Re: Electrical Twitch-Obtaining Intramuscular Stimulation in Lower Back Pain: A Pilot Study

Article *in* American Journal of Physical Medicine & Rehabilitation · December 2006

DOI: 10.1097/01.phm.0000247779.94661.2c

1 author:

Jennifer Chu
University of Pennsylvania
45 PUBLICATIONS **640** CITATIONS

SEE PROFILE

Authors:

Jennifer Chu, MD
Ka-fai Yuen, MD
Bo-han Wang, MD
Rai-Chi Chan, MD
Ira Schwartz, MD, PhD
Duncan Neuhauser, PhD

Affiliations:

From the Department of Rehabilitation Medicine (JC) and the Department of Surgery, Division of Urology (IS), Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania; the Department of Rehabilitation Medicine, Veteran's General Hospital, Tapiei, Taiwan, Republic of China (KY, BW, RCC); and the Department of Epidemiology and Biostatistics, School of Medicine, Case Western Reserve University, Cleveland, Ohio (DN).

Correspondence:

All correspondence and requests for reprints should be addressed to Jennifer Chu, MD, Department of Rehabilitation Medicine, Hospital of the University of Pennsylvania, 3400 Spruce Street, Ground White, Philadelphia, PA 19104-4283.

0894-9115/04/8302-0104/0
American Journal of Physical Medicine & Rehabilitation

DOI: 10.1097/01.PHM.0000107485.86594.8B

Research Article

Electrical Twitch-Obtaining Intramuscular Stimulation in Lower Back Pain

A Pilot Study

ABSTRACT

Chu J, Yuen K, Wang B, Chan RC, Schwartz I, Neuhauser D: Electrical twitch-obtaining intramuscular stimulation in lower back pain: A pilot study. *Am J Phys Med Rehabil* 2004;83:104–111.

Objectives: To determine if electrical twitch-obtaining intramuscular stimulation (ETOIMS) provides greater myofascial lower back pain relief than muscle stimulation or skin stimulation.

Design: In this single-blinded, crossover, pilot trial performed at a university-affiliated outpatient rehabilitation medicine department in Taiwan, 12 acupuncture-naive patients with lower back pain of 3–60 mos duration received one crossover treatment every 2 wks by monopolar needle electrode insertion at bilateral T10-S1 levels to: (1) paraspinal muscles, (2) overlying skin, and (3) paraspinal muscles with ETOIMS applied via the needle electrode at individual treatment sites. A total of 30 manual insertions per side per treatment were performed, with withdrawal after 2 secs. Beginning 1 wk before each trial and continuing until 2 wks after, patients completed a visual analog scale twice daily. In addition, on the day of treatment, patients received a physical examination and completed a visual analog scale both before and after treatment.

Results: Significant and immediate reduction in the visual analog scale levels was noted only with ETOIMS. Immediate improvement occurred in one of nine physical tests with muscle stimulation and ETOIMS only. In the 2 wks after treatment, absolute visual analog scale levels for ETOIMS were significantly lower than muscle stimulation and skin stimulation. ETOIMS resulted in a greater percentage of pain relief in the first week after treatment, although it was not statistically significant from muscle stimulation and skin stimulation.

Conclusions: ETOIMS provided significantly greater immediate and sustained myofascial lower back pain relief than muscle stimulation and skin stimulation. Although a greater percentage of pain reduction occurred with ETOIMS, it was not statistically significant.

Key Words: Skin Stimulation, Muscle Stimulation, Electrical Twitch-Obtaining Intramuscular Stimulation, Low Back Pain

Chronic low back pain is a prevalent condition, resulting in expenditure of at least $13 billion a year for medical care in the United States.[1–3] Many approaches are available for managing this condition, including physical therapy, oral or injected medications, interventional spinal methods, surgery, or alternative therapy. Although spinal interventional methods and surgery have limited management roles in chronic pain, chronic use of medications, such as narcotics, have many side-effects.

Acupuncture is a low-risk treatment commonly used in the management of musculoskeletal pain, although systematic review has not established its effectiveness.[4] The National Institutes of Health consensus report on acupuncture states that acupuncture may be useful in such pain.[5] Considering the prevalence and economic impact of chronic low back pain, acupuncture's minimal toxicity warrants attempts to increase its therapeutic efficacy. It is suggested that these attempts be based on better scientific understanding of acupuncture's local mechanism or mechanisms of action because the central analgesic actions of acupuncture seem to be nonspecific.[6] As acupuncture is characterized by needle penetration or movement, hence its name, its local analgesic effect should be secondary to those actions, regardless of whether that effect is one of placebo or not.

