ORIGINAL ARTICLE

Effects of Needle Electrical Intramuscular Stimulation on Shoulder and Cervical Myofascial Pain Syndrome and Microcirculation

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Background: To evaluate the effects of needle electrical intramuscular stimulation (NEIMS) on myofascial trigger points (MTrPs) and their epidermal blood flow.

Methods: Forty adult patients with active MTrPs in the upper trapezius or levator scapulae underwent 4 weekly NEIMS sessions. Visual analog scale (VAS) and pain pressure threshold (PPT), along with cervical and shoulder range of motion (ROM) were used as outcome measures. Microcirculatory changes were also evaluated by laser Doppler flowmetry of the epidermal area above these MTrPs. Data were collected before and after each treatment. Paired *t* tests were used to compare pre- and post-treatment data. Outcomes were presented as box plots displaying medians and 25th to 75th percentile values.

Results: VAS and PPT pain significantly improved immediately after each treatment; effects persisted till the end of the experiment. NEIMS treatment also had immediate and mid-term positive effects on cervical and shoulder ROM. There was an overall negative correlation between epidermal blood flow and VAS score before the first treatment. Regional blood flow significantly increased immediately but temporarily after each treatment.

Conclusion: NEIMS did have positive effects on myofascial pain syndrome, but the data did not indicate that increased regional microcirculation was the possible therapeutic mechanism. [*J Chin Med Assoc* 2008;71(4):200–206]

Key Words: laser Doppler flowmetry, myofascial pain syndrome, myofascial trigger point, needle electrical intramuscular stimulation

Introduction

Myofascial pain syndrome (MPS) is an important cause of muscular disability in the shoulder girdle, neck and lumbar regions. One of the most common disorders encountered by physiatrists, it is associated with muscle tenderness, typical referred pain, reduced muscle extensibility, restricted range of motion (ROM) and muscle imbalance.[1–3] It is initiated through myofascial trigger points (MTrPs) that are defined as hyperirritable spots within taut bands of skeletal muscle fiber.[1] Two basic diagnostic features of MTrPs are local tenderness and altered consistency.[4–7] In addition, this regional pain syndrome presents with muscle spasm, band-type tissue stiffness, limited articular motion, loss of strength and autonomic dysfunction.

Many treatment approaches, such as trigger point injections, stretching exercises, acupuncture, and other physical therapies have been developed to relieve the pain of MTrPs and prevent it from becoming chronic.[1–3,7–10] Needle electrical intramuscular stimulation (NEIMS), by application of an electric current through a monopolar needle to the MTrP, is considered a promising therapy that may have immediate to mid-term therapeutic effects.[11,12] NEIMS was originally performed through an electromyographic instrument. However, the bulk, expense and complications involved made it impractical for outpatient use. This study employed a recently designed portable electrical stimulator that conforms to NEIMS parameters and is inexpensive and user-friendly (NEIM-STIM SD-922P; Skylark Device & Systems Co., Taipei, Taiwan)

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(Figure 1). This study evaluated this apparatus through subjective and objective measures of pain severity and ROM. The therapeutic effects of NEIMS on MPS have not been well documented. There are several reports indicating that it disturbs the microcirculation in the relevant muscles of myalgia patients; this might be due to the electrically-induced muscle contractions which would improve epidermal and muscle circulation.[12–21] Thus, we hypothesized that NEIMS may exert its therapeutic effects through changes in regional microcirculation. We also investigated its immediate effects on regional muscle microcirculation.

Figure 1. The needle electrical intramuscular stimulation equipment used in this study (NEIM-STIM SD-922P; Skylark Device & Systems Co., Taipei, Taiwan).

Methods

This study was approved by the Taipei Veterans General Hospital ethics committee. Between January and December 2006, all patients who visited or who were referred to department of physical medicine and rehabilitation outpatient clinics were asked to participate if they were over 18, had active MTrPs in the unilateral upper trapezius or levator scapulae region, and had reliable symptoms caused by MTrP palpation of more than 6 months' duration. Subjects also had to accept NEIMS as their sole treatment during the experimental period. Patients were excluded if they showed signs of cervical disc prolapse or radiculopathy, had symptoms explained by other systemic disorders or migraines, had undergone cervical spinal surgery, abused alcohol or drugs, had previous adverse responses to acupuncture, had changes in medication or other treatments within 3 weeks of entry or who were pregnant.

