

# Effect of Therapeutic Sequence of Hot Pack and Ultrasound on Physiological Response Over Trigger Point of Upper Trapezius

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**Background:** Musculoskeletal pain is a common problem among athletes. Apart from sport injuries, the myofascial pain syndrome is another important problem that affects performance of the athlete.

**Objectives:** The aim of this study was to evaluate the effects of therapeutic sequences of the hot pack in combination with ultrasound on the physiological responses over the latent myofascial trigger point (LMTrP) of upper trapezius muscle.

**Materials and Methods:** Thirty subjects with a latent myofascial trigger point (LMTrP) in both sides of the upper trapezius muscle participated in the study (age  $27.33 \pm 4.34$  years, weight  $58.11 \pm 7.47$  kg, height  $161.50 \pm 5.82$  cm, pressure pain threshold  $2.28 \pm 0.24$  kg/cm<sup>2</sup>, pain intensity  $7.17 \pm 2.25$  VAS). All subjects received both treatments (hot pack followed by ultrasound: HP + US; and ultrasound followed by hot pack: US + HP) by randomization with a 24 to 48-hour interval between sessions. Outcome measures, including the tissue blood flow (TBF), pressure pain threshold (PPT), supra-thermal threshold (STT) and visual analog scale (VAS) were evaluated at baseline, immediately, after 30 minutes and after 60 minutes.

**Results:** The TBF and PPT significantly increased from baseline in both treatment conditions (i.e. HP + US and US + HP), while the HP + US condition showed a trend toward significant difference in VAS and STT in 45°C.

**Conclusions:** The application of HP and US treatment induces physiological responses (especially, TBF and PPT) on the LMTrP. This finding provides the direction toward the management of MTrPs condition.

**Keywords:** Treatment; Trigger Point; Pressure; Pain Threshold

## 1. Background

Musculoskeletal pain is a common problem among athletes. Apart from sport injuries, the myofascial pain syndrome is another important problem that affects performance of the athlete (1, 2). Myofascial pain syndrome is a painful musculoskeletal condition initiated from the hyperirritable spot within a taut band of skeletal muscle. This condition is related to a neuro-musculoskeletal phenomenon associated with prolonged muscle imbalance, sustained and repetitive microtrauma (3, 4). Myofascial pain syndrome starts as a peripheral disorder in which pain develops in a localized central area of muscle contraction as called the myofascial trigger point (MTrP). Within a few weeks, the phenomenon of peripheral and central sensitizations can develop and induce widespread referred pain (5). Therefore, the characteristic of MTrP is described as a painful musculoskeletal condition with a hypersensitive spot within a taut band, and reproduction of referred pain by palpation on the trigger point. The MTrP can be classified into 2 types (i.e. active and latent MTrPs). A latent myofascial trigger point (LMTrP) is usually aggravated to palpation (compression), tension and muscle contraction (5, 6). Shoulder and

scapula are the most common areas for myofascial pain syndrome, especially upper trapezius muscle among overhead sport activities such as badminton, volleyball, water polo and also swimming (1, 7-9). In clinical practice, the combination of hot pack (HP) and ultrasound (US) treatment are used to treat MTrPs. However, the sequence of applications between HP followed by US or US followed HP has not been studied for its therapeutic effects. The sequence of applications may provide different effects because these modalities can affect tissues differently. For example, HP potentially affects vasodilation of superficial tissues over the applied area via histamine-induced skin flare response (10, 11), besides, blood circulation in the deep tissue layer may be induced by the role of reflex sympathetic outflow via the isolated spinal cord (11). US has been proposed to mainly affect the muscles and tissues in the deeper layers through both thermal and non-thermal effects (12, 13). The several studies suggest that the thermal effect of ultrasound helps to increase tissue extensibility, reduce pain, increase metabolism and increase deep tissue blood flow, while non-thermal effects provide an analgesic effect on neural structures

(14-16). In previous studies, Lehmann et al. and Draper et al. reported that combined treatment of HP and US could raise the superficial and deep muscle temperature after application (17, 18). However, the sequence of HP and US applications (i.e. HP + US or US + HP) is needed to evaluate its therapeutic effects on various clinical outcomes. Most studies investigated the LMTrP pain from visual analog scale, pressure pain threshold and tissue blood flow. Valencia et al. suggested that the supra-thermal threshold was also a stronger predictor of clinical pain intensity (19), so, the supra-thermal threshold is one interesting variable to investigate the clinical pain on LMTrP. Therefore, the effect of tissue blood flow (TBF), pressure pain threshold (PPT), supra-thermal threshold (STT) and visual analog scale (VAS) may help to answer the critical questions about clinical effectiveness of the treatment sequence for LMTrP.