Traditional acupuncture uses fine acupuncture needles at acupuncture points on meridians to relieve pain. Acupuncture points, muscle trigger points, and motor end-plate zones (MEPZs) may be identical.[7,8] If so, relief of musculoskeletal pain by acupuncture would not be limited to classical acupuncture points on meridians.[7]

Gunn[9] uses intramuscular stimulation to relieve myofascial pain by dry-needling muscles, with acupuncture needles, at tender motor points. This departure from classical acupuncture, regardless of consideration as a modification or different modality than acupuncture, allows stimulation of deeper motor points by using a manual plunger for insertion, oscillation, and twirling of acupuncture needles. We have shown that musculoskeletal pain relief can be achieved by additional changes to classical acupuncture and intramuscular stimulation methods. A monopolar needle, stronger and firmer than an acupuncture needle, is used for insertion into deep motor points, eliminating the use of a plunger.[10–12]

The basis of pain relief after electromyography (EMG) is that intramuscular needle movements lead to insertional activity and microtwitches.[11] Occasionally, acupuncture needle penetration or manipulation in classical or electrical acupuncture, intramuscular stimulation, and trigger-point localization also evoke small local twitches. These observations suggest that needle insertion or manipulation induces local muscle twitches, which may mediate musculoskeletal pain relief.[9,13]

We propose that significantly greater pain relief will occur with electrical twitch-obtaining intramuscular stimulation (ETOIMS) than dry needling of the same muscle or overlying skin. If pain relief is twitch mediated, because ETOIMS applies electricity through a monopolar EMG needle electrode to deep MEPZs, potentially more MEPZs may be stimulated to twitch. The design of this pilot crossover study is to minimize bias in determining the local site of analgesic action between needle stimulation of skin, needle stimulation of muscle without electricity, and needle stimulation of muscle with electricity and to affirm that muscle stimulation is a prerequisite for pain relief.

MATERIALS AND METHODS

Overview

The design involved two experimental groups, the muscle stimulation (MS) group, in which a monopolar EMG needle electrode was inserted into multiple sites in paraspinal muscles, and the ETOIMS group, in which a monopolar EMG needle electrode was inserted into the same muscles as in the MS group, during a different phase of the crossover design, and through which an electric current was supplied at individual points. The control group received skin stimulation (SS), in which insertion of an identical monopolar EMG needle electrode was limited to the skin (i.e., no penetration into muscle and no electricity). The skin stimulated in this group was situated directly over the muscles into which the experimental groups had their needle electrodes inserted (i.e., this was where the needle electrodes penetrated during different phases of the crossover design).

A total of 12 adult patients (six men and six women) with chronic, stable, low back pain of 3–60 mos in duration (mean, 28.2 ± 19.1 mos) were admitted into the study. Patients' ranged in age from 33 to 77 yrs (mean, 53.4 ± 13.9 yrs). Subjects had diffuse lower back pain with paraspinal spasm. Trigger-point searches were not performed. There were no localizing neurologic signs in any patient (Table 1 shows the patient profile). Exclusion criteria included a history of pain extending below the buttock, drug or alcohol abuse, use of opioid-containing medication, change in character or severity of the pain within the previous 3 mos, presence of acute nerve root irritation (sciatica), previous spinal surgery, spinal nerve root or spinal cord compression, previous use of acupuncture, skin infections, open wounds, bleeding disorders (primary or drug induced), immune deficiency, valvular heart disease, pacemakers, pending medicolegal litigation, pending worker's compensation claim, inability to complete the visual analog scale (VAS), pregnancy (including if planned within the next 6

TABLE 1
Patient profile

Patient	Age	Sex	Pain Duration (mos)	MRI Diagnosis
1	47	F	36	L5–S1 spondylolytic spondylolisthesis
2	50	M	24	L3–L4 herniated nucleus pulposus
3	55	F	36	L4–L5 disc bulging with moderate extradural compression of right L5 root
4	41	F	60	L4–L5 disc bulging with mild spinal stenosis
5	33	M	12	L4–L5 herniated nucleus pulposus
6	77	F	60	L4–L5 spondylolisthesis with spinal stenosis
7	62	F	05	L4–L5 herniated nucleus pulposus with spinal stenosis
8	52	M	24	Lumbar spondylosis with scoliosis to left
9	37	M	32	L4–L5 herniated nucleus pulposus
10	62	F	03	Lumbar spondylosis
11	69	M	10	Lumbar spondylosis with spinal stenosis
12	68	M	36	Lumbar spondylosis

mos), or intent to move (i.e., potentially unavailable for follow-up). There was no discrimination regarding sex, race, or socioeconomic factors.