Subjects were invited to participate after clinical examination by a physician involved in the study. The study had an open-label, before-and-after treatment design. NEIMS was always done by the same study physician, while outcome data were measured and analyzed by another trained scholar blind to treatment status. The treatment period was 4 weeks, with 1 session per week. Outcome data were recorded before and after each session.

Treatment

NEIMS was performed with a needle electrical intramuscular stimulator (NEIM-STIM SD-922P; Skylark Device & Systems Co.) (Figure 1), a static monopolar needle stimulator to an MTrP. The investigator identified the most tender MTrP and disinfected the overlying skin with alcohol. A monopolar needle (902-DMG 37-TP/53537T; Oxford Instruments Medical, England) (the cathode) was inserted into the selected MTrP, while a round pad (1 cm in diameter) was placed in the 7th cervical spinous process (the anode). The stimulation duration was set at 1 ms, with a frequency of 2 Hz and an intensity that kept the muscular contraction visible (0–20 mA). Total application durations were 3 minutes for each MTrP.

Outcome measures

Subjective pain level was determined by a visual analog scale (VAS). The VAS was 10 cm long with no anchors between the ends, and measures ranged from 0 (no pain) to 10 (unbearable pain). The patient estimated pain by moving the pointer along the uncalibrated scale. The exact value of pain intensity could be obtained by referring the uncalibrated scale to the ruler on the back side.

This study employed pressure pain threshold (PPT) measurement. The *pressure pain threshold* is a concept that has been used to study muscular pain since the 1950s.[22] As the term suggests, the goal of the PPT is to identify the point at which pressure applied over a muscle becomes painful. The expectation is that when very light pressure is applied to a muscle, a patient will feel some pressure, but not pain. As the pressure is increased, a point is reached when the patient perceives the stimulation as painful.[22] First, the MTrP was identified and marked. A pressure threshold meter (Effegi, Alfonsine, Italy) was applied to the marked area and the pressure was gradually increased at an approximate rate of 1 kg/s. The pain threshold value was then recorded, with the same criteria applied for the next measurement. Three repetitive measurements (at 30-second intervals) were performed; the mean value of the 3 measurements was used for analysis.

ROM of the cervical spine was measured before and after treatment. This was defined as the amount of lateral flexion and rotation of the neck to both the right and left side, carried out by a goniometer. Shoulder ROM was defined as the amount of flexion, extension and abduction of the arm, also by a goniometer. Three repetitive measurements were performed continually, with their mean values used for analysis.

Regional blood flow in the marked MTrP area was measured by laser Doppler flowmetry (MSP310XP; Oxford Optronix, Oxford, UK) through a surface probe connected to a laser light source and detector unit. Output signals were continuously recorded for 15 minutes, before and after treatment, and stored for computer analysis.

Statistical analysis

With a sample size of 40 patients (SD, 3.0; type 1 and 2 errors of 5% and 10%), the smallest significant difference would be 1 VAS unit. Paired Student's t tests were used for pre- and post-treatment outcome comparisons. Spearman's product-moment rank correlation tests were used for the correlation between pre-treatment pain and tenderness and regional blood flow values. Statistical analysis was done using SPSS version 13.0 (SPSS Inc., Chicago, IL, USA) for Windows. Data were analyzed by personnel who did not participate in patient care or data collection. Two-tailed p values less than 0.05 were deemed significant.

Results

Forty patients successfully completed this study. Their median age was 45 (interquartile range [IQR], 33–51), and they were predominantly female (35/40, 87.5%). Baseline and final results are presented in Table 1. They showed a significant decrease in MTrP tenderness and increase in ROM by the end of the study. Both subjective and objective pain measures showed significant improvement ($p < 0.001$). Regional blood flow increased significantly ($p < 0.001$) along with all directions of cervical and shoulder ROM ($p < 0.05$).

Trends for each outcome parameter, before and after each treatment session, are presented with clustered box plots (median with 25th and 75th percentiles) (Figures 2–5). Subjective pain not only decreased with time, but also decreased weekly (Figure 2). PPT showed gradual weekly increases for both pre- and post-treatment values (Figure 3).

To determine the effects of NEIMS on cervical and shoulder joint ROM, cervical lateral flexion, rotation and shoulder flexion, extension and adduction were measured before and after treatment. All ROM measures had good immediate responses to treatment, but these responses declined with time. Because shoulder flexion is most important in daily life, this variable was used to represent the others (Figure 4). Treatment effects were most prominent at the initial session, where shoulder flexion had immediate, dramatic improvement. This initial effect decreased at each subsequent session. However, pre-treatment values still showed a trend toward functional improvement. Other ROM measures were similar.

