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The Effectiveness of Electroacupuncture Versus Electrical Heat Acupuncture in the Management of Chronic Low-Back Pain

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ABSTRACT

Design: Forty-two (42) subjects suffering from chronic low-back pain were matched with the nature of their occupations and then randomly allocated into: (1) an electroacupuncture group (EA); (2) an electrical heat acupuncture (EH) group or; (3) a control group.

Interventions: Subjects in the EA group and the EH group received treatment for 20 minutes on a total of 6 acupuncture points. Treatment was delivered twice per week for 4 weeks (a total of 8 sessions). Back exercise was taught to all subjects including the control group as a home program.

Outcomes measures: A numerical rating scale of pain (NPRS), straight leg raise (SLR), and Roland Morris Disability Questionnaire (RMDQ) were recorded.

Results: There were significant reduction of NPRS within the EA ($p = 0.000$), EH ($p = 0.000$), and control ($p = 0.013$) groups across sessions. Significant between-group differences were shown in session 4 ($p = 0.006$), session 8 ($p = 0.001$), and 1-month follow-up sessions ($p = 0.001$). Posthoc tests showed that the NPRS of the EH group was significantly lower than that of the EA group and the control group by session 4 ($p = 0.004$). After session 8, the NPRS of both the EA group ($p = 0.003$) and the EH group ($p = 0.001$) were significantly lower than that of the control group. Such a difference was maintained at least up to the 1-month follow-up.

Only the EA group had significant improvement in the measurement of SLR across sessions ($p = 0.000$). The between-group difference reached significance level in session 8 ($p = 0.001$) and at 1-month follow-up ($p = 0.002$). Posthoc tests showed that EA group had significantly greater gain than the EH group and the control group.

For the RMDQ score, the improvement was statistically significant within each of the three groups over time ($p = 0.000$). However, the between-group difference did not reach statistical significance.

Conclusions: Our findings suggest that 4 sessions of EH treatment over 2 weeks produced significantly greater reduction in the NPRS than that of the EA or the control. However, EA produced greater improvement in SLR and reduction in RMDQ score than that of the EH and the control.

INTRODUCTION

Chronic low-back pain (LBP) is a common condition. In the United States, the cumulative lifetime prevalence of LBP lasting for at least 2 weeks was 13.8%. The estimated direct cost of medical care for this condition was more than $8 billion annually (Deyo and Tsui, 1986).

Pain control is important for chronic LBP sufferers because pain may hinder a person from exercising, which may result in a deterioration of functional capacity. Acupuncture has been widely used for the management of various kinds of pain. The physiologic mechanism of acupuncture analgesia involves the release of endogenous opioids (Mayer et al., 1977). Electroacupuncture (EA), the application of elec-

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trical stimulation to the acupuncture needles, has also been widely practiced in the Western countries.

Lehmann et al. (1986) compared the effectiveness of transcutaneous electrical nerve stimulation (TENS) with EA in the treatment of chronic LBP. It was shown that EA produced a greater reduction in pain scores than TENS. Thomas and Lundberg (1994) found that low-frequency (2 Hz) EA was significantly better than high-frequency (80Hz) EA or needle acupuncture alone in decreasing chronic LBP and improved the range of movement at the spine.

Theoretically, heat produces vasodilatation of capillaries and arterioles. Heat increases the local circulation and removes the chemical substances that stimulate or sensitize nociceptors. Traditionally, Chinese practitioners attach a burning moxa to the needle head in order to enhance the analgesic effect produced by needle acupuncture. The heating effect via the needle can transmit heat into a deeper layer of tissue compared to the superficial heating methods such as hot packs, moxibusion, or infrared radiation (Kim, 1997). Lehmann and deLateur (1984) stated that tissue temperatures can be elevated to approximately 40°C–45°C and hyperemia is an indication of an increase in blood flow.