The institutional review board approved this controlled, single-blinded, crossover-design study. Before beginning the protocol, the patients recorded a VAS for pain twice a day for 1 wk. The order of treatment was unknown to the patients. Twelve patients received these modalities in the following sequence: MS, SS, and ETOIMS with a 2-wk washout period between the treatments. Two weeks of washout period is enough for patients with chronic pain because this is the clinical experience of the primary author.[5] The treatments were performed simultaneously without discussion of findings between personnel involved in the study.

The primary investigator trained two physiatrists within 1 day, one for performing the physical examination and the other for treatments. The trained physician, utilizing a similar technique, needled the low back for each group: MS, SS, or ETOIMS. A disposable 37-mm-long monopolar EMG needle was used for treatments. SS consisted of superficial needling of the skin, avoiding penetration of underlying fascia. MS resulted from inserting the entire length of the 37-mm-long monopolar needle, to the hub. The electrical source for ETOIMS was from the Keypoint EMG machine (Medtronic Dantec, Copenhagen, Denmark) using the following stimulus variables: pulse duration of 0.5 msecs, frequency of 2 Hz, and a current strength of 2 mA. In ETOIMS, after insertion of the 37-mm-long monopolar needle to individual points as in MS, a silent foot switch was pressed to stimulate these points. All patients completed the study, which lasted 6 wks.

General Research Procedure

A research assistant distributed and collected all study-related forms at the time of treatment, scheduled patient appointments, and followed through to obtain return of all study-related forms. The treating physician was not aware of the patients' pain levels throughout the study.

Patients received treatment in the following manner: the monopolar EMG needle electrode was inserted (along edges of intramuscular bands and muscular grooves from T10 to S1) and kept stationary for 2 secs, then withdrawn. All patients received identical numbers of needle penetrations for each of the three types of stimulation. Ten points were stimulated along the edges of intramuscular bands, along each of three vertical lines, separated by approximately 1 cm, starting lateral to the spinous process, for a total of 30 points on each side of the spine. The entire procedure lasted $<$20 mins. In the SS group, the needle was inserted into but not through the skin; in the MS and ETOIMS groups, the needle was inserted through the same skin area into underlying muscle to the same depth.

The crossover study occurred every 2 wks. Only the treating physician was aware of the sequence of the treatments, which were applied in the following order: (1) MS, (2) SS, and (3) ETOIMS. Patients were not asked questions concerning their symptoms by any of the personnel involved in the study. The patient, examining physician, research assistant, and the statistician remained blinded throughout the study.

Treatment Procedure

One Week Before Treatment. Each patient recorded a pain diary twice a

TABLE 2
Protocol sequence

(1) One wk before any treatment: 14 VAS pain measures
↓
(2) MS: pre- and posttreatment VAS and PE measures done on day of treatment
(3) One wk post-MS: 14 VAS pain measures
(4) Second wk post-MS (1 wk before SS): 14 VAS pain measures
↓
(5) SS: pre- and posttreatment VAS and PE measures done on day of treatment
(6) One wk post-SS: 14 VAS pain measures
(7) Second wk post-SS (1 wk before ETOIMS): 14 VAS pain measures
↓
(8) ETOIMS: pre- and posttreatment VAS and PE measures done on day of treatment
(9) One wk post-ETOIMS: 14 VAS pain measures
(10) Second wk post-ETOIMS: 14 VAS pain measures
↓
(11) End of trial

Summary

	MS (2)	SS (5)	ETOIMS (8)
Week before	(1)	(4)	(7)
Week after	(3)	(6)	(9)

$n = 12$ patients (14 VAS pain measures per patient in each measure above).

day for 7 days before the first treatment session. He or she marked the pain level on a standard 10-cm VAS from a score of 0, equaling no pain, to a score of 10, equaling the worst pain. The patients were instructed not to change the type of pain medications used during the course of the study. When treatments began, each patient was instructed to report any unusual reactions to the treatments on the comment section of the pain diary (Table 2).