## 2. Objectives

The objective of this study was to evaluate the effects of therapeutic sequences of the hot pack in combination with ultrasound on the physiological responses (TBF, PPT, STT, and VAS) for treatment of the latent myofascial trigger point (LMTrP) over upper trapezius muscle.

## 3. Materials and Methods

### 3.1. Participants

Thirty volunteers (6 males and 24 females) aged 20 to 40 years ( $27.3 \pm 4.3$  years), with latent MTrPs in the upper trapezius muscle bilaterally, participated in a within subjects, cross-over study design with 24-48 hours between sessions. This number of subjects obtains the power of 0.80, alpha level of 0.05 and effect size of 0.59. The latent MTrPs were a hypersensitive tender spot in the taut band area, responding to pressure in the recruited range of 2.0-2.9 kg/cm<sup>2</sup> (20). Subjects were excluded if they had any neuromuscular symptom, the history of surgery and trauma to the neck and shoulders within the past 12 months; and contraindications and precautions to hot pack and ultrasound treatments. This study protocol was approved by the ethics committee of the institution and each subject signed a consent form before start of the study.

### 3.2. Procedure

All participants randomly received both treatment conditions (i.e. HP + US and US + HP) with 24-48 hours between sessions using blocked randomization (i.e. concealed envelopes), including the hot pack followed by ultrasound (HP + US) and ultrasound followed by hot pack (US + HP). The experiment was conducted in a controlled temperature room at 25°C. Subjects were randomly allocated (concealed random orders) into the treatment conditions and experimental sides. The measurement consisted of TBF, supra thermal threshold (STT), PPT, and

VAS. The same measurements were performed again at post-treatment (immediate, after 30 minutes, and after 60 minutes). The treatment condition and measurement were applied over the most sensitive spot of latent MTrPs of upper trapezius muscle by a qualified physiotherapist, and the treatment conditions were blinded for the investigator. The reliability of this study was investigated in 15 subjects before the start of the study, and revealed the acceptable reliability values (ICC > 0.85, SEMs < 5%, CV < 20%) (Table 1).

### 3.3. Interventions

All subjects were asked to lie down in a prone position with arms by side and the neck was placed in the neutral position. The hot pack (standard size which had been stored in a hydrocollator tank of 74.5-80°C for 30 minutes) with 6-8 layers of towel was applied to cover the area of the latent MTrPs for 20 minutes. The ultrasound modality (BTL-4710 Sono Professional, BTL Medical Technologies Ltd., UK) with transducer head of 5 cm<sup>2</sup> was applied over the area of latent MTrPs of upper trapezius muscle. The treatment was carried out with continuous mode, frequency 1 MHz, intensity 1.0 W/cm<sup>2</sup> and applied by moving technique at a rate of 4 cm/s for 5 minutes.

### 3.4. Outcome Measures

#### 3.4.1. Tissue Blood Flow

TBF used a laser Doppler blood flow meter (Moor instrument DRT4, UK) assessing over the center area of latent MTrPs. The unit of TBF was reported in flux/min. The TBF measurement was recorded for 2.5 minutes, and average value was calculated (21).

#### 3.4.2. Supra-Thermal Threshold

STT was measured using a thermal sensory analyzer (Medoc Ltd., Neuro Sensory Analyzer Model TSA-II, Israel). This study used thermode size 5 cm<sup>2</sup> put over the area of latent MTrPs at upper trapezius muscle. All subjects received 3 temperature rates including 45°C, 47°C and 49°C with increased rate speed of 4°C/s from baseline temperature setting at 35°C, performed 2 time/rate and 15 seconds for rest interval between temperature rate. Numerical rating scale (NRS) was used verbally to the pain intensity with scale 0 to 100 mm in horizontal line (0 = no pain, 100 = the worst pain imaginable). The average value was calculated for statistical analysis (19).

