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Research article

Effects of Suspended Moxibustion on Delayed Onset Muscle Soreness: A Randomized Controlled Double-Blind Pilot Study

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Abstract
The objective of this study was to investigate the effects of suspended moxibustion upon tender point on delayed onset muscle soreness. The study was a randomized double-blind controlled trial with 50 subjects in each group. Subjects in moxibustion group received suspended moxibustion upon tender point (by palpation) twice. The controls received no treatment. Each subject received treatments twice, 24 hr and 48 hr after the delayed onset muscle soreness induction. The measurements of Pain Visual Analog Scale, maximum isometric muscle strength and circumference were made immediately after delayed onset muscle soreness induction, before and after every treatment session and 72 hr after delayed onset muscle soreness induction. There were no significantly statistical differences between two groups at all measurement time points on maximum isometric muscle strength and circumference. However, the Pain Visual Analog Scale scores after first treatment session and 72 hr after delayed onset muscle soreness induction in moxibustion group was less than the control group, with significant difference ($p < 0.05$). The suspended moxibustion failed to show the effect on delayed onset muscle soreness. However, results need to be cautiously interpreted because of the pilot character of this study. The suspended moxibustion has a potential effect of pain relief on DOMS from the analysis of the data of this study. A large sample size trial is needed to confirm the effect of the suspended moxibustion on DOMS in the future.

Key words: Pain, muscle injury, tender point, exercise, DOMS, moxibustion.

Introduction

Delayed Onset Muscle Soreness (DOMS) is a common myogenic pain which occurs 24 to 48 hr after unaccustomed or, in particular, eccentric exercise. It can occur in untrained people who suddenly begin to exercise or even in athletes who try to learn new training patterns (Craig et al., 1999b; Petrofsky et al., 2011). It is a benign condition which usually subsides after 3–4 days of relative inactivity. Nevertheless the symptoms of DOMS affect daily activities and athletic performance, especially in kinetotherapy, the pain and discomfort may discourage a patient from persisting in therapy or disrupt his rehabilitation progress (Douris et al., 2006; Ernst, 1998; Lau and Nosaka, 2011). Therefore, it is necessary to use some interventions to relief the symptoms of DOMS.

The mechanism of DOMS is an inflammation process which is activated by high tensile forces induced muscle strain (Douris et al., 2006). According to the mechanism of DOMS, numerous studies have investigated the efficacy of drug therapy (anti-inflammatory agents and oral analgesics) and physical therapy (massage, phototherapy, heat modalities, hydrotherapy, ultrasound, vibration, electrical nerve stimulation and laser and ice). However, those studies have yielded conflicting and equivocal results (Aminian-Far et al., 2011; Craig et al., 1999a; Craig et al., 1996; 1999b; Douris et al., 2006; Ernst, 1998; Lau and Nosaka, 2011; Petrofsky et al., 2011; Sellwood et al., 2007; Vaile et al., 2008). Three studies have investigated the effects of acupuncture on DOMS, one study reported that acupuncture has little effect upon the cardinal signs and symptoms of DOMS, and the other two studies both considered that acupuncture can relief muscle pain of DOMS.

Moxibustion is an oriental traditional therapeutic remedy by utilizing cauterization or heating with ignited flammable material applied to acupoints. There have been studies on the mechanism of moxibustion working on the local region of the human body. Xinmin et al. (1999) found that moxibustion could significantly change temperature from the skin to the muscle, with different patterns. An experiment has shown (Yuanhua and Tangyi, 1996) that moxa could emit near-infrared during the combustion process, which can stimulate the hydrogen bonds of the macromolecule in the acupoints, resulting in stimulated coherence resonance absorption effect, through the nerve-fluid system to transfer the energy needed by cells. Moxibustion could induce heat shock protein (HSP) (Kobayashi, 1995). Numerous clinical studies (Chen et al., 2012; Lee et al., 2010a; 2010b; Ren et al., 2011) demonstrated that moxibustion can relieve pain of muscle and joint. Also laboratory studies suggest that moxibustion has anti-inflammatory effect.

Suspended moxibustion, the indirect moxibustion, is a safe treatment technique and easy to be handled by treatment provider. Above all, it is conceivable that the suspended moxibustion could be a potential treatment for DOMS. However, there is no evidence to support this hypothesis. Therefore, the aim of the present study was to investigate the effects of suspended moxibustion upon tender point compared to sham treatment on symptoms and muscular performance in exercise-induced DOMS.

