

The Evaluation of Electrodermal Properties in the Identification of Myofascial Trigger Points

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Objectives: To determine whether skin resistance measurements can objectively identify the location of myofascial trigger points (MTPs) and to differentiate between 3 states.

Design: Static group comparison.

Setting: Climate-controlled laboratory.

Participants: Forty-nine participants (age, 20.5 ± 2.6 y) were assigned to 1 of 3 groups based on clinical examination result: absent ($n=21$), latent ($n=16$), or active ($n=12$) MTP.

Interventions: Not applicable.

Main Outcome Measure: Skin resistance (in kilo-ohms).

Results: The 16 data points were divided into 3 categories for analysis: MTP site, surrounding tissue proximal to the MTP (first ring), and area furthest from the MTP (second ring). There was a significant increase in skin resistance between the MTP ($403.64 \pm 124.73 \text{ k}\Omega$), first ring ($419.66 \pm 123.04 \text{ k}\Omega$), and second ring ($454.61 \pm 163.19 \text{ k}\Omega$) ($P < .01$). The measurements did not differ significantly between the 3 MTP states.

Conclusions: The changes in skin resistance between the MTP and the surrounding tissue support the inclusion of this technique to help identify MTPs. The similarity between MTP states warrants investigation into the physiologic differences at specific anatomic locations.

Key Words: Electrodermal response; Myofascial pain syndromes; Rehabilitation.

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MYOFASCIAL PAIN IS AMONG the most common complaints encountered in clinical practice.^{1,2} The presence of myofascial trigger points (MTPs) is strongly associated with myofascial pain. However, the evaluation of MTPs does not include quantitative measurements, and the condition can be frequently misdiagnosed.^{3,4} Although there is literature examining the reliability of clinical examinations,^{5,6} there is little research describing objective and reliable methods for determining the presence of an MTP. If it could be shown that the skin resistance at the site of MTPs is different from that at adjacent tissue, a clinician

could quantitatively identify MTPs and therefore assess myofascial pain.

Myofascial pain is induced by a sudden and excessive burden on the muscle, sustained muscular contraction in a shortened position, or repeated muscular activity.⁷ When pain is present, specific MTPs can be located in 1 or more of the involved muscles. These points are defined as small (diameter, 3–4 mm), circumscribed, and highly localized hyperirritable regions within palpable taut bands of skeletal muscle.^{8,9} Several clinical characteristics are common to all MTPs. Compression of the MTP can elicit local and/or referred pain, and rapid compression of the muscle fibers may cause a local twitch response. Local twitch responses are identified by a quick contraction of muscle fibers surrounding the MTP. Along with musculoskeletal changes, a localized autonomic dermal reaction occurs at the site of the MTP, including vasoconstriction, pilomotor response, and hypersecretion.^{6,9} These characteristics vary in intensity between patients and MTP sites.

MTPs are classified into latent and active states. An active MTP causes pain spontaneously or in response to movement, whereas compression is required to elicit pain or discomfort with a latent MTP.⁹ Latent MTPs are more common than active ones and often cause tenderness and motor dysfunction.¹⁰ During a clinical examination, compression of MTPs in each state will elicit pain. However, the compression of an active MTP will produce pain that is similar to the patient's original complaint.⁷ Recent research has shown that clinical differences between these 2 states may be secondary to biochemical changes within the MTP.¹¹ Shah et al¹¹ showed an increase in proinflammatory neuropeptides (ie, substance P, bradykinin, norepinephrine) and cytokines (ie, calcitonin gene-related peptide, tumor necrosis factor- α , interleukin- 1β) between active and latent MTPs. Pain pressure thresholds (PPTs) and pH levels were also lower in active MTPs.¹¹

Although clinical examinations and full patient history remain a standard for evaluating MTPs, the reliability of these examinations are questionable. Hsieh et al⁶ presented poor interexaminer reliability for taut band palpation. The use of both trained and experienced examiners increases the reliability, but many clinicians who assess MTPs are not adequately qualified. Gerwin et al⁵ had 4 experienced physicians complete a 3-hour training session. The most reliable signs among these 4 examiners were spot tenderness, pain recognition, and the presence of a taut band. These clinical findings were considered the minimum criteria for identifying trigger points. Several pressure algometers have been tested for a greater objectivity during palpation of MTPs. However, the intraexaminer reliability was low because of inconsistencies in maintaining a constant pressure.^{3,4} A microanalytic technique was recently presented as a valid invasive method for differentiating between states of MTPs by comparing the biochemical characteristics of each region.¹¹ Biochemical changes to an area, like those found by Shah,¹¹ may have a direct relationship with bioelectric mea-

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surements (eg, skin resistance), presenting a noninvasive and objective diagnostic option.

