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# Effects of Inter-electrode Distance on Delayed Onset Muscle Soreness in Microcurrent Therapy

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**Abstract.** [Purpose] This study examined the effect of the distance between the two electrodes on delayed onset muscle soreness during microcurrent therapy. [Methods] In this study 24 healthy women who hadn't exercised regularly for six months were selected and randomly divided into two groups. Delayed onset muscle soreness (DOMS) was induced and experimental Group 1 were given microcurrent treatment with the electrodes attached at a close distance evaluated. Experimental Group 2 received the same treatment with the electrodes attached at a greater distance apart. Visual analogue scale pain and the RIII reflex were evaluated after inducing DOMS and after one day, two days, three days and four days of microcurrent treatment. [Results] The visual analogue scale and amplitude of RIII amplitude only showed significant differences with the length of time of the treatment. [Conclusion] This study found that difference of interelectrode distance has no influence on VAS pain and the RIII reflex of DOMS. Although there were no significant differences in RIII amplitude, we suspect that it may be influenced by current parameters such as frequency and intensity.
**Key words:** DOMS, Microcurrent, RIII reflex test

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## INTRODUCTION

The muscle damage theory of Delayed Onset Muscle Soreness (DOMS) indicates that muscle pain is caused by tiny lacerations of the muscle during strenuous exercise[1–3)], and the muscular spasm theory states that muscle pain induced by exercise causes muscular spasms, which cause local ischemia, inducing secretion of pain producing substances which then stimulate the peripheral ends of autonomous nerves[4)].

It is known that delayed onset muscle soreness increases the intensity of pain within 24 hours after exercise, reaches a peak between 24 and 48 hours, disappears within 5–7 days after exercise[5)], and causes muscular weakening, edema, and limitation of range of motion[6)].

Methods of treating delayed onset muscle soreness have been performed in various ways. Rodenburg et al.[7)] mentioned that performance of warm-up, passive stretching and massage are effective. In addition, when pulsating ultrasonic waves as an electrical therapy were applied, symptoms of inflammation like pain and edema were reduced and it was published that it increased the rate of therapy in many situations like damage of soft tissue, scar tissue, musculoskeletal pain, joint diseases and edema[8)]. Moreover, it has been reported that transcutaneous electrical nerve stimulation increases the range of motion and reduces pain[9)].

Microcurrent therapy is a type of subsensory stimulation which is mostly applied to acute lesions like pain, swelling, inflammations and cuts[10)]. Microcurrent creates potential differences across sensitive channels of the cells within the body. It also opens the cell membrane, and increases ATP (adenosine triphosphate) and protein generation by stimulating the chemical processes of $Ca^{2+}$ ion, and fosters recovery and healing of cells[11)]. The effects of pain decrease and wound healing can be obtained by providing electrical energy at the celllevel, which can create a potential difference across the cell membrane[11, 12)].

As the distance between the electrodes increases, the number of parallel paths increases and the current tends to flow more deeply within the tissues[13)] but the effects of electrode distance have not been clearly defined. Therefore, this study examined the effects of applying microcurrent with different electrode spacings on delayed onset muscle soreness.

## SUBJECTS AND METHODS

This study selected 20 healthy women randomly and di-

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vided them into two groups. Before the experiment, subjects were given an explanation about the whole process of the experiment, and the experiment was conducted after obtaining the subjects' consent to participation in the experiment. In addition, this study was approved by the research ethical committee of Kwangju Women's University.

The research subjects were those who had no nerve, muscular or musculoskeletal diseases, had practiced no regular exercise in the previous six months, and didn't take medicine which might have affected the experiment. They were also instructed not to perform excessive motions or regular exercise except daily activities during the experiment. The general characteristics of the research subjects are presented in Table 1.

We connected a performance recorder (PR1, HUR labs, Finland) to an air pressure muscular strength exercise device (5530 leg extension/curl rehab, HUR, Finland), and measured the maximal eccentric strength of the knee joint flexors three times. After measuring the maximal eccentric strength of the left and right knee joint flexors three times, the mean value was calculated and delayed onset muscle soreness in the biceps femoris muscle was induced. To induce delayed onset muscular soreness, the subjects were asked to lean back on the back of the manual exercise equipment, fix their body using a belt, keep their hip joint at 90°, sit with their knee joint relaxed, exert the mean value of maximal eccentric strength, and perform a total of 15 sets of knee joint flexion exercises, 15 times a set. Eccentric exercise was performed for 20s with a 5s rest, and 20s of rest between sets. The measurer instructed the subjects to use the knee joint flexors. The measurer counted while delayed onset muscle soreness was induced.