Regional blood flow increased significantly after each session. However, this effect was transient and did not persist to the next session (Figure 5). Distribution of VAS gain before and after the 4 treatment sessions is shown in Figure 6. Median VAS gain was –2 (IQR, –1 to –4), with most patients (13/40, 32.5%) having a VAS gain of –4 to –5. One patient even had

Table 1. Pre- and post-treatment protocol values*

	Pre-treatment (1st visit)	Post-treatment (4th visit)	$p^{\dagger}$
Visual analog scale	5.3 ± 1.95	3.05 ± 1.87	< 0.001
Pressure pain threshold (kg)	2.25 ± 0.70	4.13 ± 0.93	< 0.001
Superficial skin blood flow (BPU)	127.3 ± 114.35	310.22 ± 234.62	< 0.001
Range of motion (degrees)			
Neck lateral flexion to left	30.80 ± 7.88	35.12 ± 6.82	0.014
Neck lateral flexion to right	29.85 ± 7.54	34.15 ± 6.81	0.003
Neck rotation to left	64.60 ± 11.12	68.33 ± 13.84	0.039
Neck rotation to right	63.22 ± 11.74	68.37 ± 11.74	0.017
Shoulder flexion	149.9 ± 9.29	156.07 ± 11.12	0.014
Shoulder extension	44.30 ± 8.66	49.60 ± 8.64	0.004
Shoulder abduction	166.17 ± 7.77	169.63 ± 7.92	0.002

Data are presented as mean ± standard deviation; †paired t test (n = 40). BPU = blood per unit.

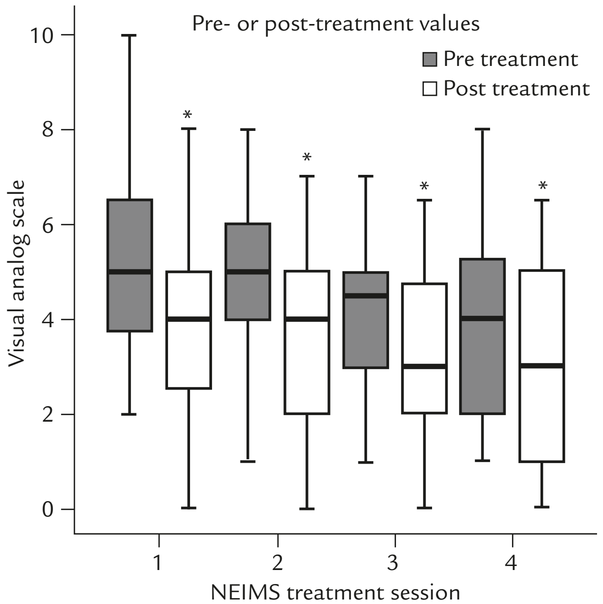

Figure 2. Effect of repeated NEIMS treatment on visual analog scale. *Significantly different from pre-treatment at $p < 0.001$ ($n = 40$).

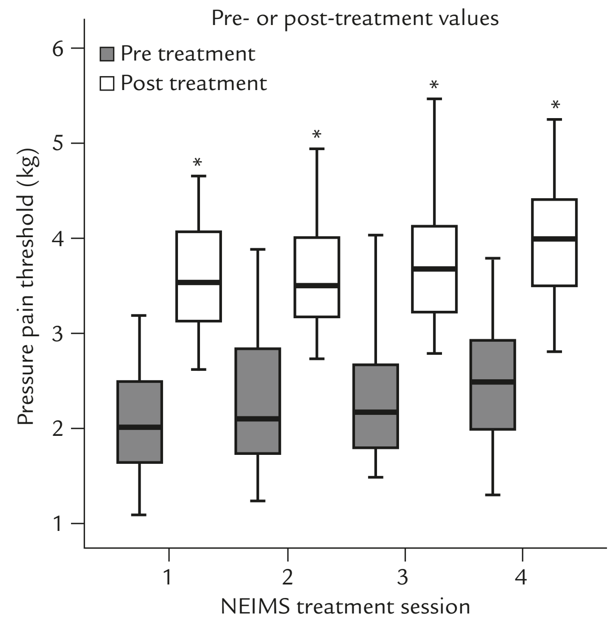

Figure 3. Effect of repeated NEIMS treatment on pressure pain threshold. *Significantly different from pre-treatment at $p < 0.001$ ($n = 40$).