Skin conduction and its reciprocal, skin resistance, are terms used to identify the skin's ability to transmit or resist electric current.¹² Pain is a primary factor influencing the skin's capacity for electricity and specifically decreasing skin resistance.^{13,14} The biochemical changes seen in active MTPs¹¹ are a result of painful stimuli increasing the rate of blood flow and sweat secretion from sweat glands and ducts.¹⁵ The increased sweat content can account for variations in skin resistance.¹² Several studies¹⁶⁻¹⁸ have documented the accuracy of skin conductance measurements as a method for identifying acupuncture points. Our study used the reported relationship between MTPs and either traditional¹⁹ or tertiary²⁰ class acupuncture points as a foundation for objectively measuring skin resistance at MTP sites. The purpose of our study was to determine the effectiveness of skin resistance in identifying the location of the MTP when compared with the surrounding tissue. Skin resistance was also used to determine potential differences between 3 states of MTPs.

METHODS

Participants

Forty-nine volunteers, between 18 and 30 years of age (mean age, 20.5±2.6y), participated in this study. All participants completed a health history questionnaire to determine any upper-extremity pathology, past or current medical conditions, and current medications. Before participation volunteers read and signed an informed consent form that was approved by Temple University's institutional review board, and Health Insurance Portability and Accountability Act guidelines for patient privacy were adhered to throughout the study.

Subjects were excluded from the study based on several factors collected from the health history questionnaire: (1) current use of anabolic substances, stimulants, depressants, muscle relaxants, pain medications, and anti-inflammatory medication; (2) surgery or posttraumatic incidence of the upper extremity within the past 12 months; and (3) serious medical conditions such as cancer, heart abnormalities, cardiovascular disease (including heart disease, blood pressure abnormalities, anemia, bleeding disorder, stroke), definable neurologic abnormalities (including fibromyalgia, epilepsy, headaches, head injury), lung disease, liver disease, kidney disease, oral and/or dental health problems, serious psychosocial disorder, or cognitive impairment.

The participants were classified according to the clinical questionnaire and physical examination. Twenty-one participants (6 men, 15 women; age, 19.5±1.2y; height, 171.45±8.43cm; weight, 72.57±10.56kg) had no signs or symptoms of an MTP within the palpated area of the trapezius and were assigned to the absent MTP group. Twenty-eight volunteers presented with an MTP and were allocated to the experimental group. Within the experimental group, each participant was substratified as having a latent (6 men, 10 women; age, 21.6±2.6y; height, 170.10±8.84cm; weight, 73.09±12.01kg) or active (2 men, 10 women; age, 21.0±3.6y; height, 169.97±9.96cm; weight, 65.99±1.78kg) MTP based on the pain elicited by compression to the site.¹⁴ Participants followed the same protocols in all examination methods.

Clinical Assessment

Within the health history questionnaire, every patient identified the most painful area on a body diagram. A

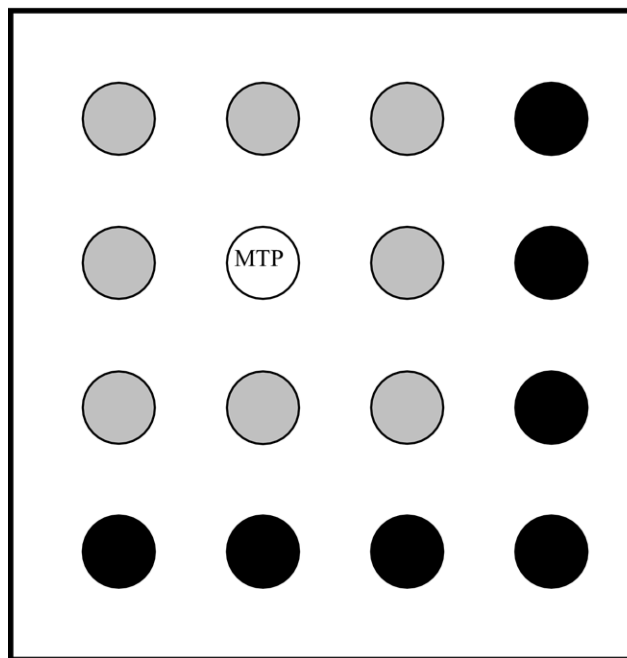


Fig 1. Sixteen-well grid. Legend: black circle, second ring; gray circle, first ring; white circle, MTP site.

physical examination was completed to find the exact location of the MTP. Although the concerns about reliability for a clinical examination were considered, it is the most clinically relevant comparison model. The minimum criteria for this protocol included location of a taut band within the trapezius and palpation to reproduce the most pain (latent MTP) or the most referred pain, similar to the chief complaint (active MTP). These points were subsequently marked with a permanent marker. All clinical examinations were completed by the same examiner with clinical experience in MTPs among patient populations. For the asymptomatic participants, a location was marked on the trapezius that corresponded with a common region for MTPs.²¹ All of the points denoted by the permanent marker underwent a PPT examination. Participants were placed in a prone position. The punctate tenderness gauge^a was applied directly to marked points, perpendicular to the skin, and the level of discomfort was recorded in ounces and converted into newtons. Three trials were completed and then averaged.