#### 3.4.3. Pressure Pain Threshold

PPT was assessed using a digital pressure algometer (Somedic AB, Sollentuna, Sweden) with rubber tip of 1 cm<sup>2</sup>. The unit used was kilo-Paskal (kPa). The measurement performed pressure vertically over the latent MTrPs with rate increase speed of 40 kPa/s until the subject felt change from pressure to starting pain, which was indi-

cated by pressing a button. This protocol was performed 3 times with 30 seconds for rest interval, and the average value was calculated for further analysis (21).

3.4.4. Visual Analog Scale

VAS was assessed in local pain evoked by standardized pressure at 3 kg/cm<sup>2</sup> to the latent MTrPs of upper trapezius muscle by using a digital pressure algometer. The pain scale was reported in a horizontal line at 0 to 10 cm (0 = no pain, 10 = worst pain) (21).

3.5. Statistical Analysis

Mixed model repeated measures ANOVA was used in this study. The alpha level was set at P < 0.05.

4. Results

No interaction effects between the treatment conditions and time were evident. However, there was significant difference of the main effect (time) within the treatment condition (in comparison to the baseline). Table 2 showed a significant increase from baseline of the TBF and PPT un-

der the HP + US and US + HP conditions (P < 0.05). Table 3 showed a significant increase from baseline of the visual analog scale (VAS) and 45°C of supra-thermal threshold (STT) under the HP + US condition only (P < 0.05).

**Table 1.** Intraclass Correlation Coefficients, Coefficient of Variation and Standard Error of Measurements for Pain Visual Analog Scale, Tissue Blood Flow, Supra-Thermal Threshold, and Pressure pain Threshold Over the Myofascial Trigger Point <sup>a</sup>

Measurements	ICC	CV, %	SEMs, No. (%)
VAS	0.92	7.55	0.13 (2.16)
TBF	0.92	11.10	0.36 (3.05)
STT			
45°C	0.91	5.92	0.97 (1.69)
47°C	0.90	3.82	0.88 (1.15)
49°C	0.97	1.57	0.22 (0.23)
PPT	0.85	6.80	5.87 (2.55)

<sup>a</sup> Abbreviations: CV, coefficient of variation; ICC, intraclass correlation coefficients; PTT, pressure pain threshold; SEMs, standard error of measurements; STT, supra-thermal threshold; TBF, tissue blood flow; VAS, visual analog scale.

**Table 2.** Primary Outcomes (Tissue Blood Flow, Pressure Pain Threshold) at Latent MTrPs <sup>a, b, c</sup>

Conditions	Tissue Blood Flow, Flux/Min				P Value <sup>b</sup>
	Baseline	Immediate <sup>b</sup>	Post 30 Minutes <sup>b</sup>	Post 60 Minutes <sup>b</sup>	
HP + US	11.28 ± 3.90	59.44 ± 41.24	41.96 ± 28.76	30.78 ± 24.50	< 0.0001
US + HP	12.15 ± 4.59	66.57 ± 28.94	33.52 ± 18.62	28.14 ± 17.17	< 0.0001
<b>Pressure Pain Threshold, kPa</b>					
HP + US	182.30 ± 31.05	201.16 ± 40.10	207.16 ± 44.31	218.46 ± 41.60	< 0.001
US + HP	168.40 ± 29.14	193.76 ± 23.77	205.83 ± 24.00	214.70 ± 26.59	< 0.001

<sup>a</sup> no significant differences of baseline between conditions.

<sup>b</sup> Statistically significant P < 0.05 compared with baseline.

<sup>c</sup> Data are presented as mean ± SD.