Methods

Study design

The present study was a randomized, controlled, double blinded trial to investigate the effects of suspended moxibustion upon tender point in DOMS patients.

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Subjects

Fifty healthy student volunteers were recruited from the Shandong Normal University. Exclusion criteria included: cardiovascular, pulmonary, metabolic, neurological, psychiatric and musculoskeletal diseases, pregnancy, history of active hemorrhaging, heat or moxibustion sensitivity, participated in an exercise strength training program within 6 months, and the use of any medications. Subjects were instructed to refrain from any form of physical exercise for at least 1 week prior to as well as during the entire study period. Any drinks containing caffeine or alcohol were forbidden during the entire study period.

Ethics

Volunteers were informed of the procedures and voluntarily participate in the present study by signing a consent form. The study was approved by the Faculty of Physical Education of Shandong Normal University and followed the Declaration of Helsinki recommendations for research involving human subjects (Harriss and Atkinson, 2011).

Study settings

The present study took place at the exercise science and rehabilitation laboratory of the faculty of physical education of Shandong Normal University. There are an isokinetic dynamometer which can be used to induce DOMS and several therapeutic beds which can provide an environment for moxibustion therapy.

Procedures

Subjects attended the research according to their individual schedule in consecutive 4 days. On the first day, after the measurements of height, weight, maximum isometric muscle strength of nondominant elbow flexors and circumference of nondominant upper arm, each subject performed a DOMS induction protocol (See next paragraph) by an isokinetic dynamometer. Each subject received twice treatments 24 hr and 48 hr after the DOMS induction. The measurements of Pain Visual Analog Scale (Pain VAS), maximum isometric muscle strength and circumference were made immediately after DOMS induction, before and after every treatment session and 72 hr after DOMS induction.

Sample size

As a preliminary study, there were no data available to determine the sample size of the present study. An intergroup difference was reported in a published study in which 40 subjects were recruited to investigate the effects of acupuncture on tender points for DOMS. Thereby, given a predicted dropout rate of 20%, we determined 50 subjects recruited in the present study, 25 people in each group

Randomized treatment Allocation

Subjects were randomly assigned following simple randomization procedures to two groups: moxibustion group and control group. The randomization sequence was generated by the designer of the present study using a random number table.

DOMS induction

We used a modified method which was mentioned in Lau's research (Lau and Nosaka, 2011) to induce DOMS. This protocol consisted of ten sets of six maximal voluntary eccentric contractions of the nondominant elbow flexors against the lever arm of an isokinetic dynamometer (Con-trex, Switzerland) moving at a constant velocity of 90°per second. In each eccentric contraction, the elbow joint was forcibly extended from a flexed (90°) to a fully extended (180°) position in 1 second. After each eccentric contraction, the isokinetic dynamometer returned the arm to the flexed position at a constant velocity of 9° per second, which gave a 10-second rest between contractions. The rest period between sets was 2 minutes. In our research, several subjects could not complete all of the ten sets of contractions because of lack strength. We encouraged these subjects to perform the contractions as much as possible and finished the exercise until they felt exhausted.

Interventions

Moxibustion group: Subjects in this group lied supine on the therapeutic bed and received a 20 minutes suspended moxibustion upon tender point until there was local skin blush, but no pain. Tender point was identified (by palpation) as the most tender area at the front midline of the nondominant upper arm. The tender point was typically located on the distal third of the belly of biceps brachii approximately over the musculotendinous junction. We used a box to suspend the burning moxa stick which was carbonized, without smoke and smell upon the tender point. A hole with three spring leaf on the top of box is used to fix the moxa stick and adjust the interval between moxa stick and skin. Two holes on the sides of box are used to keep ventilation and watch the burning status of the moxa. A wire netting is fixed on the bottom of box to prevent skin burned by ashes of burning moxa. The treatment provider was trained on this moxibustion protocol by the study designer who has a qualification of Traditional Chinese Medicine practitioner.

Control group: Subjects in this group lied supine on the therapeutic bed and rest for 20 minutes.

Measurements

Pain assessment: Subjective pain was assessed by using the Pain VAS. We wrote a Pain VAS application which could run on a panel computer with the Android system. A 10-centimeter line with "no pain" marked at one end and "maximum pain" marked at the other appeared on a panel computer screen when the application was running. Subjects were asked to mark a short vertical line across the Pain VAS scale line on the screen using their forefingers to indicate their current level of pain after a full elbow flexion. The score of each assessment calculated by computer and appeared on the computer screen when the investigator clicked the *result* button on the computer screen.

