to 0.74)	−5.6	<0.001
Other parameters: pain scale (VAS)	5.2 (1.9)	2.6 (1.9)	−2.6 (−3.2 to −2.0)	9.4	<0.001	4.6 (1.4)	4.8 (1.4)	0.2 (0.31 to 0.72)	−0.9	0.407
Pressure pain threshold (PPT)	3.0 (0.95)	4.4 (1.1)	1.4 (1.1 to 1.7)	−10.8	<0.001	2.7 (1.0)	2.7 (1.0)	0.0 (−0.26 to 0.20)	0.3	0.791
Muscle tension (VAS)	4.7 (1.7)	2.3 (1.9)	−2.5 (− 3.2 to −1.7)	7.0	<0.001	4.1 (1.8)	4.5 (2.1)	0.4 (−0.48 to 1.2)	−0.9	0.375
Body flexibility	2.6 (7.4)	4.9 (7.1)	2.4 (1.3 to 3.4)	−4.7	<0.001	−1.3 (8.5)	−3.9 (9.2)	−2.6 (−3.9 to −1.37)	4.4	<0.001
State anxiety inventory (STAI)	40.1 (9.4)	31.4 (7.4)	−8.7 (−11.4 to −5.9)	6.6	<0.001	39 (5.7)	36.7 (10.7)	−2.3 (−2.5 to 7.2)	1.0	0.325

Note: TTM is traditional Thai massage. A difference at the level of $P < 0.05$ is considered statistically significant. ms^2 = millisecond square.

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

Parameter	TTM ($n = 18$)	Control ($n = 18$)	Difference (95% CI)	F value	P value
Heart rate variability (HRV)					
Total power frequency (TPF): ms^2	2043.2	1273.3	769.9 (237.4–1302.4)	23.55	0.006
Low frequency (LF): ms^2	505.9	418.9	87.0 (−97.5–271.6)	10.02	0.344
High frequency (HF): ms^2	973.2	379.3	593.9 (339.5–848.2)	36.24	<0.001
Low frequency to high frequency ratio (LF/HF ratio)	0.59	1.3	0.72 (0.45–0.9)	25.89	<0.001
Other parameters					
Pain scale (VAS)	2.4	5.1	2.7 (1.9–3.4)	45.57	<0.001
Pressure pain threshold (PPT)	4.3	2.8	1.5 (1.1–1.8)	106.75	<0.001
Muscle tension (VAS)	2.0	4.7	2.7 (1.6–3.7)	20.67	<0.001
Body flexibility	3.0	−2.0	5.0 (3.3–6.7)	250.86	<0.001
State anxiety inventory (STAI)	31.1	37.0	5.9 (0.8–11.1)	10.19	0.026

Note: TTM is traditional Thai massage; a difference at the level of $p < 0.05$ is considered statistically significant. ms^2 = millisecond square.

associated perception of pain, muscle tension and stress is discussed in more detail as follows.

(a) *Increased HRV and relaxation*. TTM is known to promote relaxation and decrease stress and anxiety (Chaithavuthi and Muangsiri, 2005; Cowen et al., 2006). Delaney et al. (2002) and Benson et al. (1974; Benson, 1983) suggest that these findings are probably the result of an increased relaxation response and an overall reduction in the defence-arousal (stress) response as a result of TTM, possibly mediated by increased parasympathetic and decreased sympathetic activity. Other studies report an association between massage and increased levels of serotonin (5HIAA) and dopamine, again indicating modulation of the autonomic nervous system and expected decreased anxiety (Field et al., 2007; Carney et al., 1995). Our study verified these findings of decreased perceived stress and anxiety, while also providing evidence for the physiological mechanism behind these outcomes, i.e., enhanced PNS activity and increased HRV.

(b) *Decreased pain and PNS activity*. Mackawan et al. (2007) showed that TTM onto low back muscle for 10 min can temporarily relieve pain in patients with non-specific low back pain and proposed that this may be explained by gate-control theory. The study reported in this paper demonstrated that self-reported pain intensity was reduced after TTM treatment and that the pain pressure threshold (PPT) correspondingly increased. Increased PPT after TTM is consistent with findings by Chatchawan et al. (2005) and with the theory proposed by Simons (2002) that local pressure may normalize the length of sarcomeres by stretching the involved muscle fiber, consequently increasing the energy supply to the area and decreasing MTrP sensitivity. Decreased pain has been shown to increase cardiac parasympathetic activity and decrease sympathetic activity (Tousignant-Laflamme and Marchand, 2006; Hummel and van Dijk, 2006), a relationship supported by our study.

(c) *Patient position and PNS activity*. TTM onto back muscle in prone position may stimulate the parasympathetic nervous system by increasing regional cerebral blood flow (rCBF). Ouchi et al. (2006) reported that pressure stimulation by massage onto the back muscles in the prone position increased rCBF in the parietal (precuneus) and occipital cortices, which leads to greater activity in this area and stimulates an increase in parasympathetic activity. It is, therefore, feasible that the position of the treatment group when receiving TTM in our study assisted in increasing HRV.

(d) *Pressure massage and HRV*. Moderate pressure massage may involve stimulation of pressure receptors, which has been shown in animal studies to activate the vagus, leading to increased heart rate variability (Uvnas-Moberg, 1994). Since TTM is a type of pressure massage it is feasible that the same mechanism was at least partly responsible for the increase in HRV observed in our study.

Immediately after treatment, the TTM group showed an improvement in body flexibility. A previous study showed that TTM could increase body flexibility in patients with back pain associated with myofascial trigger point (Chatchawan et al., 2005). The potential mechanism proposed was that TTM might stimulate proprioceptors (spindle cell and Golgi tendon organs) in targeted muscles, resulting in reduced muscle spasm and adhesion in tissue (Chatchawan, 2005). In the control group, body flexibility reduced after the control session. Lying prone for a reasonably long time (30 min) can, thus, be proposed to exacerbate the stiffness of the involved muscle.

Limitations of the study

The present study has some limitations as follows. The respiratory rates of participants in this study were monitored using the BIOPAC Respiratory Transducer SS5LB, which might have caused some discomfort to the participants due to the fairly constrictive chest band. In future studies, a more comfortable method for assessing respiratory rate should be found. The present study only evaluated the immediate effect of TTM, which may not correlate with a longer term effect. However, studies by Chatchawan et al. (2005) found that pain intensity and PPT were still significantly improved 3 weeks after TTM and Cowen et al. (2006) established that STAI improvements remained for up to 48 h, which was the limit of follow-up in that study.

Conclusion

The results of this study suggest that TTM onto the back muscle for 30 min in the prone position is effective in increasing cardiac parasympathetic activity, reducing sympathetic activity and reducing pain and stress in patients with back pain associated with myofascial trigger point (MTrP). This treatment technique is a non-pharmacologic intervention with no side effects. Since, this massage technique can be easily taught to partners or family members of patients, we suggest that TTM should be considered as one of the alternative treatments for MTrP.

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