**Table 3.** Secondary Outcomes (Visual Analog Scale, Supra-Thermal threshold) at Latent MTrPs <sup>a, b, c</sup>

Conditions	Visual Analog Scale, 10 cm				P value
	Baseline	Immediate	Post 30 Minutes	Post 60 Minutes	
HP + US	7.16 ± 2.17	6.34 ± 2.36 <sup>b</sup>	6.52 ± 2.44 <sup>b</sup>	6.26 ± 2.43 <sup>b</sup>	< 0.046 <sup>b</sup>
US + HP	7.18 ± 2.32	6.72 ± 2.58	6.52 ± 2.78	6.62 ± 2.67	< 0.099
<b>Numerical Rating Scale With Supra-Thermal Threshold [100]</b>					
<b>HP + US</b>					
45°C	49.20 ± 24.71	43.45 ± 23.99 <sup>b</sup>	42.78 ± 26.05 <sup>b</sup>	43.23 ± 26.97 <sup>b</sup>	< 0.045 <sup>b</sup>
47°C	60.70 ± 24.82	61.08 ± 24.70	63.68 ± 29.35	59.63 ± 26.80	< 0.421
49°C	86.98 ± 18.11	88.66 ± 16.43	89.35 ± 15.17	88.91 ± 17.29	< 0.438
<b>US + HP</b>					
45°C	46.81 ± 21.20	43.28 ± 26.39	40.25 ± 25.14	40.23 ± 21.36	0.053
47°C	64.06 ± 25.37	62.46 ± 29.61	66.01 ± 27.49	60.56 ± 27.48	< 0.574
49°C	89.38 ± 17.40	87.45 ± 17.51	88.03 ± 17.33	89.78 ± 15.59	< 0.438

<sup>a</sup> No significant differences of baseline between conditions.

<sup>b</sup> Statistically significant P < 0.05 compared with baseline.

<sup>c</sup> Data are presented as mean ± SD.

## 5. Discussion

In this study, the authors hypothesized that the treatment sequence of HP followed by US (HP + US) would affect the physiological variables greater than the US followed by HP (US + HP) application. The results revealed that both methods of treatment applications provided a similar physiological response on TBF and PPT. However, the application of HP followed by US (HP + US) could provide a greater beneficial effect on the VAS and STT (45°C). To our knowledge, this present study is the first study comparing the clinical effectiveness of treatment sequence between the HP and US modalities on physiological changes for management of LMTrP condition. The combination mechanism of HP followed by US could be explained by the HP inducing an increase of blood circulation in the superficial tissue and leading to fluid distribution in the trigger point area and therefore decreasing tissue density. Thus, the US wave can transmit through the deeper layer of tissues and can be absorbed by those tissues easier (22) and lead to increase both of deep and superficial tissue blood flow. Lehmann et al. and Draper et al. supported the idea that the tissue temperature increased after treatment with hot pack followed by ultrasound applications. Raising in tissue temperature for both of superficial and deep tissue layers are the characteristics of HP and US modalities respectively that may play an important role in these physiological changes (17, 18). Thermal effect further induced blood circulation toward the treated area, resulting in physiological changes and clinical outcomes such as reduced muscle spasm, altered threshold of receptors, minimizing hypoxia, alleviating pain and promoting the healing process (10, 14, 23, 24). Surprisingly, acoustic cavitation mechanism of the micro-bubbles from ultrasonic wave also enhances mechanical micro-massage oscillation that may be able to stimulate neural circuit for promoting tissue blood circulation (13). Although, our results did not show a significant difference of treatment sequence in every outcome measure, but some outcome measures of “HP followed by US” showed that the latent myofascial trigger point (LMTrP) disorder relatively improved as demonstrated in pain VAS and STT (i.e. 45°C) better than “US followed by HP”. It also should be addressed that interpretation for the subjective pain VAS scale should be performed with care as the volume of change was relatively small and there was risk of bias. Interestingly, the STT of 47°C and 49°C was not sensitive for differentiating changes between treatment conditions. The fear and anxiety of the high temperature through threshold tester may influence the outcomes (25). In terms of limitation, it should be noted that we did not measure the intra-muscular and tissue temperature directly. Insertion of the needle into the body may cause ethical concern and make it hard to find the volunteers. However, we may find out indirectly from the tissue blood flow (laser Doppler flow meter) (26). On the other hand, it should be stated that this study en-

hanced internal validity of the studies, we performed the investigator blind procedure, established reliability of the measurement prior to data collection, and engaged the within-subject with cross-over design to minimize the heterogeneity of the subjects, and regular follow-up intervals up to 1 hour on various physiological outcomes. These could provide clinical information and direction toward the therapeutic application for a musculoskeletal condition such as MTrPs. The combined treatment of HP and US modalities enhanced clinical benefits on the LMTrP. The application of HP followed by US treatment seems to promote physiological responses (i.e. VAS, TBF, PPT, STT in 45°C) on the MTrPs better than that of the US followed by the HP treatment. We hope that this research could provide the potential direction toward the clinical application for treatment of LMTrP and may be used as a guideline for the MTrPs management.

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