

Correlation between Pressure Pain Threshold and Soft Tissue Displacement in Muscle Pain Conditions

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Objective: To determine the correlation between pressure pain threshold (PPT), displacement pain threshold (DPT) and pain visual analog scale (VAS) in patients with delayed onset muscle soreness (DOMS) and myofascial pain syndrome (MPS).

Material and Method: PPT and DPT were measured in the same time by modified Algometer[™] commander. This study used the algometer for measuring PPT (N/cm²), in three groups of subjects, including DOMS (n = 10), MPS (n = 10), and asymptomatic (n = 10). The DPT represented the displacement of the algometer probe on the skin in millimeters, while measuring PPT. The DOMS was induced in the non-dominant biceps brachii muscle. The subjects with active myofascial trigger point (MTrP) at the upper trapezius muscle were recruited into the MPS group. DOMS group rated pain by VAS during elbow movement, while the MPS group rated at resting. Spearman's rank coefficient of correlation was used for data analysis.

Results: The results showed correlation between PPT and DPT in the asymptomatic biceps brachii muscle ($r_s = 0.77$, $p = 0.001$) and DOMS group ($r_s = 0.65$, $p = 0.04$). No correlation was found between MPS and the asymptomatic upper trapezius muscle.

Conclusion: A correlation was found between PPT and DPT in biceps brachii muscles. This finding suggested that to assess the DOMS, the PPT and DPT accurately are required for identifying pain and tissue softness.

Keywords: Pressure pain threshold, Muscle tenderness, Muscle measurement, Delayed onset muscle soreness, Myofascial trigger point

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Numerous patients have commonly suffered from muscle pain. Muscle strain, tear, and delayed onset muscle soreness are considered acute conditions found in all ages. In addition, chronic muscle pain condition includes myofascial pain syndrome (MPS) commonly found among office workers.

Pain and tenderness are two main symptoms used to identify and evaluate the severity of the conditions. To measure pain, the visual analog scale (VAS) is usually applied. The limitation that it relies on individual perception may be prone to bias. The pressure pain threshold (PPT) has been developed to minimize this consequence. The PPT measures the minimal pressure when pain is perceived. When the pressure is applied on the superficial soft tissue including muscle at a consistent rate, the PPT can be

identified. However, the PPT may be altered due to relaxation and variations of muscle tone.

In addition, muscle is a viscoelastic tissue, which responds to the same load differently⁽¹⁾. At the initial phase of measurement, less pressure can produce more displacement, whereas at the final phase, more pressure can produce less displacement. The displacement response to the load may represent yielding of the soft tissue.

To use the PPT, it must be considered whether the pain threshold decreases (less pressure can induce pain); it represents the worsening of the symptoms. In the case where the muscle is more relaxed, the PPT decreases. In this circumstance, it cannot be completely said that the symptom had worsened. This phenomenon was supported by a previous study determining stretching exercise for the trigger point in the upper trapezius muscle. They found conflicting behavior of the PPT and displacement pain threshold (DPT)⁽²⁾. They reported that after the stretching, the PPT seemed to exhibit no change, but the DPT decreased significantly. The decrease of DPT implied an increase of the muscle

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tone.

Thus, it would be interesting to identify the correlation between PPT and DPT in patients with delayed onset muscle soreness (DOMS) and myofascial pain syndrome (MPS). This study chose the biceps brachii as a target muscle for DOMS because of the ease to induce and assess. Postural stress is the most common cause of MPS related to neck and shoulder pain⁽³⁾. In this case, the upper trapezius muscle was used as the representative of MPS.

Material and Method

The present study employed a cross sectional design to identify the correlation between PPT and DPT. The study was set at the laboratory of the Faculty of Physical Therapy, Mahidol University. The present study was approved by the Mahidol University Institutional Review Board (MU-IRB COA. No. 2008/280.3012) and subjects received all information of the study before signing the consent form.

Healthy subjects and patient with an active myofascial trigger point (MTrP) at the upper trapezius muscle aged between 18-35 years were recruited in the study. Three groups of subjects were enrolled this study, DOMS, MPS, and asymptomatic. Healthy subjects, students, and staff of the Faculty of Physical Therapy, Mahidol University were recruited in the DOMS and asymptomatic groups. The subjects with active MTrP in the upper trapezius muscle were recruited from patients who came for treatment at the Physical Therapy Center of the Mahidol University Faculty of Physical Therapy.