Day of Treatment. The patient returned the previous week's pain diary on the day of treatment. The research assistant provided and collected from the patient a pretreatment pain level VAS sheet. The examining physiatrist performed the following examinations on the patient: spine flexion (distance in centimeters from the tip of the third digit to the floor on maximal forward flexion); flexion, abduction, external rotation, and extension testing (vertical distance in centimeters between the lateral end of the ipsilateral knee crease and the surface of the bed, with the ipsilateral heel on the contralateral knee cap); and a straight-leg raising test (in degrees) using a goniometer. None of the patients had straight-leg raising testing that caused radicular pain (Table 2).

With the patient standing and bearing weight on the test side, the following measurements were made: the ability to lift the heel off the floor by supporting weight on the forefoot (vertical distance in centimeters between the floor surface and plantar surface of the heel measured) and the ability to lift the toes off the floor by supporting weight on the heel (vertical distance in centimeters between the floor surface and the plantar surface of the metatarsophalangeal joint of the great toe measured). The patient was instructed to hold the examination table only for balance and to avoid using arm strength to perform these tests. Measurements included were those that can be easily performed, and the physiatrists involved in the experiment were already familiar with these techniques. Although their techniques were reassessed after training, formal repeatability tests were not done.

Immediately after treatment, the research assistant provided and collected from the patient the posttreatment pain level VAS sheet. The examining physiatrist who was blinded to the type of treatment the patient had received then performed the physical examination immediately after the treatment. Finally, the patient received a pain diary to be filled out twice daily for the next 2 wks and was instructed to return after 2 wks.

Data Analysis

The analysis of variance test was used with significance set at $P < 0.05$ for comparison of VAS levels, percentage of pain relief, and physical examination changes between groups immediately after treatment and for each of the 2 wks after treatments. The software used was by Statistica (Tulsa, Oklahoma).

RESULTS

Immediate, posttreatment, absolute VAS levels were reduced signifi-

TABLE 3
Day of treatment pain levels before and immediately after MS, SS, and ETOIMS

	MS	SS	ETOIMS
Before treatment	3.8 ± 1.8	4.0 ± 1.8	3.5 ± 1.4
Immediately after	3.9 ± 1.8	3.5 ± 2.3	2.3 ± 1.1[a]

[a] $p < 0.01$.

cantly only with ETOIMS ($P < 0.01$, Table 3). The percentage of immediate improvement in physical tests was significant in one out of nine tests after MS (improvement in heel lift, $P < 0.05$) and ETOIMS (improvement in flexion, abduction, external rotation, and extension test, $P < 0.05$), but no significant changes occurred with any of the tests after SS. In the 2 wks after treatment, absolute VAS levels for ETOIMS were significantly lower than those for MS and SS ($P < 0.05$ for MS and $P < 0.0001$ for SS) (Table 4). There was a tendency to have increased pain after SS treatment. ETOIMS treatment resulted in a greater percentage of pain relief in the first week after treatment, although this was not statistically significant from that of MS and SS (Fig. 1).

DISCUSSION

Gunn[9] postulates that myofascial pain involves mechanical traction of muscle fibers shortened by denervation on pain-sensitive regions, such as bones, tendons, joints, nerves, and blood vessels. To desensitize and relax these muscle fibers, at tender motor points he mechanically inserts, twirls, and oscillates acupuncture needles. Potentially, these tender muscle motor points fit the clinical description of myofascial trigger points, although Gunn's definition of motor points[9] was not equivalent to the classical description of the motor point as being the most sensitive site to electrical stimulation. Monopolar EMG needle insertion at MEPZs or the nerve-muscle junction results in electrical activity identical to that noted at myofascial trigger points.[8,11,14] The elicitation of endplate spikes, grouped single–muscle fiber discharges, fasciculations, and myokymic discharges cause microtwitches. These discharges or microtwitches can cause immediate muscle fiber contraction and then relaxation, which may be the basis of pain relief with needling tender MEPZs.[11,13,14] Similarly, elicitation of microtwitches may be the basis of pain relief in methods in which needle manipulation and movement are integral elements, such as intramuscular stimulation and classical and electrical acupuncture. Muscle contraction and relaxation can be induced with ETOIMS and should produce more predictable musculoskeletal pain relief. This has been the clinical experience of the primary investigator.[12]