Because the burning of moxa produces smoke, gum, and odor, hospitals in the Western countries are reluctant to use moxa needle therapy. To overcome these problems, an electronic heater for acupuncture was first developed in Japan in 1993. The device produces radiant heat from a ceramic heater. It heats up the body part without producing smoke and is supposed to be a good alternative to moxa needle therapy. An electronic heater for acupuncture usually consists of 4 channels of ceramic heating board. The heater can transmit heat with the temperature range from 38°C to 48°C. There is a choice of constant or intermittent heat transmission.

Ishimaru et al. (1993) compared the effectiveness of electrical heat acupuncture (EH) to needle acupuncture in patients suffering from chronic LBP. They found that EH was significantly more effective than needle acupuncture for improving the flexion range of lumbar movement and reducing the pain score immediately after the treatment. No other study has been done on EH.

Thomas and Lundberg (1994) demonstrated that EA was more effective than needle acupuncture for reducing chronic LBP. Ishimaru et al. (1993) also demonstrated that EH was more superior to needle acupuncture for decreasing pain and improving flexion range of lumbar movement for people with chronic LBP. However, the relative effectiveness of EA and EH for producing the short-term or long-term effects in the treatment of chronic LBP has not been examined. The present study was a double-blinded, randomized, controlled trial. We aimed to investigate the relative effectiveness of 8 sessions of EA and EH in the treatment of chronic LBP in terms of pain relief, straight leg raise (SLR), and disability score across treatment sessions. Also, we examined the correlation between the outcomes of (1) a numerical rating scale of pain (NPRS) and SLR and (2) NPRS and the Roland Morris Disability Questionnaire (RMDQ) over time.

MATERIALS AND METHODS

Subjects

Forty-five (45) patients suffering from chronic LBP were recruited from a local physiotherapy outpatient clinic. Three (3) patients withdrew from the study. Therefore, there were, altogether, 42 subjects who completed the study (30 women and 12 men). The inclusion criteria were patients, ages 20–55, who had suffered from LBP that radiated down to the thigh or calf area for at least 3 months with positive SLR findings. The LBP was caused by mechanical conditions but not by cancer or tuberculosis. The exclusion criteria were patients suffering from repeated histories of LBP, previous surgery on the back or hip, spinal stenosis with claudication, patient planning for back surgery, systemic arthritis, fracture spine, grades 3–4 spondylolisthesis, osteoporosis, or neurologic deficits.

Because the physical work demand of a subject would affect the treatment results, subjects were first matched with the nature of their work according to the physical demands characteristic of such work as manual handling of ordinance in United States, which classifies manual handling >50 lbs as heavy, 30 lbs as medium, and <30 lbs as light. This was to guarantee a similar job nature of the subjects across the groups. The subjects were randomly assigned into the EA, EH, or the control groups. Informed consent was obtained before the treatment. The principal investigator performed the acupuncture treatment. The two assessors who performed the measurement and the subjects were blinded to the group allocation of each subject.

Instruments

Electroacupuncture. A dual channel EA machine (Model Cefar Acus II, No. 1306, by Cefar Medical AB, Lund, Sweden) was used. The machine produced a square wave with an alternating polarity impulse, with a frequency range from 1 Hz to 999Hz. Different preset modes of fixed or mixed frequency were delivered by the 4 channels.

Electrical heat machine. An electrical heat machine (Cefar Acutherm, No. 3035, by Cefar Medical AB, Lund, Sweden) was used to produce electrical heat in addition to the needles. The machine consisted of 4 channels in which heat was delivered from 38°C to 48°C through an incandescent board. There was a hole in the center of the incandescent board where the needle was inserted.

Experimental procedures

The treatment area for EA was first sterilized with 70% alcohol using an alcohol swab. Six acupuncture points were

selected. A total of four local acupuncture points (Dachangshu BL-25, Guanyuanshu BL-26) over the bilateral side of the lower back (Lehman, et al., 1983, 1986; Mendelson et al., 1983) and two extra distal points over the buttock (Huantiao GB-30) and leg (Zusanli ST-36 or Weizhong BL-40) were added over the painful leg. The acupuncture needles were inserted and manipulated to achieve a *de qi* sensation. Needles for the acupuncture point Guanyuanshu BL-26 on the bilateral side and the extra distal points over Huantiao GB 30) and leg (Zusanli ST 36 or Weizhong BL40) were attached to the EA machine. An alternate frequency of 2/15 was used. Chen et al. (1994) found that 2/15 Hz of EA was more effective than a fixed frequency of 2 Hz, 15 Hz, or 100 Hz in a "tail-flick" latency response in rats. The treatment was carried out twice per week for a total of 8 treatment sessions and each session lasted for 20 minutes.