Maximum isometric muscle strength: The voluntary maximal isometric strength of the elbow flexor was measured by using an isokinetic dynamometer. Subjects performed two 3-second maximal isometric contractions at elbow joint angles of 90°. They had a 30-second rest between two contractions. The higher torque of the two measures was used for further analysis.

Circumference: Using a constant-tension tape, the measurements of circumference were taken from 4 sites (3 centimeters below and 5, 9, and 13 centimeters above the elbow crease) of the nondominant arm while the arm was hanging relaxed by the subject's side. We marked the 4 sites by using a semipermanent ink marker for obtaining consistent measures. Each cite was measured twice and an average of two was calculated. Finally, the mean value of the four measurement sites was used for further analysis (Lau and Nosaka, 2011).

Blinding procedure

Allocation was retained by the study designer until the end of the study to ensure allocation concealment. Investigator of the outcome assessments and data analysts were kept blinded to the allocation, and subjects and treatment provider were advised not to reveal their group allocation to the outcome investigators. Subjects were blinded as to which intervention was considered treatment. The treatment provider did not take outcome measurements.

Statistical analysis

Baseline characteristics were analyzed with analysis of variance (for continuous measures) and the chi-square test (for nominal data) to assess for differences among the 2 study groups.

We applied a mixed-effects analysis (ie, 6×2 model; time × group) to analyze the effects on Pain VAS, maximum isometric muscle torque, and circumference, with the levels immediately after DOMS induction, before and after twice treatment session and 72 hr after DOMS induction. If statistically significant, the mixed model used for each outcome variable was followed by independent-sample t test between two groups on six time points.

All data c data are presented as mean (±SD). Data analysis was performed with SPSS statistical software version 21.0

Results

Subjects

Fifty subjects were randomly assigned to the groups: moxibustion group (n = 25 male), controlled group (n = 25 male). Two subjects in moxibustion group dropped out. The reason for dropouts was that two subjects refused to do the DOMS induction. The data from 48 subjects who completed the study included in the final analysis. Figure 1 shows the flow of subjects following the recommendation of the Consolidated Standards of Reporting Trials (CONSORT).

The ranges of the age, weight and height of the subjects were 18-20 years old, 64-79 kilograms and 1.74-1.85 meters, respectively. No differences were found among the groups for the values of age, weight and height by using one way ANOVA analysis. Table 1 shows the data of subject characteristics.

Table 1. Subject characteristics for each group. Data are means (±SD).

Demographic	Control group (n = 25)	Moxibustion group (n = 23)
Age (years)	19.08 (.76	19.00 (.74
Weight (kg)	72.17 (5.88	70.41 (6.24
Height (m)	1.80 (.04)	1.80 (.05)

Analysis of variance (for continuous measures) and chi-square test (for nominal data) were used to compare the baseline characteristics among the 2 groups.

Pain VAS scores

Table 2 shows the mean Pain VAS scores of two groups respectively at each measurement time point we had

