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EFFECTS OF ACUPUNCTURE THERAPY ON THE ELECTROMYOGRAPHY ACTIVITY OF THE RECTUS FEMORIS AND TIBIALIS ANTERIOR DURING MAXIMAL VOLUNTARY ISOMETRIC CONTRACTION IN COLLEGE STUDENTS

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ABSTRACT

Acupuncture has been increasingly used in the treatment of muscle damage associated with sports activities. However, studies on the immediate effects of one-time acupuncture on the muscles of athletes are clearly lacking. Thus, this study aimed to examine the effects of acupuncture therapy on the maximal voluntary isometric contraction (MVIC) electromyography (EMG) of the rectus femoris and tibialis anterior muscles. This study was conducted among 20 healthy male college students who had no musculoskeletal disease. The participants were subjected to 3 different experimental conditions and subsequently grouped based on these conditions: real acupuncture, sham acupuncture, and control. A 7-day washout period was implemented to avoid any transient effects on the physiological and psychological conditions of the participants. Subsequently, an electromyogram patch was attached on the most developed area in the middle of the origin and insertion of the rectus femoris and tibialis anterior muscles. The percent MVIC, which was used to standardize the signal from the electromyogram, was determined, and the maximal value from the MVIC of the rectus femoris and tibialis anterior muscles was measured. The MVIC EMG activities of both femoris ($F = 6.633$, $p = 0.003$) and tibialis anterior ($F = 5.216$, $p = 0.008$) muscles were significantly different among all groups. Accordingly, the results of a posthoc test showed that the real acupuncture group had higher MVIC EMG activities in the femoris ($p = 0.002$) and tibialis anterior ($p = 0.006$) muscles compared with the control group. These results suggest that treatment with real acupuncture resulted in significantly higher MVIC EMG activities of the rectus femoris and tibialis anterior muscles than the other treatments. Hence, acupuncture may be helpful in the improvement of muscle strength among athletes in the physical fitness field.

Acupuncture was developed 3000 years ago in China, and since then, it has become one of the most frequently used alternative medicines worldwide that are recognized for their positive physiological effects.[1] Recently, the frequency of acupuncture usage in the treatment of sports-related muscle damage has increased. For example, 12% of American college athletes experienced acupuncture treatment, and this percentage is higher than that of American adults who utilized the same treatment.[2]

Additionally, several studies on the effects of acupuncture on performance improvement of athletes have been conducted, with strength being the most frequently studied outcome. For instance, Osborne et al. reported that treatment with acupuncture in the middle of a match was effective in increasing strength, alleviating pain, and improving range of motion.[3] Furthermore, Hubscher et al. reported that the isometric extension strength of the knee was improved through acupuncture on the acupoint.[4] Ozerkan et al. also showed that soccer players who were treated with acupuncture experienced increased isokinetic flexion and extension strength of the knee.[5] Moreover, Huang et al. demonstrated that the dorsi and plantar flexion strengths of the ankle improved by 21.3% following a 4-week acupuncture treatment compared with another ankle without any treatment.[6] Larisa et al. also reported increased isometric strength and electromyography (EMG) activation after acupuncture stimulation.[7]

Nevertheless, studies on the immediate effects of one-time acupuncture treatment that is directly applied in the field on the muscles of athletes are still significantly lacking. Therefore, this study aimed to examine the effects of acupuncture therapy on the maximal voluntary isometric contraction (MVIC) EMG activities of the rectus femoris and tibialis anterior muscles.

METHODS

Participants

This study was conducted among 20 healthy male college students who had no musculoskeletal diseases (age, 21.35 ± 4.12 years; height, 174.14 ± 7.75 cm, weight, 73.03 ± 9.91 kg; body mass index, 24.04 ± 2.61 kg/m^2; and percent body fat, 16.22 ± 4.58%).