The location of the selected acupuncture points were as follows:

- BL-25 (Dachangshu)—1.5 inch from the spinous process of L4 on the bilateral side
- BL-26 (Guanyuanshu)—1.5 inch from the spinous process of L5 on the bilateral side
- GB-30 (Huantiao)—outer 1/3 of the line joining the greater trochanter and S2 intervertebral foramen
- ST-36 (Zusanli)—1 inch directly below and one middle finger breadth lateral to the inferior border of the tibial tuberosity *or* BL-40 (Weizhong)—midline of the popliteal fossa

For the group receiving EH, the same acupuncture points adopted in the EA group were also used in the EH group. The attachment method of the acupuncture needle to the EH machine was the same as that of the EA machine. The two channels of ceramic heating board were connected to the acupuncture needles Guanyuanshu BL-26 over the back. The other two were placed over the distal points of Huantiao GB-30 and leg (Zusanli ST-36 or Weizhong BL40) with adhesive tape fixing the ceramic board to the skin. The temperature was adjusted to 42°C, with an intermittent mode of 5 seconds on and 5 seconds off. This was to avoid overheating the skin (Lehmann and deLateur, 1984). Subjects were warned to provide immediate feedback if there was any intolerable heat (Fig. 1).

The control group performed back exercises only. This included 6 mobilization exercises and 1 abdominal stabilization exercise. The subjects were encouraged to perform the mobilization exercises 20 times and the stabilization exercise 10 times. Subjects were instructed to perform the whole set of exercises 3 times per day at home.

The EA and EH groups were instructed to perform the same set of back exercises as the control group. Therapists monitored compliance of the prescribed home exercises of all subjects throughout the study. In addition, all subjects were instructed to keep their analgesic consumption and activity levels constant.

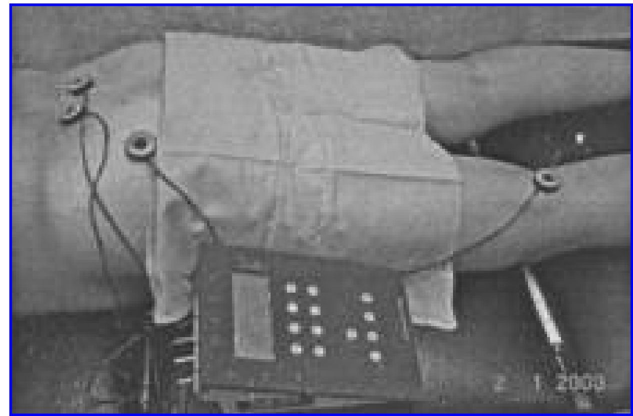

FIG. 1. Electrical heat acupuncture treatment.

Assessment was performed at baseline (before treatment delivered during session 1), after treatment at session 4 and session 8, and at the 1-month follow-up.

The NPRS was used for recording pain. The subjects were asked to select a number from 1 to 10 that represented the intensity of pain. SLR was examined when each subject was positioned in a supine lying position without pillow support. Standard procedures to measure SLR were adopted (Brieg and Troup, 1979). The procedure was demonstrated by one assessor and the angle of hip-flexion range was measured by another assessor. Both assessors were blinded to the allocation of subjects to treatment groups. When a subject had bilateral involvement, the SLR of the more affected side was taken. The RMDQ was adopted to record the influence of LBP on subjects' daily functioning (Roland and Morris, 1983).