All subjects underwent physical examination to screen for the criteria of the study. The subjects were excluded if they: a) were menstruating, b) had a history of systematic disease, c) were using anti-inflammatory medication, d) showed signs of nerve root irritation or e) had a history of injury in the upper quarter musculoskeletal system that could be harmful while participating the study.

The healthy subjects were randomly assigned to DOMS and asymptomatic groups. Ten were randomly assigned to the DOMS group, and asked to perform eccentric exercise using the non-dominant arm. It consisted of 8 sets of 8 eccentric contractions with a weight of 110% of the subject's one-repetition maximum⁽⁴⁾. Each eccentric contraction lasted 4 seconds with 30 seconds rest between repetitions. A metronome was used to control the speed. The researcher assisted returning the weight to the starting position. The subjects were in standing position with back and legs

contacting a wall to minimize the compensatory movement. Criteria for DOMS included feeling discomfort or pain, tenderness in the muscles, complaint of difficulty moving the elbow, and feeling tension at the end range of elbow flexion-extension in the arm caused by the eccentric exercise within 8-24 hours⁽⁵⁾. The subjects in DOMS were measured for pain by the VAS, PPT and DPT 24 hours after the eccentric exercise. Inclusion criteria of the active MTrP were resting pain in the referred pain zone^(6,7), and palpable trigger point in the muscle fibers⁽⁶⁻⁸⁾.

An algometer (Algometertm Commander, J Tech Medical Industries) was used to measure PPT by pressing the probe perpendicular to the skin with an increasing rate of pressure at 5N/second⁽⁹⁻¹³⁾. The areas of measure were at the non-dominant biceps brachii muscle for the DOMS and asymptomatic groups and at the upper trapezius muscle for the MPS and asymptomatic groups.

The DPT was measured by marking a 50 millimeter scale on the algometer probe and synchronizing the end pressure with the light signal. Video was taken while measuring PPT. The image of the probe touching on the skin was laid over the frame that the light turned on. The displacement indicated the DPT as seen in Fig. 1.

The present study measured pain VAS of subjects in the MPS group while resting, and measured pain VAS while moving the elbow in the DOMS group. The protocol for testing PPT and DPT started from subjects sitting comfortably to measure the trapezius muscle and lying supinely to measure the brachii muscle. They were asked to press the signal operator button using the non-tested arm immediately when pain was elicited. PPT and DPT were measured 3 trials and the mean was used.

Statistical analysis

This study used Spearman's rank correlation coefficient (r_s) to determine the correlation between DPT and PPT, and between DPT and VAS. The critical value was set at $\alpha = 0.05$. The correlation coefficient (r) was interpreted following the Portney guidelines⁽¹⁴⁾. The correlation coefficient from 0.00 to 0.25 signified no relationship; from 0.25 to 0.50 designated a fair degree of relationship; from 0.50 to 0.75 represented a moderate to good relationship and a value more than 0.75 indicated good to excellent relationship.