To investigate the time effects (before and right after treatment) of one-time acupuncture treatment, the participants were randomly assigned into 3 treatments groups: real acupuncture, sham acupuncture, and control groups. However, this study was also designed to allow the participants to experience 3 treatment conditions (real and sham acupuncture and control) through a randomly ordered cross progress. For example, participant "A" experienced being assigned in all treatment groups by receiving real acupuncture, sham acupuncture, and control treatments in order with 1-week washout period in between treatments. This 1-week washout was implemented to ensure the absence of the accumulative effect of repetitive acupuncture treatment at each stage of treatment. A placebo effect was also avoided by informing the participants that the study was conducted to investigate the differences between various acupuncture areas, although the study was actually performed to identify the difference between real and sham acupuncture in terms of their effects. A trained Korean medicine doctor provided the real and sham acupuncture and control treatments. A double-blind method was applied by ensuring that the researcher who measures the muscle strength do not know which kind of acupuncture was applied to the participant.

Acupuncture Treatment

Various studies reported that sham acupuncture exerted good effects on the body[8] and remained effective although the acupuncture was conducted on the skin or other areas without an acupoint.[9,10] Thus, designing the treatment plan of this study to include acupuncture, sham acupuncture, and control treatments is important to clearly investigate the effects of this therapy.[10]

The participants of the real acupuncture group received acupuncture treatment in a comfortable lying position or lying with the face down for 15 min. The size of the needle was 0.30 × 40 mm (DongBang AcuPrime® Ltd., Exeter, UK), and the depth of acupuncture was 5–30 mm based on the body structure of the participants in accordance with the modified acupuncture protocol developed by Hubscher et al.[4]

Meanwhile, the participants of the sham acupuncture group received acupuncture treatment on

an area that is more than 2.5 cm apart from acupoint, with the needle allowed to stick into the skin layer. The length of the acupuncture treatment in the sham acupuncture group was 15 min, similar to that of the real acupuncture group.

Unlike the participants of the first two group, those of the control group only received skin stimulation using the Park Sham Placebo Device (DongBang AcuPrime® Ltd., Exeter, UK), which has a blunt point that becomes shorter and does not penetrate the skin. In short, this device only conducts stimulation using a magnetic needle.[11] This device prevents the occurrence of a placebo effect as the participants felt that they received real acupuncture although the needle did not penetrate their skin. The control group also received the treatment on a skin area that was not an acupoint and sensitive. Additionally, the control group comfortably received the treatment by lying with their eyes closed or face down, similar to that of real and sham acupuncture groups.

EMG MEASUREMENTS

The measurement of the muscle EMG activities was conducted by removing the body hair and washing the skin with alcohol to reduce the presence of debris and lotion to minimize the noise when attaching the electrode on the selected area. A well-prepared skin has a resistance degree of 0.2–0.9 kΩ. Moreover, a retest was conducted to minimize the signal error on the EMG if in doubt as the skin resistance can change over time. The distance between the electrodes was 1.5 cm. Whether each EMG signals was correctly measured was determined. Additionally, an electromyogram patch was attached on the most developed area in the middle of the origin and insertion of rectus femoris and tibialis anterior muscles. Subsequently, the percent MVIC, which is used to standardize the signal from the electromyogram, was determined, and the maximal value was measured by contracting the rectus femoris and tibialis anterior muscles maximally.[12]

Statistical Analyses

All the data in this study were expressed as mean and standard deviation. One-way analysis of variance was conducted before and after treatment to investigate in detail the differences between groups. Furthermore, Tukey's honest significant difference posthoc test was conducted. SPSS Statistics (version 18.0 for Windows; SPSS Inc., Chicago, IL, USA) was used for all analyses, and $p < 0.05$ was considered statistically significant.

RESULTS

Table 1 shows the differences in the MVIC EMG activities of the rectus femoris and tibialis anterior muscles after needle withdrawal acupuncture therapy.