Data analysis

Initially, repeated measures analysis of variance (ANOVA) were used to examine the changes made within the groups across treatment sessions, and the between-group difference for the NPRS, SLR, and RMDQ. The α level was set at 0.05. However, significant interactions between "groups" and "sessions" were found in the results of the NPRS ($p = 0.000$) and SLR ($p = 0.009$). This means that the change in the outcome measures across sessions were not the same in the three groups. Therefore, a one-way ANOVA was performed separately for "sessions" and "groups" in all data analysis. The Bonferroni correction was used to adjust the α level to 0.016. A Pearson correlation was used to find out the correlation between NPRS and SLR, as well as NPRS and RMDQ scores.

RESULTS

Baseline characteristics of the subjects

The baseline measurements of age, history of pain, and measurement of NPRS were comparable among the 3 groups

Table 1. Demographic Characteristics of Subjects

	EA (n = *14)*	*EH* (n = *14)*	*Control* (n = *14)*	p *value*
Age	39.71 ± 12.15	39.07 ± 9.17	40.92 ± 8.30	0.884
Gender (% of female)	76%	71%	62.3%	
Light job demand (n)	12	11	12	
Moderate job demand (n)	0	1	0	
Heavy job demand (n)	2	2	2	
History of low back pain (month)	8.71 ± 7.06	11.92 ± 12.10	10.93 ± 9.25	0.653
Numerical rating scale of pain	5.57 ± 1.16	5.71 ± 0.91	6.14 ± 1.61	0.466
Straight leg raise (°)	63.92 ± 12.11	63.57 ± 10.27	59.28 ± 10.35	0.465
Roland Morris Disability Questionnaire (out of 24)	10.71 ± 4.23	11.21 ± 4.21	11.07 ± 3.49	0.944

Values are mean ± standard deviation.
p value showed difference between the 3 groups at the baseline.
EA, electro-acupuncture; EH, versus electrical heat acupuncture; n, number of subjects.

(all $p > 0.05$; Table 1). There were nearly equal numbers of subjects classified as light, moderate, or heavy job demand in each group.

Change in the NPRS scores across treatment sessions

For the EA group, a 56.37% cumulative reduction in NPRS was observed from session 1 to the follow-up session (Table 2). Such a decrease in NPRS across sessions reached significance level ($p = 0.000$) (Table 2). For the EH group, a 60.24% cumulative reduction in pain was found from the baseline to the follow-up. Again, the change recorded across sessions reached significance level ($p = 0.000$). For the control group, significant pain reduction was also demonstrated over time ($p = 0.013$) but the cumulative reduction was only 15.14%, which was much lower than that of the EA and EH groups.

A significant between-group difference was found in session 4 ($p = 0.006$), session 8 ($p = 0.001$), and the follow-up ($p = 0.001$). Posthoc testing showed that the NPRS score of the EH group was lower than the EA and the control groups in session 4 ($p = 0.004$). While in session 8, the scores of both the EA group ($p = 0.003$) and the EH group ($p = 0.001$) were significantly lower than that of the control group. The between-group difference was more-or-less maintained in the follow-up session.

Changes in SLR across treatment sessions

The within-group effect showed that the SLR in the EA group increased significantly across sessions ($p = 0.000$; Table 3). The cumulative increase in SLR over the whole study period was 20.66%, with the greatest gain (12.3%) achieved from session 4 to session 8. An increase in SLR was also found in the EH group and the control group but this was not statistically significant.

There was a significant between-group difference recorded in session 8 ($p = 0.001$), and the follow-up session ($p = 0.002$). Posthoc testing showed that the EA group had

Table 2. The Change in Numerical Rating Scale of Pain Across Treatment Sessions

	EA	*EH*	*Control*	p *value (between-group)*
Baseline	5.57 ± 1.58 (0%)	5.71 ± 1.58 (0%)	6.14 ± 1.61 (0%)	0.466
Session 4	4.36 ± 1.78 (−21.72%)	3.36 ± 1.86 (−41.16%)	5.57 ± 1.50 (−9.28%)	0.006
Session 8	3.07 ± 1.90 (−44.88%)	2.86 ± 1.75 (−48.65%)	5.50 ± 1.83 (−14.59%)	0.001
Follow-up	2.43 ± 1.87 (−56.37%)	2.27 ± 2.15 (−60.24%)	5.21 ± 1.88 (−15.14%)	0.001
p value (within-group)	0.000	0.000	0.013	

EA, electro-acupuncture; EH, versus electrical heat acupuncture.
Values are mean ± standard deviation.
Values in parenthesis are percentage changes with respect to the baseline, negative values refer to reduction of pain.