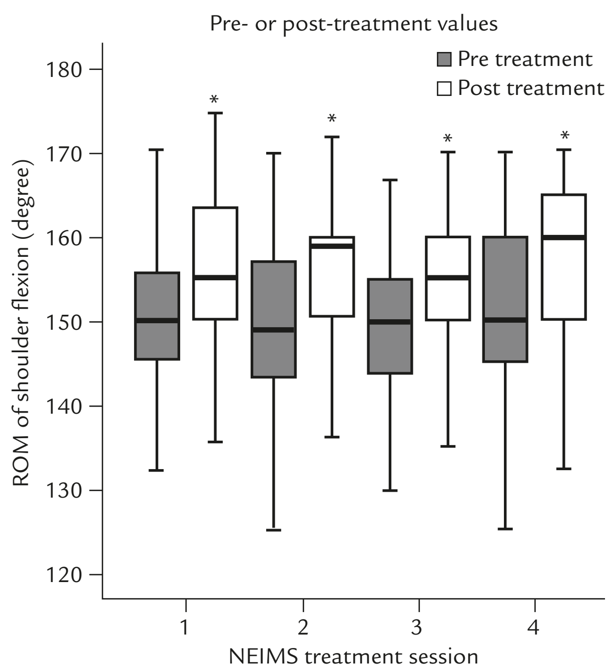

Figure 4. Effect of repeated NEIMS treatment on shoulder flexion range of motion (ROM). *Significantly different from pre-treatment at $p < 0.001$ ($n = 40$).

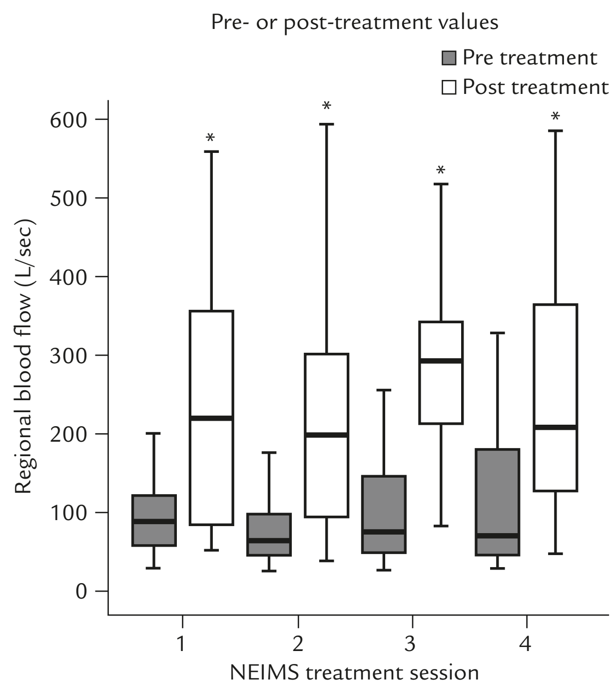

Figure 5. Effect of repeated NEIMS treatment on superficial skin blood flow above trigger points. *Significantly different from pre-treatment at $p < 0.001$ ($n = 40$).

a VAS gain of –8. The relationships between subjective and objective pain intensity and baseline regional blood flow are shown in Figure 7. Although not statistically significant, there was a negative correlation trend between blood flow and baseline VAS score ($\gamma s = -0.15$; $p = 0.31$) (Figure 7A). Similarly, there was a less-than-significant positive correlation between blood flow and pre-treatment PPT ($\gamma s = 0.18$; $p = 0.24$) (Figure 7B). These results suggest that intense pain might be associated with weak microcirculation.