Results

Ten healthy female subjects were randomly

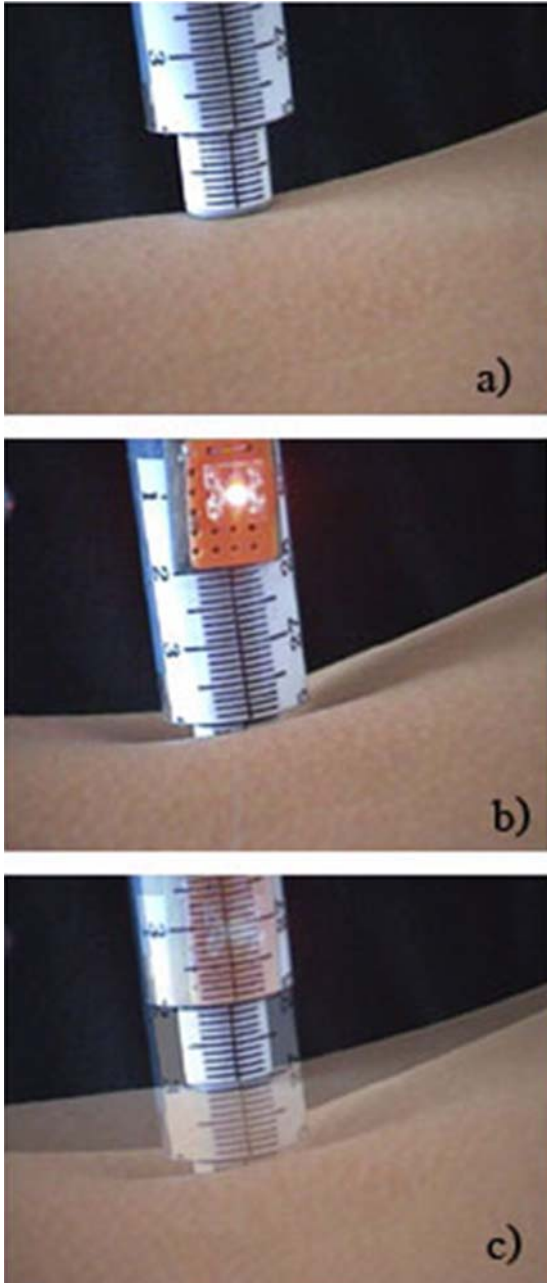


Fig. 1 DPT measurement from video frame: a) the probe touching the skin, b) when the light signal was turned on, and c) the superimposed image of displacement of the algometer probe which identified the DPT.

assigned to the DOMS group. The only male and nine females were assigned to the asymptomatic group. Ten subjects (2 males and 8 females) had MPS of the upper trapezius muscle and three had MTrP on the left side.

Mean and SD of all parameters are shown in Table 1. The DOMS and MPS group showed the PPT, DPT and VAS from the biceps and upper trapezius. The asymptomatic group showed data of the biceps, and upper trapezius muscle PPT and DPT.

Spearman's rank coefficient revealed a correlation between PPT and DPT in the biceps brachii muscle of both DOMS ($r_s = 0.65, p = 0.04$) and asymptomatic ($r_s = 0.77, p = 0.001$) groups. The result did not show a correlation between PPT and DPT of the upper trapezius muscle in both MPS ($r_s = 0.53, p = 0.12$) and asymptomatic ($r_s = 0.52, p = 0.12$) groups. No correlation was found between VAS and PPT in both DOMS ($r_s = 0.17, p = 0.64$) and MPS ($r_s = -0.32, p = 0.37$) groups. The result did not show a correlation between VAS and DPT in DOMS ($r_s = 0.28, p = 0.43$) and MPS ($r_s = -0.14, p = 0.71$) groups. Fig. 2 shows the scatter plot between PPT and DPT in patients with DOMS and MPS.

Discussion

The DOMS condition used in this study represented acute muscle pain, whereas, MPS represented chronic muscle pain, normally caused by postural stress⁽³⁾. Different muscles may respond to the pressure in different manner. This study found correlations in some muscles. This study could not find any correlation between PPT and DPT in the trapezius muscle both with and without MPS, but found a correlation between PPT and DPT in the biceps brachii muscle with DOMS. The result did not support the study of Andersen et al in 2006⁽¹⁵⁾, where no correlation was found in DOMS. This different result may be due to the different targeted muscle and method. The previous study measured PPT and muscle hardness at several areas of the tibialis anterior muscle with DOMS and used the average to identify the PPT and muscle hardness⁽¹⁵⁾.

Using PPT to measure pain and evaluate the improvement of the treatment may not absolutely represent the true response of patients with muscle pain condition. Indeed, the PPT depended on the softness of the soft tissue including the muscle⁽¹⁶⁾. Therefore, to measure the true symptoms of the patients, PPT could indicate the pain threshold response to the pressure, but could not determine the softness of the tissue. DPT reveals much the muscle allows the probe to move into the muscle. The greater displacement may indicate more relaxation of the muscle. This study suggests using the PPT combined with DPT to determine a more accurate muscle condition.