TABLE 1 Differences between the Maximal Voluntary Isometric Contraction Electromyography Activities of the Rectus Femoris and Tibialis Anterior Muscles after Needle Withdrawal Acupuncture Therapy

Muscle	Test	Control (n = 20)	Sham acupuncture (n = 20)	Real acupuncture (n = 20)	Overall F	Overall p
Rectus femoris (mV)	Pre	2172.51±556.60	2207.25±579.40	2141.93±552.26		
	Post	2078.67±567.10	2298.19±461.11	2404.77±580.53		
	Difference	−93.84±242.45	90.94±290.64$^{N/S}$	262.85±380.22$^{\#\#}$	6.633	0.003**
Tibialis anterior (mV)	Pre	2033.75±712.68	1995.32±930.66	2082.49±503.96		
	Post	1865.98±790.60	2167.16±821.07	2590.23±403.55		
	Difference	−167.77±783.36	171.85±671.84$^{N/S}$	507.74±497.13$^{\#\#}$	5.216	0.008**

$^{**}p < 0.01$ through one-way analysis of variance.
N/S = not significant; $^{\#\#}p < 0.01$, when compared with the control group (Tukey's honest significant difference post-hoc test).

No significant differences in the MVIC EMG activities of both femoris ($F = 6.633$, $p = 0.003$) and tibialis anterior ($F = 5.216$, $p = 0.008$) muscles were observed among all groups. Accordingly, the result of the posthoc test showed that the real acupuncture group had higher MVIC EMG activities in the femoris ($p = 0.002$) and tibialis anterior ($p = 0.006$) muscles than the control group.

DISCUSSION

Acupuncture is a therapy where a sharp needle is inserted into the skin through an acupoint, a specific area that is targeted to alleviate pain. Acupoint refers to a response point that is linked to an internal body organ and known as an area with decreased bioelectrical resistance and increased conductivity.[13,14]

Acupuncture originated from ancient China and is based on the meridian theory. This therapy is used to manage pain around the magnetic needle area, functional disability in the internal organ, and both pain and functional disability in distant areas. However, the effects of acupuncture remain to be clearly investigated, although several studies attempted to reveal the mechanisms behind the effects of acupuncture.[1,15]

In the present study, the real acupuncture group showed significantly increased maximal EMG activity compared with the control group. This finding is attributed to the effect of the needle stimulation on the afferent sense and elevated muscle EMG activity and substances, such as adenosine diphosphate and calcium ions, which continuously increased until 1 hour of acupuncture treatment, thereby affecting muscle contraction.[16,17] Furthermore, Lo et al. reported that the cerebral motor cortex was activated through transcranial magnetic stimulation (TMS)[18] at least 15 minutes after needle removal. This finding supports the result of this study in which the effects of acupuncture were attributed to the afferent sensory nerve stimulation.

Additionally, various applications will be possible considering that the EMG activities of the muscles was increased following acupuncture stimulation. Flexing the quadriceps as much as possible by avoiding flexion and extension motion on the knee when conducting early-stage rehabilitation after ACL surgery is important.[19] Moreover, acupuncture stimulation on the quadriceps in this rehabilitation phase helps patients to resume their daily life activities after surgery by assisting with maximum muscular contraction.

This study has some limitations to consider when interpreting the results. First, this study did not include various physical fitness variables, such as cardiorespiratory endurance, muscular endurance, flexibility, power, agility, and balance, in the analysis. Hence, further comprehensive study that incorporates these physical fitness variables in the analysis are necessary.

For patients with muscular dystrophy, muscular contraction exercise on the joints of the limbs can prevent muscular dystrophy or weakness to some degree. However, excessive muscular contraction exercise can cause muscle damage. Hence, resistance exercise to prevent muscular dystrophy among patients with muscular atrophy should be performed.[20] Furthermore, performance of isometric muscular contraction exercise following acupuncture stimulation can lead to a more stable rehabilitation among these patients.

Second, the participants in this study do not represent the entire college student population in Korea because they were recruited from only one university in the country. Lastly, this study only consists of a small sample population ($n = 20$). Thus, future studies that involve a large number of participants are needed. However, despite these limitations, the findings of this study remains significant because they are specific to the effects of acupuncture among the youth.

CONCLUSION

The results of this study suggest that the maximal EMG activities of the rectus femoris and tibialis anterior muscles significantly increased after

treatment with real acupuncture. Hence, acupuncture may be helpful in the improvement of the muscle strength of athletes in the physical fitness field.

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