The microcurrent therapy device used was a low-frequency therapeutic apparatus (endomed 482, Enraf-Nonious B.V. Co., Netherlands). A frequency of 30 Hz, intensity of 100 μA, and alternating polarity was used. Carbon rubber electrodes of 4 × 6 $cm^2$ were inserted into a sponge pad. In experimental Group I, two electrodes were attached to the biceps femoris muscle vertically and in experimental Group II, one electrode was attached to the biceps femoris muscle and the other one was connected to the biceps femoris tendon vertically. Treatment was conducted for 20 min a day, for 4 days from the onset of delayed muscle soreness.

The outcome measures of the study were visual analogue scale (VAS) pain and the RIII reflex. All evaluations were performed five times: immediately after delayed onset muscle soreness, and after one, two, three and four days of treatment The evaluations were repeated three times to reduce errors and the average was calculated.

The subjects were asked to adopt a prone position for the assessment of the degree of pain when their knee joint was bent VAS scores range from 0 without pain to 10, the severest pain, and the subjects were asked to indicate the degree of their pain to the tester.

The RIII reflex of the lower limb with delayed onset muscle soreness was evaluated using EMG (neuro-EMG-micro, Ivanovo, Russia). The subjects were asked to adopt a prone position on a bed, bend their hip joint to about 130° using a pillow under the abdomen and the knee joint to about 120°, and the ankle was positioned. When recording the action potential, we used a band-pass filter of 5–2,000 Hz, a sampling rate of 20,000 Hz, and the notch filter was on. Test stimulation was a square wave of six pulses in a pulse train of 1 ms.

**Table 1.** General characteristics of subjects (n=20)

| Group | Experimental group I (n=10) | Experimental group II (n=10) |
|---|---|---|
| Age (years) | 20.8 ± 0.9 | 21.9 ± 1.0 |
| Height (cm) | 160.8 ± 4.7 | 161.1 ± 3.7 |
| Weight (kg) | 54.3 ± 8.2 | 56.2 ± 8.1 |

Before attaching the electrodes, the attachment sites were cleaned with alcohol and conductive gel was applied to the fibula before attatchment of the ground electrode, a rectangular AgCl electrode, 2.3 × 2.6 $cm^2$ (disposable EMG electrode F3001, Fiab, Italy).The active electrode was attached halfway along the biceps femoris long head, and the recording electrodewas attached to the biceps femoris tendon 2 cm above the knee. After applying gel, electrical stimulation was applied to the passage of the sural nerve from lateral malleoulus. The negative pole was positioned proximally and the positive pole was located 2 cm below the negative pole. Stimulation was increased by 1 mA at 10s. Intervals, and the first stimulation intensity showing the RIII reflex was chosen to reflect the threshold. Value of increasing 1.2 times from the minimum threshold was recorded. Stimulation was given three times at 10s. intervals and amplitude values of RIII reflex the time window of 90–180 ms were analyzed.

Statistical analysis was performed with Widows SPSS 12.0 program. Repeated measures ANOVA were used to analyze the changes of the two groups according to the duration of treatment. The significance level was chosen as $\alpha$=0.05.

## RESULTS

Changes of the visual analogue scale pain with treatment duration within each group are shown in Table 2. Both experimental groups I and II showed a peak in VAS pain one day after DOMS induction, and showed gradual decrease from two days after induction to four days after induction. Repeated measures analysis revealed no significant differences in interactions between treatment duration and group, but there were statistically significant changes of VAS with treatment duration (F=39.79, p=0.000). Visual analogue scale pain of in experimental group I was 5.17 ± 2.62 immediately after induction, 5.25 ± 2.05 on the first treatment day, 4.17 ± 2.12 on the second treatment day, 2.42 ± 1.83 on the third treatment day, and 1.33 ± 1.3 on the fourth treatment day. Visual analogue scale pain of experimental group II was 4.08 ± 2.19 immediately after induction, 4.50 ± 1.73 on the first treatment day, 3.75 ± 1.96 on the second treatment day, 2.75 ± 1.76 on the third treatment day, and 1.42 ± 0.79 on the fourth treatment day.