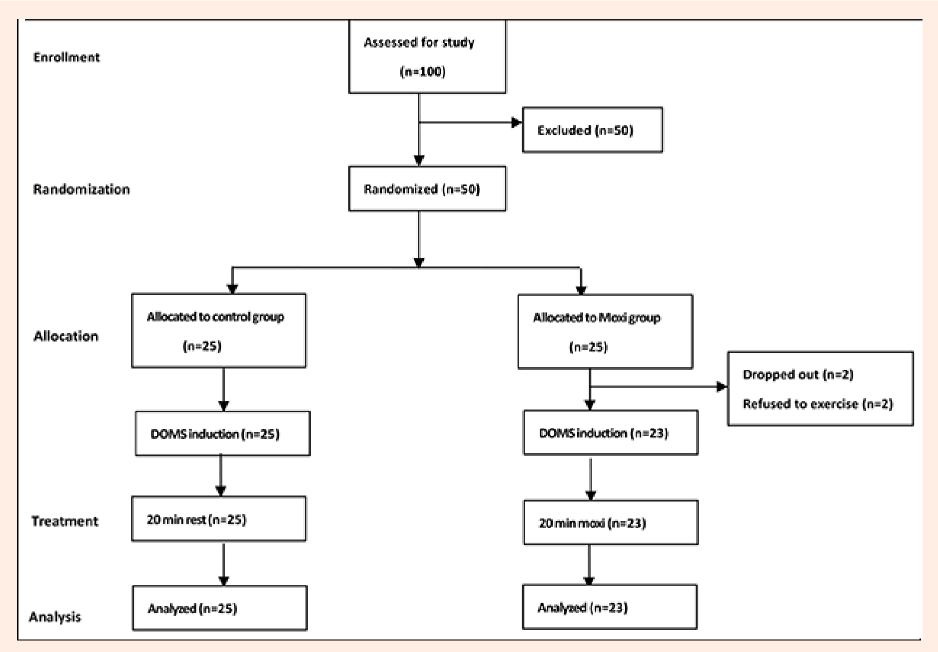

Figure 1. Subject participation flow in the study. moxi = moxibustion

Table 2. **The means (±SD) of PAIN VAS, maximum isometric muscle strength and circumference in two groups.**

Measure	Moxi Group (n=23)	Control Group (n=25)	Mixed-Methods Analysis, P	Independent-sample t test Moxi vs Control
Pain VAS				
Baseline	.00	0.00	.111	
Immediate	1.82 (1.54)	1.64 (1.38)		.792
Per-24	3.35 (.93)	3.71 (1.26)		.092
Post-24	3.29 (1.20) *	4.11 (1.36)		.006
Per-48	2.91 (1.33)	3.24 (1.16)		.637
Post-48	2.89 (1.36)	3.21 (1.17)		.382
72	1.41 (.79) *	1.99 (1.01)		**.030**
Maximum Isometric Muscle Strength				
Baseline	51.59 (12.31)	58.27 (14.52)	.062	
Immediate	44.69 (13.73)	43.04 (15.55)		**.019**
Per-24	43.13 (13.64)	43.11 (16.21)		.170
Post-24	36.74 (10.98)	38.97 (15.58)		.345
Per-48	41.66 (13.85)	40.56 (16.31)		.102
Post-48	39.19 (13.43)	37.01 (15.33)		.062
72	46.84 (15.19)	43.11 (19.37)		.053
Circumference (cm)				
Baseline	25.76 (2.07)	25.72 (2.11)	.805	
Immediate	26.08 (2.00)	26.16 (2.14)		.323
Per-24	25.90 (1.99)	26.00 (2.11)		.422
Post-24	25.91 (1.989	25.97 (2.10)		.747
Per-48	25.94 (1.97)	25.94 (2.08)		.644
Post-48	25.92 (1.90)	25.84 (1.92)		.345
72	25.92 (1.93)	26.05 (2.06)		.223

Control = control group, Moxi = moxibustion group. Mixed-methods analysis was the global test indicating differences within and between groups. Post hoc testing was performed with unpaired t tests by comparing change since baseline between groups. immediate = immediately after DOMS induction, per- = per-treatment, post- = post-treatment, 24 = 24 hours after DOMS induction, 48 = 48 hours after DOMS induction, 72 = 72 hours after DOMS induction, Pain VAS =Pain Visual Analog Scale, MIMS= maximum isometric muscle strength. ANOVA =Analysis of Variance. * = $p < 0.05$ (comparison between group).

scheduled. Immediate and *per-treatment of 24 hr*, two groups showed a similar tendency. There were no statistically significant differences among two groups ($p > 0.05$). However, there were detailed differences between moxibustion group and control group at post-treatment of 24 hr after DOMS induction and 72 hr after DOMS induction. The Pain VAS scores at post-treatment of 24 hr after DOMS induction in moxibustion group decreased, while the same comparison showed an increase in control group. The Pain VAS scores at 72 hr after DOMS induction in moxibustion group were lower than the control group. Both differences were significant ($p < 0.05$, by repeated measurement test).

Maximum isometric muscle strength

Table 2 shows the mean values of maximum isometric muscle torque at elbow joint angles of 90°. The maximum isometric muscle strength decreased at immediately, 24 hr and 48 hr after DOMS induction in two groups. There was no improvement of the maximum isometric muscle strength at any time points in moxibustion group. There were no statistical differences significantly among two groups at all measurement time points except immediately after DOMS inducion.