Table 1. Mean and standard deviation (SD) of all parameters in asymptomatic, DOMS, and MPS groups

	Biceps		Upper trapezius	
	Asymptomatic (n = 10)	DOMS (n = 10)	Asymptomatic (n = 10)	MPS (n = 10)
Age (years)	20.10±2.77	21.80±1.62	20.10±2.77	22.33±2.11
BMI	20.32±2.91	21.11±2.32	20.32±2.91	21.40±3.23
PPT (N/cm ²)	12.12±4.24	10.72±3.54	19.31±6.53	12.13±4.93
DPT (cm)	1.73±0.35	1.40±0.22	1.81±0.28	1.16±0.23
VAS (cm)	-	6.11±0.40	-	4.13±1.19

PPT = pressure pain threshold; DPT = displacement pain threshold; VAS = visual analog scale

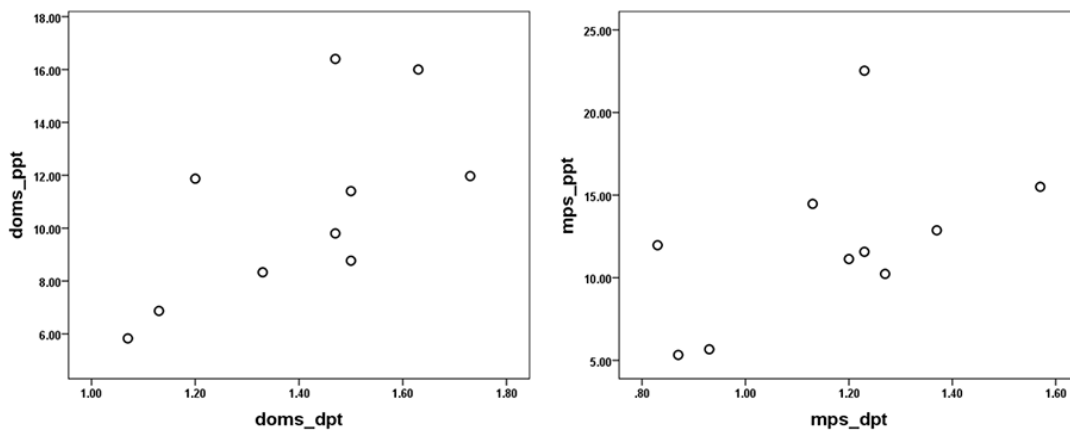


Fig. 2 Scatter plot of PPT and DPT of DOMS and MPS groups. PPT (N/cm²) was shown in the Y axis, while DPT (cm) was shown in the X axis.

However, this characteristic was not observed in the upper trapezius in both the MPS and asymptomatic muscle. This may have resulted because of the different type of muscle working. In addition, MPS is a muscle pain condition related to muscle hyperactivity^(17,18). The present study may not have excluded a subject who had latent MTrP of the upper trapezius muscle in the asymptomatic group. The latent MTrP may have affected PPT and DPT responses. The finding of no correlation between PPT and DPT means that the pain threshold not only depended on pressure but also displaced the soft tissue.

The present study measured DPT based on load displacement of the soft tissue similar to the muscle hardness meter. The result of this study confirmed the study of Ashina et al⁽¹⁹⁾. The hardness of the upper trapezius muscle in patients with chronic tension type headache was greater than normal⁽¹⁹⁾. According to the result, PPT may measure the displacement of the skin to detect improvement of the symptoms. However, DPT

does not reflect muscle softness alone, rather, it reflects the soft tissue softness including skin, subcutaneous tissue, fascia, and muscles.

Limitation and future study

The present study did not calculate the sample size and used a limited number of subjects. From the result, a large variation of PPT was noted especially in the asymptomatic upper trapezius muscle. Further study may include a greater number of subjects and exclude subjects with latent MTrP in the muscle to avoid type II error.

Conclusion

The present study found a correlation between PPT and DPT in the biceps brachii muscle in both DOMS and asymptomatic groups. Therefore, the DPT may be used to evaluate muscle pain and provide results similar to the PPT. However, this manner was not found in the upper trapezius muscle in both MPS

and asymptomatic groups. Therefore, DPT may not be used to provide similar results as the PPT for the upper trapezius muscle. Finally, the DPT may be considered as one evaluating tool for muscle pain condition and should be used in conjunction with PPT to obtain more information regarding the muscle.

What is already known on this topic?

PPT is usually used to determine muscle pain condition. A previous study indicated that only PPT alone could not completely detect symptom changes⁽²⁾. Muscle hardness represents a displacement response to muscle pressure^(1,16,20). It was found that the muscles were harder than normal in the patients with MPS and chronic tension-type headache^(19,21). This muscle hardness may alter the PPT. PPT; muscle hardness was found to have no correlation in patients with DOMS of the tibialis anterior⁽¹⁴⁾.

What this study adds?

This study found a positive correlation between PPT and DPT in the biceps brachii muscle and in acutely sensitized condition. Different muscles may respond differently to pressure.