The results from this study support the hypothesis that ETOIMS produces greater immediate pain relief than nonelectrical stimulation of muscle and significantly greater pain relief than nonelectrical stimulation of skin. If only dealing with a spinal cord pain gate mechanism, the superior analgesia of muscle over skin might be accounted for by the diameter of involved afferents. Muscle afferents are larger (12–21 μm) than skin afferents (6–12 μm).[15]

Intramuscular contraction and immediate relaxation of treated muscle fibers with simultaneous eccentric contraction of the antagonist muscle may relieve pain from stretch effects on the agonists and antagonistic muscle fibers. Stretching of tight muscles is common in clinical rehabilitation to relieve pain, to diminish muscle tension and tenderness, and to enhance range of motion. Muscle stretching exercises are commonly used in sports activities to gain flexibility.[16] Possibly because of muscle stretching effects, treatments that involved muscle, MS and ETOIMS (not SS), immediately improved physical measures. The lack of improvement in other physical measures may be related to the associated residual lower back pain that persisted immediately after treatment.

Despite widespread use, the mechanism behind the effects of stretching remains controversial. A reduction in passive stiffness of the muscle tendon unit may be the

TABLE 4
Pain levels after MS, SS, and ETOIMS in the two weeks following applications

	Pain Levels				
		After Stimulation		Significance *P* Value	
Patient No.	Before Treatment	Week 1	Week 2	Week 1	Week 2
Muscle					
12	4.6 ± 2.1	4.4 ± 2.1	4.2 ± 1.9	0.29	0.05
Skin					
12	4.2 ± 1.9	3.9 ± 2.1	4.3 ± 2.3	0.27	0.78
ETOIMS					
12	4.3 ± 2.3	3.3 ± 1.5	3.7 ± 1.9	0.00001	0.0001

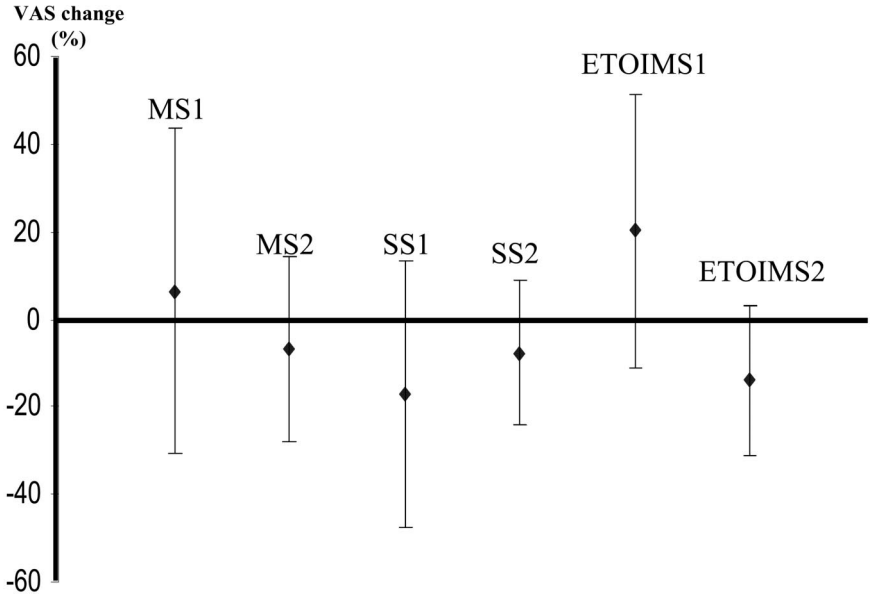

Figure 1: Percentage of change in pain levels after muscle stimulation (*MS*), skin stimulation (*SS*), and electrical twitch-obtaining intramuscular stimulation (ETOIMS). *VAS*, visual analog scale; *MS1* and *MS2*, weeks 1 and 2, respectively, after MS; *SS1* and *SS2*, weeks 1 and 2, respectively, after SS; *ETOIMS1* and *ETOIMS2*, weeks 1 and 2, respectively, after ETOIMS.

mechanism for the beneficial effects of stretching.[17–19] External muscle stretching, such as focal muscle massage, may be effective in stretching the superficial muscle fibers, but the degree of stretching may not be as much as that of muscle contraction and relaxation. Also, external muscle stretching procedures may not provide adequate stretch to deep muscle fibers that may be focally shortened. Surface electrical stimulation, such as faradic and interferential currents, may exert muscle stretching effects more effectively on shortened superficial muscle fibers than on deep muscle fibers. With surface electrical stimulation, less current reaches deeply situated MEPZs. Placing needle electrodes directly into deeper muscle tissues via ETOIMS enables delivery of electrical stimuli to these fibers.