During the trials for PPT, a subjective pain report was used to express the amount of pain experienced with compression. Pain was assessed on a numeric scale of 0 to 10. Participants were asked to verbalize the level of pain within the range of 0 (no pain) and 10 (the most pain ever experienced).

Electrodermal Measurements

Participants were placed in a prone position on a massage table so that the cervical spine remained aligned. An 11×12.5-cm grid was constructed out of cardstock and used to identify 16 points on each patient. The holes denoting each location were 6mm in diameter with 2cm between the center of each circle (fig 1). The grid was taped to the patient with the marked MTP visible in 1 space. To avoid skin trauma and minimize differences to the local electrical environment, there was no preparation to the skin before grid

placement. A hypoallergenic and nonsensitizing ultrasound gel was used as a conducting material.^b The gel filled each hole and was not replaced between trials. The gel was isolated to each space to ensure there was no transfer of signals between sites.

A Keithley electrometer 610B^c with a low-noise coaxial lead and a Neuroline Ag/AgCl self-adhesive, disposable ground electrode^d was used to measure skin resistance at the site of an MTP and the surrounding area. The 610B electrometer uses a direct current and produces a meter noise of $\pm 10\mu\text{V}$. It has an accuracy of $\pm 1\%$ of full scale on all ranges exclusive of noise and drift. The input impedance is greater than $10^{14}\Omega$ shunted by 22 pF.

The 20×15-mm ground electrode was attached to the acromion, and the active lead was the unterminated end of the low noise coaxial cable. The active lead was placed in contact with the space containing the MTP and the surrounding 15 wells. The lead was held perpendicular and in full contact with the skin until the output stabilized and a measurement was made. The skin resistance (in kilo-ohms) was recorded 3 times at each space on the grid and averaged. The disposable ground electrode was replaced between participants; the active lead was removed of excess ultrasound gel, cleaned, and sterilized with alcohol and was used for all trials. The electrometer was zeroed before each trial. Input parameters were turned off, and the electrometer was corrected for internal noise to recalibrate between participants. This protocol resulted in high intraexaminer reliability (intra-class correlation coefficient model 3,1=.95). All tests were completed in a climate-controlled room to regulate external stimuli (eg, room humidity, ambient temperature).

Data Analysis

For this study's purpose the 16-well grid was divided into 3 categories of data: MTP, the first ring of points around the MTP, and the furthest (second) ring of measurements. The measurements used for each of the categories were means of the averaged 3 trials at each of the 16 spaces. A 3 (group) by 3 (location) analysis of variance (ANOVA) with repeated measures on location was performed for the skin resistance measurements. Post hoc analysis was performed using paired-sample *t* tests with Bonferroni adjustments. Effect size was reported as partial η^2 . A Pearson correlation analysis was used to compare skin resistance with the clinical examination results (PPT and subjective pain report) at the MTP sites. All levels of probability were set at a significance level of .05. All statistical analysis was performed using SPSS.^e

RESULTS

Figure 2 shows the means for each space on the 16-well grid for all 3 states of MTP. The results of the ANOVA test with repeated measures showed statistical significance for resistance between locations ($F_{2,48}=9.28$, $P<.01$; effect size, .17; power, .87). There was a significant difference in resistance between the active point and both the first and second rings ($t_{48}=-3.75$, $P<.001$) for all 3 groups combined (table 1). The second ring had significant increases in the skin resistance compared with the first ring ($t_{48}=-2.7$, $P=.01$). No significant group differences were detected ($F_{2,48}=.10$, $P=.90$; effect size, .005; observed power, .07).

The Pearson correlation was used to compare all dependent variables within this study. Significant correlations were found between the subjective pain report (pain) and the PPT ($r=-.38$, $P<.01$).

390.08	398.41	415.63	680.63
<i>421.67</i>	<i>428.02</i>	<i>440.94</i>	<i>457.67</i>
408.89	416.94	426.25	416.06
389.84	392.06	421.03	425.79
<i>431.04</i>	<i>410.10</i>	<i>443.96</i>	<i>459.89</i>
417.08	415.28	432.92	436.52
390.00	406.59	424.05	426.59
<i>439.79</i>	<i>443.75</i>	<i>441.88</i>	<i>462.00</i>
419.03	426.67	444.03	460.30
396.98	402.38	419.84	419.44
<i>429.51</i>	<i>535.00</i>	<i>437.35</i>	<i>458.33</i>
440.77	445.00	451.67	469.86

Fig 2. Mean electric skin resistance (in kilo-ohms) measurements of all trials at each space in the 16-well grid for 3 states of MTP. Legend: boldface, active MTP; gray square, space containing site of MTP; italics, latent MTP; roman type, tissue absent of MTP.