Table 3. The Measurement of Straight Leg Raise Across Sessions

	EA	*EH*	*Control*	p *value (between-group)*
Baseline	63.93 ± 12.12 (0%)	63.57 ± 10.27 (0%)	59.29 ± 10.35 (0%)	0.465
Session 4	68.93 ± 13.18 (7.82%)	66.79 ± 9.32 (5.07%)	59.64 ± 8.87 (0.59%)	0.066
Session 8	76.79 ± 11.54 (20.12%)	68.57 ± 9.29 (7.87%)	60.71 ± 9.58 (2.40%)	0.001
Follow-up	77.14 ± 10.87 (20.66%)	67.86 ± 10.69 (6.75%)	61.43 ± 12.63 (3.6%)	0.002
p value (within-group)	0.000	0.270	0.763	

EA, electro-acupuncture; EH, versus electrical heat acupuncture.
Values are mean ± standard deviation in degree.
Values in parenthesis are percentage changes with respect to the baseline.

a significantly greater increase in the angle of SLR than that of the control group in session 8 ($p = 0.000$) and in the follow-up session ($p = 0.002$; Table 3).

Change in RMDQ scores across treatment sessions

The change in RMDQ scores across time was similar in the three group (Table 4). The RMDQ scores significantly decreased ($p = 0.000$) across treatment sessions. However, no significant between-group difference was found in any treatment session.

Relationship between NPRS and SLR/RMDQ in session 8

The results showed no significant correlation among the percentage of changes in NPRS and SLR in the EA group ($r^2 = 0.000$; $p = 0.957$), the EH group ($r^2 = 0.019$, $p = 0.636$), and the control group ($r^2 = 0.130$, $p = 0.205$).

There was no significant correlation between the NPRS and RMDQ in the EA group ($r^2 = 0.082$, $p = 0.320$). There was a weak correlation in the EH group ($r^2 = 0.385$, $p = 0.018$) as well as in the control group, ($r^2 = 0.294$, $p = 0.045$).

DISCUSSION

Change in NPRS scores of the three groups

In the first 2 weeks of treatment, EH produced significantly greater pain reduction than EA. The thermal effect produced by EH probably produced additional antinociceptive effects on the endorphinergic pain modulation by needle acupuncture alone. Heat can increase the local circulation and remove the chemical substances such as histamine, bradykinin, and prostaglandins caused by chronic inflammation, which stimulates or sensitizes the surrounding nociceptors (Thompson, 1994).

Pain reduction was also observed in the control group across sessions. This might be the result of the therapeutic

Table 4. The Change in Roland Morris Disability Questionnaire Scores Across Treatment Sessions

	EA	*EH*	*Control*
Baseline	10.71 ± 4.23 (0%)	11.21 ± 4.21 (0%)	11.07 ± 3.50 (0%)
Session 4	8.57 ± 4.01 (−19.98%)	7.93 ± 5.14 (−29.26%)	9.36 ± 3.56 (−15.45%)
Session 8	7.64 ± 3.75 (−28.66%)	8.36 ± 4.65 (−25.42%)	8.79 ± 3.40 (−20.60%)
Follow-up	5.93 ± 3.79 (−44.63%)	8.00 ± 5.66 (−28.64%)	8.57 ± 3.48 (−22.58%)
p value (within-group)	0.000	0.000	0.000

EA, electro-acupuncture; EH, versus electrical heat acupuncture.
Values are mean ± standard deviation.
Values in parenthesis are percentage changes with respect to the baseline, negative values refer to reduction of the score.

effect of exercise (Donchin et al., 1999; Elnaggar et al., 1990; Hansen et al., 1992). Subjects in all 3 groups were instructed to perform home exercises. However, the total percentage of pain reduction in the control group was 26.2%, which was far smaller than that the other two treatment groups with EA at 56.37% and EH at 60.24%.