Changes in the amplitude of the RIII reflex with treatment duration within each group are shown in Table 3. Repeated measurement analysis revealed no significant differ-

**Table 2.** Change of VAS

| Group | Pre | 1st day | 2nd day | 3rd day | 4th day |
|---|---|---|---|---|---|
| I | 5.2 ± 2.6 | 5.3 ± 2.1 | 4.2 ± 2.1 | 2.4 ± 1.8 | 1.3 ± 1.3 |
| II | 4.1 ± 2.2 | 4.5 ± 1.7 | 3.8 ± 2.0 | 2.8 ± 1.8 | 1.4 ± 0.8 |

Mean ± SD. There was only a significant difference attributable to the treatment period ($F=39.79$, $p<0.001$).
Group I: Two electrodes were attached to the biceps femoris muscle vertically.
Group II: One electrode was attached to the biceps femoris muscle and the other was attached to the biceps femoris tendon vertically.

**Table 3.** Changes of amplitude of RIII reflex (Unit: μV)

| Group | Pre | 1st day | 2nd day | 3rd day | 4th day |
|---|---|---|---|---|---|
| I | 170.4 ± 68.1 | 135.0 ± 58.0 | 137.1 ± 143.3 | 144.3 ± 45.6 | 140.3 ± 40.1 |
| II | 156.3 ± 70.2 | 141.8 ± 36.6 | 130.3 ± 37.3 | 109.0 ± 39.3 | 98.2 ± 35.3 |

Mean ± SD. There was only a significant difference attributable to the treatment period ($F=4.150$, $p<0.05$).
Group I: Two electrodes were attached to the biceps femoris muscle vertically.
Group II: One electrode was attached to the biceps femoris muscle and the other was attached to the biceps femoris tendon vertically.

ences in interactions between treatment duration and group, and the main effect test, but there was a statistically significant difference in RIII amplitude with treatment duration ($F=4.150$, $p=0.015$). The RIII amplitude of experimental group I was 170.43 ± 68.07 immediately after induction, 134.97 ± 58.01 on the first treatment day, 137.11 ± 45.09 on the second treatment day, 144.32 ± 45.59 on the third treatment day, and 140.32 ± 40.05 on the fourth treatment day. The RIII amplitude of experimental group II was 156.25 ± 70.21 immediately after induction, 141.80 ± 36.63 on the first treatment day after induction, 130.33 ± 37.33 on the second treatment day, 108.97 ± 39.31 on the third treatment day, and 98.15 ± 35.34 on the fourth treatment day.

## DISCUSSION

We recorded the changes in visual analogue scale pain a subjective pain scale. Both groups showed significant differences in visual analogue scale with treatment duration. There was no significant difference between the two groups. Experimental group II showed an increase in VAS pain after delayed onset muscle soreness was induced and a decrease after 4 days of therapy. Experimental group I showed a greater decrease in VAS pain after 2–3 days of therapy than experimental group II.

Oh[14] reported that microcurrent stimulation was effective at fostering the process of cut healing, and that a stimulation intensity of 50 μA was more effective than those of 100 μA and 300 μA in the process of cut healing as judged by gross observation, and histological and immunohistological results. His results may differ from those of this study due to current intensity differences.

Cho[15] reported that in a comparison of pain between an experimental group using microcurrent and a control group containing foot pain patients in their fifties, there were significant differences in visual analogue scale pain before and six weeks after the experiment only in the experimental group. So it was known that microcurrent therapy reduces pain compared to a control group. This study also showed decreases in visual analogue scale pain in both groups, but there were no significant differences between the groups.

RIII amplitude showed no statistically significant differences between the two groups. Experimental group II showed an increase immediately after induction of delayed onset muscle soreness, decreases on after the 4th day of therapy, whereas experimental group I showed an increase immediately after induction,a decrease after the 1st day of therapy, and increases on after the 2nd to the 4th day of treatment. The RIII reflex shows variation with the mental condition of subjects and their external environment[16], and it has been reported that the laboratory environment and full knowledge of the experiment by subjects affected the results of RIII reflex measurements.

Kim[17] reported measuring the RIII reflex during pain caused by erythema in normal adults. The RIII reflex increased after erythema was induced, but it was reduced by therapy, and there was no significant difference. Ju and Gwon[18] found that the maximum amplitude of the RIII reflex of healthy adults was reduced in fixed frequency treatment and modulated frequency treatment, but there was no significant difference the between fixed frequency and modulated frequency treatment groups. In this study, although both groups showed no significant differences, group II showed a greater decrease than group I in RIII amplitude.

The distance between the electrodes proved to be inconsequential in microcurrent therapy, but different outcomes might be found in a future experiment in which current strength and frequency, as well as the distance between electrodes are investigated.; on the ground that decrease range of pain aspect becomes a little bit higher when the distance between electrodes is adjusted to be farther than this experiment.

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