DISCUSSION

The purpose of this study was to determine whether skin resistance could be used as a means of isolating MTPs from surrounding tissue and determining latent versus active MTP states. Our findings suggest that the presence of an MTP causes a localized decrease in skin resistance regardless of latent or active states. This supports the hypothesis that bioelectric changes are caused by an MTP in highly localized hyperirritable regions.^{8,9}

Regardless of MTP state, skin resistance measurements showed what may be considered a gradient where there was significantly less resistance at the MTPs than the surrounding area. The skin resistance significantly increased with distance from the MTP. Our data appear to agree with the integrated hypothesis theory suggesting that underlying sarcomeres are shortened at the MTP site, causing a localized hypoxic region.¹⁰ The hypoxic state would increase nociceptors and other sensitizing substances in the area, as reported by Shah et al.¹¹ These biochemical changes induce greater blood flow and secretion from sweat glands via stimulation of the autonomic nervous system. These physiologic differences may account for acute variations in electrodermal measurements at the pathologic site, as found in this study.

Studies completed by Reichmanis et al^{16,17} show a change in skin conduction measurements at the documented acupuncture points, regardless of the presence of clinical symptoms associated with each point. Comparatively, our study showed a change in skin resistance at the MTP, regardless of the ability to reproduce pain with palpation to the area. MTPs develop in common anatomic locations, to the extent that MTP mapping has been documented.²¹ Although normal tissue does not contain MTPs, false-negative results during the clinical examination can occur. One study surveying 200 asymptomatic 17- to 35-year-olds found that approximately 50% of the participants had asymptomatic latent trigger points in the shoulder girdle.²² With minimal discomfort during activities of daily living, an asymptomatic MTP could present as normal tissue. Because the absent

Table 1: Electric Skin Resistance Measurements for Normal Tissue, Active MTPs, and Latent MTPs

Group	MTP (k Ω)	First Ring (k Ω)	Second Ring (k Ω)
Normal tissue (n=21)	392.06 \pm 107.15	404.45 \pm 103.58	453.10 \pm 173.37
Latent MTP (n=16)	410.10 \pm 144.42	436.38 \pm 145.69	463.02 \pm 172.38
Active MTP (n=12)	415.28 \pm 134.56	423.98 \pm 129.40	446.03 \pm 129.40
Total (N=49)	403.64 \pm 124.73*	419.66 \pm 123.04*	454.61 \pm 163.19*

NOTE. Values are mean \pm standard deviation.

* $P < .01$.

MTP group in this study was tested according to the mapping provided by Travell and Rinzler,²¹ false-negative results would make the differences between the skin resistances of the absent MTP and experimental groups negligible.

Shah et al¹¹ were able to differentiate between MTP types biochemically, with differences seen between all groups immediately after a local twitch response. In contrast, we were unable to determine significant variations in skin resistance measurements between tissue groups. The methodology used by Shah¹¹ differed from that of the current study. Specifically, the local twitch response was elicited in the middle of collecting interstitial fluid,¹¹ whereas our electric skin measurements were collected in the absence of a local twitch response. The disturbance to the tissue could increase the autonomic response to a level that differentiates all 3 states of MTPs. Regardless of the local twitch response, the biochemical milieu showed activity by the autonomic nervous system. The presence of the neuropeptides and cytokines at the site of an MTP would cause changes to vasodilation and sweat secretion to the localized area. This correlates with our data that there was a change in the electrodermal response of an absent MTP and the surrounding tissue.

One of the most common traits of MTPs is reproducible pain with palpation. It has high intraexaminer reliability and is considered necessary to identify MTPs.⁵ A correlational analysis was completed for comparisons of clinical characteristics. The subjective pain report showed a negative correlation to the PPT evaluation, suggesting that more painful areas could withstand less applied pressure. This is comparative to a study by Hong et al,²³ who showed significant correlation between pain intensities and the incidence of reproducible pain or a local twitch response.

CONCLUSIONS

The clinical significance of this study is supported by the changes in skin resistance at the location of the MTP and surrounding tissue. Skin resistance was shown to be an optional method for objectively identifying the location of MTPs compared with the surrounding tissue. The findings support claims made by commercial products, such as the Neuroprobe,^f that MTPs can be located using electrodermal tools. This study examined electric skin resistance for MTPs in a superficial muscle. Further research should include the capacity of electric skin measurements to identify MTPs in a deep muscle group. The fact that certain anatomic locations create physiologic signs identifying MTPs but do not always exhibit clinical symptoms is significant enough to warrant more investigation. Future research should include the comparison of the biochemical changes found by Shah¹¹ and the electrodermal properties at the site of MTPs for further understanding of the physiologic changes to the area.

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