Muscle contractions improve skin and muscle circulation. Electrical stimulation–induced contractions improve circulation of the lower leg by the physiologic pumping action of muscle, reducing venous stasis/pooling and edema.[20] Immediately after muscle contraction, muscle microvessels exhibit increased convective (flow of red blood cells) and diffusive (perfused capillary surface area) transport.[21] The use of low-frequency transcutaneous nerve stimulation (2 Hz), producing moderate muscle contractions, leads to a transient, local increase in blood flow in muscle and skin.[22–24] A recent report with blood flow measurements in the common femoral artery showed that surface-twitch contractions at 3 Hz increase perfusion in human leg muscles.[25] Therefore, ETOIMS-mediated muscle contractions may produce pain relief through the following mechanisms of action: spinal cord reflex closure of the pain gate, intramuscular exercise, and enhanced tissue perfusion.

Our data suggest that pain relief occurs when needle stimulation involves deep-muscle MEPZs and increases with the number of MEPZs stimulated, as is possible with ETOIMS. To elicit twitches for MS and ETOIMS, a firm monopolar EMG needle electrode was used instead of a fine, flexible needle, such as that used in acupuncture and intramuscular stimulation. The monopolar electrode, unlike the acupuncture needle, provides the tensile strength necessary to penetrate through tight, superficial muscles, enabling it to reach deeper muscle layers. This noncutting needle is also designed for repeated needle penetration into muscle.

Percutaneous electrical nerve stimulation (PENS) for treatment of low back pain involves the insertion of multiple acupuncture needles (ten or more) into soft tissue or muscle in the lower back to a depth of 20–40 mm in a dermatomal distribution and the use of current strength of <25 mA, stimulation frequency of 4 Hz, and pulse width of 0.5 msecs for 30 mins.[26] No muscle contractions are visibly elicited with PENS, but the electrical stimulation provides tapping sensations, possibly indicating minute needle movements. The mechanism of pain relief in PENS is believed to be caused by central neuromodulation from stimulation of sensory nerves at the dermatomal level.[27] We suggest that the PENS effect is primarily related to needle electrical stimulation of deep muscle MEPZs with associated microtwitch-induced tissue mobilization because minute needle movements can elicit insertional activity. The depth of 20–40 mm stimulated by PENS is similar to that of our MS and ETOIMS depth of 37 mm.

In our trial, needle insertion with withdrawal after 2 secs was used to keep all three types of treatment uniform. Two seconds of 2-Hz stimulation is the standard electrophysiologic setting for repetitive stimulation of neuromuscular junctions, to fatigue abnormal or susceptible MEPZs, which is the principle used in ETOIMS. This study confirmed that musculoskeletal pain relief can be achieved by MS and ETOIMS, without employing designated acupuncture needles, inserting these needles at classical acupuncture points, twirl-

ing and oscillating the inserted needles, or keeping multiple needles stationary for 20–30 mins, as in classical acupuncture or PENS.

This study also reveals that ETOIMS management of lower back pain can be satisfactorily produced after a brief period of training. The treating physician can confidently visualize or palpate the intramuscular and intermuscular grooves. In contrast with classical acupuncture, this makes needle placement in MS and ETOIMS objective and, consequently, easily standardized. Sham acupuncture, which involves needle stimulation at nonacupuncture points, has been noted to have some analgesic effects.[5] It is possible that pain reduction by such needle puncture occurs by stimulation of MEPZs. In our trial, the fact that no analgesic effects were obtained from needle stimulation of skin suggests that the mechanism of sham acupuncture pain relief involves needle penetration into and stimulation of muscle. This is further supported by the fact that PENS (in which the needles are inserted to a depth of 20–40 mm, involving MS) has been noted to be more effective than transcutaneous nerve stimulation.[26] In addition, transcutaneous nerve stimulation therapy, which does not involve MS, is only marginally more effective than placebo treatment.[28,29]

For all treatment conditions, the VAS scores on the day of treatment were lower than the reported weekly scores. As patient pain was usually lower in the morning and because most treatments occurred in the morning, this contributes to this finding. The pretreatment week's pain levels were the average of the twice-daily (morning and evening) VAS recordings and, thus, were higher than the VAS reported on the morning of the treatment. The lower pretreatment pain score for ETOIMS is not a reflection of the effects of the same order of treatment starting always with MS because SS produced more pain for 2 wks after the treatment (Fig. 1). This helps establish that a 2-wk washout period is sufficient for patients with chronic pain, confirming the clinical experience of the primary author.[10–12]

Potential bias was inadvertently introduced in this study because the treatment was not randomized and because patients could not be adequately blinded to use of the electrical stimulus, despite utilizing an out-of-sight, silent switch. Also, electrical stimulation might have a placebo effect for which there was no control.