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Potential conflict of interest:

None.

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ความสัมพันธ์ระหว่างแรงกดที่ทำให้เจ็บกับการเคลื่อนที่ของเนื้อเยื่อในกล้ามเนื้อที่มีอาการปวด

สิริกาญจน์ สมประสงค์, ศิริณี เมฆโหรา, รุ่งทิวา วัจนละอิตติ, โสภา พิชัยยงค์วงศ์

วัตถุประสงค์: ระบุความสัมพันธ์ระหว่างแรงกดที่ทำให้เจ็บ ระยะการเคลื่อนที่ของเนื้อเยื่อที่ทำให้เกิดความเจ็บ และระดับความเจ็บปวด ในผู้ที่มีอาการเจ็บกล้ามเนื้อหลังจากการออกกำลังกายและกล้ามเนื้อ และพังผืดอักเสบเรื้อรัง

วัสดุและวิธีการ: วัดแรงกดที่ทำให้เจ็บและระยะการเคลื่อนที่ของเนื้อเยื่อที่ทำให้เจ็บในขณะเดียวกัน โดยใช้เครื่องวัดความเจ็บปวดที่ได้รับการพัฒนาเพื่อวัดแรงกดที่ทำให้เจ็บ (นิวตัน/ตารางเซนติเมตร) ในผู้เข้าร่วมวิจัย 3 กลุ่มรวมทั้ง ผู้ที่เจ็บกล้ามเนื้อหลังจากการออกกำลังกาย (10 คน) ผู้ที่กล้ามเนื้อและพังผืดอักเสบเรื้อรัง (10 คน) และผู้ที่ไม่มีอาการ (10 คน) ระยะการเคลื่อนที่ของเนื้อเยื่อที่ทำให้เกิดความเจ็บใช้บอกระยะทางที่หัวเครื่องวัดความเจ็บปวดเคลื่อนลงไปบนผิวหนังขณะวัดแรงกดที่ทำให้เจ็บ โดยมีหน่วยเป็นมิลลิเมตร การออกกำลังกายออกนอกช่วงที่ไม่ถนัดใช้เพื่อทำให้เกิดการเจ็บกล้ามเนื้อหลังจากการออกกำลังกาย กลุ่มกล้ามเนื้อและพังผืดอักเสบเรื้อรังเป็นผู้เข้าร่วมวิจัยที่มี จุดกดเจ็บที่ทำให้เกิดอาการในกล้ามเนื้อ ในกลุ่มเจ็บกล้ามเนื้อหลังออกกำลังกายจะถูกประเมินระดับความเจ็บปวดขณะเคลื่อนไหวข้อศอก ในขณะที่กลุ่มกล้ามเนื้อและพังผืดอักเสบเรื้อรังจะวัดความเจ็บขณะพักทดสอบความสัมพันธ์ โดยใช้ค่าสัมประสิทธิ์สหสัมพันธ์แบบ Spearman ($p < 0.05$)

ผลการศึกษา: ผลการวิจัยแสดงความสัมพันธ์ระหว่างแรงกดที่ทำให้เจ็บกับระยะการเคลื่อนที่ของเนื้อเยื่อ ที่ทำให้เกิดความเจ็บในกล้ามเนื้อข้อศอกของกลุ่มที่ไม่มีอาการ ($r = 0.77, p = 0.001$) และกลุ่มที่เจ็บหลังการออกกำลังกาย ($r = 0.65, p = 0.04$) แต่ไม่พบความสัมพันธ์ในกล้ามเนื้อของกล้ามเนื้อที่ไม่มีอาการและกลุ่มกล้ามเนื้อและพังผืดอักเสบเรื้อรัง

สรุป: พบความสัมพันธ์ระหว่างแรงกดที่ทำให้เจ็บกับระยะการเคลื่อนที่ของเนื้อเยื่อที่ทำให้เกิดความเจ็บในกล้ามเนื้อ ข้อศอก ข้อเสนอแนะที่ได้จากผลการวิจัยนี้คือ ควรวัดทั้งแรงกดที่ทำให้เจ็บและระยะการเคลื่อนที่ของเนื้อเยื่อที่ทำให้เกิดความเจ็บในผู้ที่เจ็บหลังการออกกำลังกาย เพื่อระบุค่าความเจ็บปวดและความนิ่มของเนื้อเยื่อ