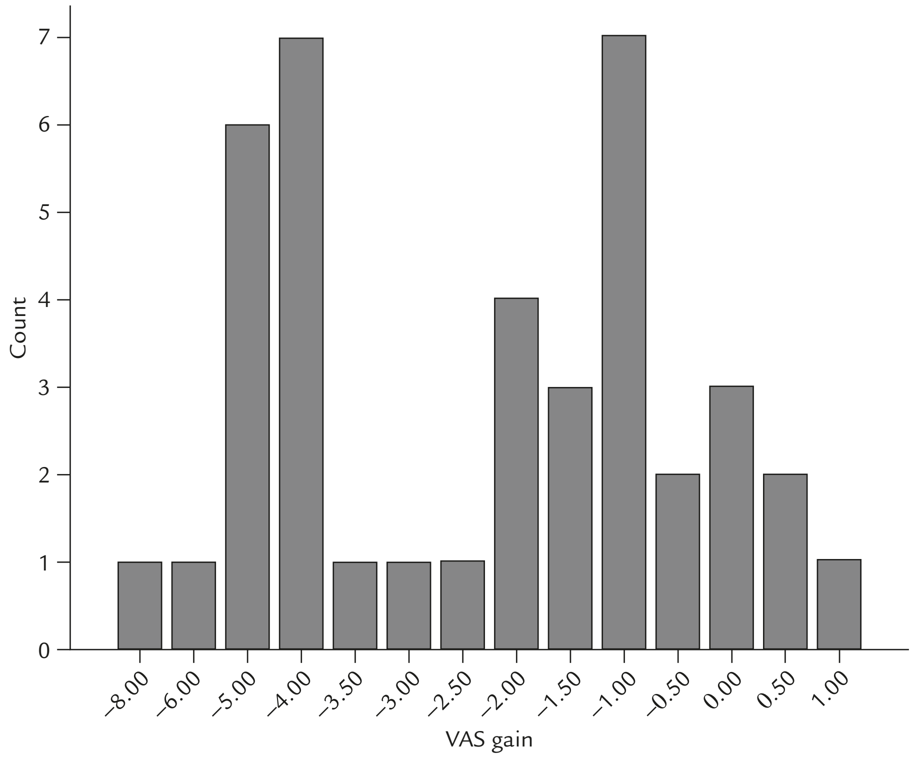

Figure 6. Distribution of visual analog scale (VAS) gain before and after the experiment ($n = 40$).

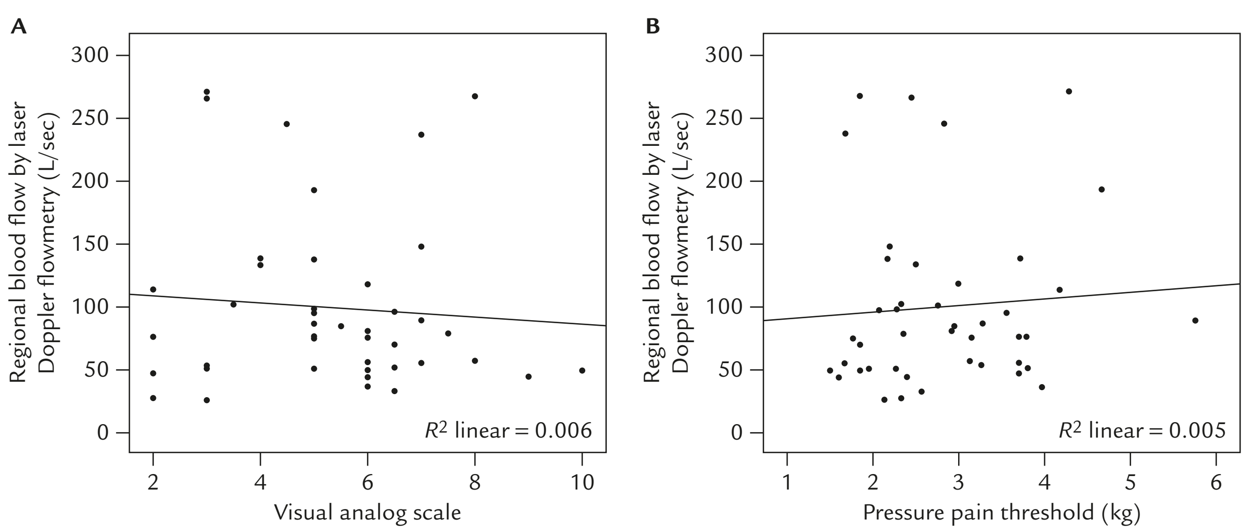

Figure 7. (A) Correlation between visual analog scale and regional blood flow before the first treatment. Spearman's product-moment rank correlation test: $\gamma s = -0.15$, $p = 0.31$, $n = 40$. (B) Correlation between pressure pain threshold and regional blood flow before the first treatment. Spearman's product-moment rank correlation test: $\gamma s = 0.18$, $p = 0.24$, $n = 40$.