There were no complications or adverse effects related to this study. The treatment sequence (crossover) was not randomly assigned because a test trial showed that manual insertion of the needle to stimulate skin was very painful, inducing posttreatment pain. To prevent patient drop-off, we kept the protocol sequence of MS, then SS, and then ETOIMS. The same order of treatments was used for all patients, with ETOIMS treatment 4 wks after MS. Therefore, there is the potential that the VAS levels after SS and ETOIMS were affected by MS. However, cumulative effects of MS do not influence the subsequent pain reduction by ETOIMS because after SS, the pain was noted to increase (Fig 1). SS may inadvertently apply inadequate stimulus to the underlying muscle fibers, allowing them to shorten and tighten without relaxation, aggravating the pain.

A previous, noncontrolled, clinical study suggested that there is an analgesic effect of ETOIMS in musculoskeletal pain.[12] This study confirmed that ETOIMS and, to a lesser extent, MS are effective in reducing VAS levels in low back pain and that SS is not effective. We also showed that a single treatment with ETOIMS produced qualitatively a higher percentage of pain reduction than MS and SS (Fig. 1). On the basis of our findings, further controlled study involving a larger patient population, randomly assigned treatments, and longer follow-up is warranted.

REFERENCES

1. Deyo RA, Cherkin D, Conrad D, et al: Cost, controversy, crisis: Low back pain and the health of the public. *Ann Rev Public Health* 1991;12:141–56

2. Videman T, Battie MC: A critical review of the epidemiology of idiopathic low back pain, in Weinstein JN, Gordon SL (eds): *Low Back Pain: A Scientific and Critical Overview*. Rosement, IL, American Academy of Orthopedic Surgeons, 1996

3. Hart LG, Deyo RA, Cherkin DC: Physician office visits for low back pain: Frequency, clinical evaluation, and treatment patterns from a U.S. national survey. *Spine* 1995;20:11–9

4. van Tulder MW, Cherkin DC, Berman B, et al: Acupuncture for low back pain (Cochrane Review), in *The Cochrane Library, Issue 4, 1999*. Chichester, UK, John Wiley and Sons, 1999

5. NIH Consensus Conference: Acupuncture. *JAMA* 1998;280:1518–24

6. Stux G, Pomeranz B: *Basics of Acupuncture*. Berlin, Springer Verlag, 1995, pp 1–250

7. Melzack R: Acupuncture and related forms of folk medicine, in Wall PD Melzack R (eds): *Textbook of Pain*. Edinburgh, Churchill Livingstone, 1984, pp 691–700

8. Simons DG, Travell JG, Simons LS: *Myofascial Pain and Dysfunction: The Trigger Point Manual, Vol 1. Upper Half of the Body*. Baltimore, Williams and Wilkins, 1999

9. Gunn CC: *Treatment of Chronic Pain: Intramuscular Stimulation for Myofascial Pain of Radiculopathic Origin*. London, Churchill Livingston, 1996

10. Chu J: Twitch-obtaining intramuscular stimulation: Observations in the management of radiculopathic chronic low back pain. *J Musculoske Pain* 1999;7: 131–46

11. Chu J, Schwartz I: The muscle twitch in myofascial pain relief: Effects of acupuncture and other needling methods. *Electromyogr Clin Neurophysiol* 2002; 42:307–11

12. Chu J, Neuhauser D, Schwartz I, et al: The efficacy of automated/electrical twitch obtaining intramuscular stimulation (ATOIMS/ETOIMS) for chronic pain control: Evaluation with statistical pro-

cess control methods. *Electromyogr Clin Neurophysiol* 2002; 42:393–401

13. Hong CZ: Lidocaine injection versus dry needling to myofascial trigger point: The importance of the local twitch response. *Am J Phys Med Rehabil* 1997;73: 256–63