Circumference

The changes of circumference in two groups showed a similar tendency (see Table 2). The mean values of circumference of all groups increased at immediately, pre-treatment of 24 hr after DOMS induction, then began to decrease at post-treatment of 24 hr after DOMS, and reached the lowest at post-treatment of 48 hr after DOMS. There were no statistical differences significantly among two groups at all measurement time points.

Discussion

In the present study, according to the increases of Pain VAS and circumference and the decrease of muscle strength at 24 hr after DOMS induction as well as the recovery at 72 hr after DOMS induction, we considered that we succeeded to induce the occurrence of DOMS by the exercise protocol using the isokinetic dynamometer. The successful model of DOMS guaranteed the precise evaluation of the effects of interventions on DOMS.

The results of Pain VAS in the present study showed no statistical differences significantly between two groups at immediately, per-treatment of 24 hr, per-treatment of 48 hr and post-treatment of 48 hr after DOMS induction, while there were statistical differences significantly between two groups at post-treatment of 24 hr and 72 hr after DOMS induction. Moreover, the studies of Hubscher et al. (2008) and Itoh et al. (2008) reported that tender point acupuncture could relief the perceived pain of subjects with DOMS. Therefore, we considered that the moxibustion upon tender point had an antalgic effect on DOMS. Ischemia causes muscle contraction and spasm, leads to generation of material inducing pain, and further causes muscle tonic spasm, resulting in more severe pain in the local area, which is one of the possible mechanisms for the onset of pain symptoms in DOMS (He et al., 2008) We speculate that moxibustion can improve the local temperature to improve muscle blood flow, thereby relieve muscle spasms, and ultimately alleviate of pain. In addition, the local heat treatment can also improve muscle viscosity, improve muscle flexibility, which is could be another possible mechanism to relieve the pain of DOMS.

According to the results of muscle strength in the present study, we hold that the treatment of suspended moxibustion upon tender point has no effects on muscle strength recovery. To the best of our knowledge, many studies reported that non-pharmaceutical treatments like vibration (Lau and Nosaka, 2011), acupuncture (Hubscher et al., 2008), interferential therapy (Minder et al., 2002) and massage (Frey Law et al., 2008) did not favor the muscle strength recovery after DOMS induction. Our results of muscle strength were consistent with those prior studies. However, a research (Wenquan, 1994) reported that using moxibustion upon some acupoints, such as Xuehai (SP 10), Fengshi (GB 31), Zusanli (ST 36), could benefit the recovery of the decreased muscle strength caused by DOMS. In our future research, we should design a trial using moxibustion upon some acupoints to observe and verify the effect of moxibustion on the recovery of muscle strength after DOMS induction.

The results of circumference in the present study demonstrated that the tender point suspended moxibustion has no advantage on reducing the swelling of DOMS compared with other treatments. This was consistent with the prior studies which evaluated the effects of other non-pharmaceutical treatments on reducing the swelling of DOMS (Douris et al., 2006; Howatson and Van Someren, 2003; Lau and Nosaka, 2011; Sellwood et al., 2007; Vaile et al., 2008)

As a pilot study, there are several limitations in the present study. Firstly, although we determined the sample size by referring a prior study about acupuncture, the sample size of the present study were not large enough to detect the differences, because the suspended moxibustion as a mild treatment might have lower efficacy than acupuncture. Secondly, we only stimulated one tender point using the suspended moxibustion without combining other acupoints in 20 minutes. If we added more acupoints and prolonged the treatment duration, the effects of the suspended moxibustion on DOMS might be improved. Finally, we did not detect the prevent effects of suspended moxibustion on DOMS in the present study. We should add treatments twice before DOMS induction and immediately after DOMS induction in the future study.

Conclusion

According to the results of this study, the suspended moxibustion as a mild treatment lacks of effects of muscle strength recovery and reducing swelling on DOMS. However, results need to be cautiously interpreted because of the pilot character of this study. The suspended moxibustion has a potential effect of pain relief on DOMS from the analysis of the data of this study. A large sample size trial is needed to confirm the effect of the suspended moxibustion on DOMS in the future.

Acknowledgment

The authors declare that there is no conflict of interests regarding the publication of this article.

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Key points

- Moxibustion can relief pain of muscle and joint via anti-inflammatory effect, however, no evidence to support that moxibustion can be used on DOMS before the present study.
- The suspended moxibustion has effect of pain relief on delayed onset muscle soreness.
- A large sample size and treatment stimulation enhanced clinical study is needed to confirm the pain relief effect of the suspended moxibustion on DOMS in the future.

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