A previous study showed that EA and TENS were not significantly different from control group for reducing chronic LBP (Lehmann et al., 1986). As 58% of the subjects in this study were receiving worker's compensation benefits and another 20% were receiving long-term payment from their current employers, it is possible these subjects might have overestimated their pain levels and reported a smaller percentage of improvement. In contrast, the present study produced a significantly reduction in pain (56.37%) in the EA group and (60.24%) in the EH group compared to that of the control group (15.14%). This might be because the present study excluded subjects who suffered from injury on duty to eliminate possible overestimation of pain, and therefore, a more accurate results may have been produced.

Changes in straight leg raise across sessions

Only the EA group had significant improvement in SLR measurement across sessions. However, there was no significant correlation for NPRS and SLR in each group (all $p > 0.05$). This means that the decrease in NPRS did not necessarily improve performance in SLR.

In the present study, the SLR was measured when the tested leg was elevated passively and slowly until it elicited the usual pain over the leg or the back. If the SLR was limited by pain together with significant resistance and neural tension, a reduction in pain produced by EA or EH might not have necessarily improved the SLR angle. When nerve-root inflammation causes adhesion and fibrotic changes, significant tension and resistance may result. Pain reduction produced by acupuncture may not be effective for mobilizing neural tissue to improve the SLR measurement. For those cases, neuromeningeal mobilization could be used as an adjunct therapy to acupuncture.

However, it is difficult to differentiate whether the limitation of SLR is caused by "pain dominant" or "resistance dominant" factors. Because the subjects were randomly assigned into the three groups, we assumed that the causes of reduced SLR would be similarly distributed in the 3 groups.

Our findings showed that EA was more effective than EH or the control for improving passive SLR across sessions. Hanai (2000) demonstrated that electrical stimulation of the posterior tibial nerve and sciatic nerve resulted in a decrease in nociceptive radicular pain in cats. It is possible that EA can produce a greater stimulation on the tibial nerve or sciatic nerve than EH. This decreases the neurogenic pain, and subsequently improves the SLR.

The change in RMDQ scores across treatment sessions

Apart from the physiologic dimension of pain, people suffering from chronic LBP are usually affected by the psychosocial dimension of pain. Therefore, no significant between-group difference was noted in the disability score. The result was not in parallel with the NPRS, which showed that the two treatment groups had significantly lower scores than the control group.

Although the three groups showed similar improvements in the RMDQ score across sessions, the EA group demonstrated a slightly greater percentage of improvement than the other groups. Li et al. (1992) showed that EA with the stimulation of Zusanli (ST 36) could normalize colon function. This might improve the appetite and improve the RMDQ score. In addition, Han (1986) showed that the application of EA for 30 minutes could decrease depression and improve emotional behavior. The therapeutic effects of EA might explain a greater percentage of improvement in the RMDQ score than the EH and control group.

Comparison of EH to the application of a superficial heat treatment in adjunct to needle acupuncture

Traditionally, some acupuncturists apply needle acupuncture, and heat a diffused treated area with an infrared lamp. The infrared lamp with 100–200 w is usually applied at a distance of 40–50 cm away from the skin so that the patient feels warm during needle acupuncture. This application is different from EH because infrared radiation produces a diffuse heating effect. EH produced a heating effect that is confined to the acupuncture points. Therefore, we speculate that the physiologic and the clinical effects produced by EH could be different from the application of an infrared lamp treatment in adjunct to needle acupuncture. This should be clarified in future study.

CONCLUSIONS

The addition of either EA or EH to exercise is more effective than exercise alone in reduction of chronic LBP. But EH seems to be more efficient for producing analgesic effect in the initial 2 weeks of treatment. In contrast, EA plus exercise is a better choice if the patients have more problems in SLR or greater disability as reflected by RMDQ.

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