14. Hong CZ, Simons D: Pathophysiologic and electrophysiologic mechanisms of myofascial trigger points. *Arch Phys Med Rehabil* 1998;79:863–72

15. Preston D, Shapiro B: *Electromyography and Neuromuscular Disorders: Clinical-Electrophysiologic Correlations. Section 1: Overview of Nerve Conduction Studies and Electromyography*. Boston, Butterworth-Heinemann, 1998

16. Gleim GW, McHugh MP: Flexibility and its effects on sports injury and performance. *Sports Med* 1997;24:289–99

17. Rosenbaum D, Hennig E: The influence of stretching and warm-up exercises on Achilles tendon reflex activity. *J Sports Sci* 1995;13:481–90

18. Magnusson SP, Simonsen EB, Aagaard P, et al: Mechanical and physiological responses to stretching with and without preisometric contraction in human skeletal muscle. *Arch Phys Med Rehabil* 1996;77:373–8

19. Halbertsma JP, van Bolhuis AI, Goeken LN: Sports stretching: Effect on passive muscle stiffness of short hamstrings. *Arch Phys Med Rehabil* 1996;77: 688–92

20. Faghri PD, Van Meerdervort HF, Glaser RM, et al: Electrical stimulation-induced contraction to reduce blood stasis during arthroplasty. *IEEE Trans Rehabil Eng* 1997;5:62–9

21. Pittman RN: Oxygen supply to contracting skeletal muscle at the microcirculatory level: Diffusion *vs.* convection. *Acta Physiol Scand* 2000;168:593–602

22. Sherry JE, Oehrlein KM, Hegge KS, et al: Effect of burst-mode transcutaneous electrical nerve stimulation on peripheral vascular resistance. *Phys Ther* 2001;81:1183–91

23. Wikstrom SO, Svedman P, Svensson H, et al: Effect of transcutaneous nerve stimulation on microcirculation in intact skin and blister wounds in healthy volunteers. *Scand J Plast Reconstr Surg Hand Surg* 1999;33:195–201

24. Cramp AF, Gilsenan C, Lowe AS, et al: The effect of high- and low-frequency transcutaneous electrical nerve stimulation upon cutaneous blood flow and skin temperature in healthy subjects. *Clin Physiol* 2000;20:150–7

25. Janssen TW, Hopman MT: Blood flow response to electrically induced twitch and tetanic lower limb muscle contractions. *Arch Phys Med Rehabil* 2003;84: 982–7

26. Ghoname EA, Craig W, White P, et al: Percutaneous electrical nerve stimulation for low back pain: A randomized crossover study. *JAMA* 1999;281:818–23

27. Hamza MA, Ghoname EA, White P, et al: Effect of the duration of electrical stimulation of the analgesic response in patients with low back pain. *Anesthesiology* 1999;91:1622–9

28. Deyo RA, Welsh NE, Martin DC, et al: A controlled trial of transcutaneous electrical nerve stimulation (TENS) and exercise for chronic low back pain. *N Engl J Med* 1990;328:246–52

29. Marchand S, Charest J, Li J, et al: Is TENS purely a placebo effect? A controlled study on chronic low back pain. *Pain* 1993;54:99–106

Continuing Call for Papers

The primary purpose of *The American Journal of Physical Medicine & Rehabilitation* (AJPM&R) is to facilitate the dissemination of scholarly work on the practice, research, and educational aspects of physical medicine and rehabilitation. Toward fulfilling its purpose, the AJPM&R invites submission of original papers, particularly in the categories given below, for consideration to publish:

Scientific research papers: Scientific investigations that advance the field of physiatric medicine.

Literature reviews: Critical summaries and assessments of previously published information on topics related to the field of physical medicine and rehabilitation. Because of space limitations, reviews will be accepted only under special circumstances.

Case studies: Presentations of the diagnosis, treatment, and outcomes of individual cases of specific conditions to improve patient care.

Brief reports: Short articles reporting on research techniques, statistical techniques, and educational and clinical aspects of physical medicine and rehabilitation.

Clinical notes: Comments on patient diagnosis or treatment resulting from personal clinical experience.

Commentaries: Indepth, editorial-like, articles on matters relating to the clinical, scientific, and educational aspects of physical medicine and rehabilitation.

Letters to the Editor: Objective critiques and comments covering material published in a recent issue of the *Journal*.