Discussion

MPS is the most common cause of painful muscular dysfunction in outpatient clinics. It is characterized by muscles in a shortened or contracted state with increased tone and stiffness. Current treatments are far from optimal. NEIMS, a recently developed treatment that applies needle electrical simulation to an MTrP, showed promising preliminary results.[11,12] This study indicated that NEIMS has immediate and mid-term efficacy in pain reduction for MTrPs. This was demonstrated objectively through increases in cervical and shoulder ROM and subjectively through significant decreases in VAS. After treatment, there was sustained improvement in VAS, PPT and ROM, indicating that the therapeutic effects of NEIMS could last for 1 week. However, the data also indicated that regional blood flow changes were transient. Despite the strong immediate increases after NEIMS treatment, microcirculatory flow above the MTrPs decreased to baseline. Also, this study did not address intramuscular blood flow. Further investigation by needle probe of laser Doppler flowmetry is needed in the future.

Our study confirmed the previous observations that intense pain tended to correlate with low baseline blood flow, suggesting that reduced microcirculation plays a role in the pathophysiology of MPS.[14–21] Such observation could be explained by Simons et al's energy crisis concept.[1] The concept postulates that trauma or a marked increase in the endplate release of acetylcholine can result in excessive release of calcium from the sarcoplasmic reticulum. This calcium produces maximal contracture of a segment of muscle. The sustained contractile activity would markedly increase metabolic demands and would choke off local circulation. Severe local hypoxia and tissue energy crisis could sensitize local nociceptors. We also observed that there were significant increases in epidermal blood flow immediately after each treatment, which probably stemmed from muscle contraction. Muscle contractions can increase muscular blood flow and perfusion.[23] However, this study showed no persistent increase in regional blood flow. Pre-treatment values at each session were not significantly different from baseline values. This phenomenon has been observed for a similar electrical therapeutic technique, transcutaneous electrical nerve stimulation (TENS). When TENS intensity is sufficient to cause moderate muscle contraction, it causes a transient local increase in blood flow.[24–26] Because the analgesic effects of NEIMS last longer than the microcirculatory effects, the therapeutic effects can only be partly explained by the increase in transient regional blood flow.

Another possible mechanism of NEIMS may be *hyperstimulation analgesia*, the purported blockage of superficial pain by intense stimulation or counterirritation.[26] This intense stimulation can be in the form of dry needling or acupuncture, and therefore could also be present in NEIMS. In this study, our patients did not complain of pain and only felt rhythmic muscle contraction and relaxation sensation during each treatment session. Therefore, the hyperstimulation analgesia mechanism, if present, might only play a minor role. The gate control theory proposed by Melzack and Wall may provide another perspective.[26,27] The theory suggests that in each dorsal horn of the spinal cord, there is a gate-like mechanism, with activity in the large-diameter fibers (A-beta) tending to close the gate and possibly blocking ascendance of nociceptive phenomena, while activity in the small diameter fibers (A-delta and C) tends to open it. In this study, if our patients had felt a tingling sensation but no pain, then gate control may be a possible mechanism. However, our patients did not experience any tingling.

Mechanisms such as intramuscular conditioning and strengthening, desensitization of nociception, removal of nociceptors and desensitization and relaxation of MTrPs also need to be further investigated to explain the therapeutic effect of NEIMS. Additionally, dry needling of the MTrP has been reported to be an effective mode of treatment for MPS.[7] The effect of dry needling has been associated with the elicited local twitch responses which were suggested to closely relate to the activity (or pain intensity) of an MTrP.[27] The procedure of NEIMS invariably replicates a dry needling process; therefore, the effects of NEIMS on local twitch response and its association with MTrP should also be explored as a possible mechanism for the therapeutic effects of NEIMS in the future.

This study had several limitations. The ethical issues surrounding the invasive nature of this treatment prevented the recruitment of healthy controls. The inherent bias of this condition could not be eliminated from the study. The limitations of laser Doppler flowmetry also warrant consideration. This technique is very sensitive to motion artifacts caused by tissue movements that are not caused by blood flow. We excluded some extreme values in an attempt to weed out these artifacts. Changes in blood flow over time might also be affected by probe placement precision. Finally, this study did not cover long-term effects. A quality-of-life survey would also be useful.

In conclusion, this study is in line with previous studies that showed NEIMS to be a promising treatment with immediate and mid-term therapeutic effects on pain and ROM in MPS. However, its positive effect on regional blood flow was only transient; results did not indicate increased regional microcirculation to be the positive mid-term effect mechanism. The significance of correlation between blood flow and therapeutic efficacy warrants further study.

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