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Original Research

Effect of Topical Sports Cream Containing *Cymbopogon schoenanthus* on Acute Recovery Markers Following Exercise-Induced Muscle Fatigue in Competitive Athletes: A Pilot Study

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Abstract

Background: Muscle fatigue following high-intensity or repetitive training causes reduced muscle strength, restriction of blood flow, and increased muscle pain. The application of topical sports cream (TSC) as a recovery method has recently gained attention. However, few studies have investigated the effects of topical sports cream containing *Cymbopogon schoenanthus* (*CS*) on acute recovery markers. This study aimed to examine the effects of the acute application of a TSC containing *CS* after exercise-induced muscle fatigue on acute recovery markers. **Methods**: Ten taekwondo athletes (male: 5, female: 5) participated in this study. In a crossover design with 2-week intervals, participants were randomly assigned to two clinical trial groups: TSC and placebo cream (PC). Isokinetic dynamometers were used to create exercise-induced muscle fatigue, and the subjects repeatedly performed external and internal shoulder rotations. TSC containing *CS* was applied to the shoulder muscles of the subjects after the exercise. Maximum voluntary isometric contraction, muscle pain, blood flow, and skin temperature were measured before, during, immediately after, 30 min after, and 60 min after exercise. **Results**: A significant interaction effect was found in blood flow between time and group ($p = 0.032$, $\eta_p^2 = 0.157$). However, there was no statistically significant interaction effect between time and group for maximum voluntary isometric contraction (MVIC), muscle pain, and skin temperature ($p > 0.05$). **Conclusions**: Acute application of TSC containing *CS* is effective in increasing blood flow during the recovery period following exercise-induced muscle fatigue.

Keywords: *Cymbopogon schoenanthus*; muscle fatigue; muscle pain; topical sports cream; recovery

1. Introduction

Routines that require repetitive high-intensity muscle contraction or movements to which one is unaccustomed cause muscle fatigue in athletes [1,2]. This phenomenon can reduce athlete muscle strength and restrict blood flow to contracting muscles, resulting in insufficient oxygen delivery and inadequate removal of metabolic waste products [3]. Furthermore, muscle fatigue increases muscle pain and skin temperature and accordingly reduces physical conditioning in athletes [4,5]. Muscle pain does not only negatively affect athletes' psychological status but also restricts muscle contractions and reduces muscle strength [6,7].

Therefore, there is an urgent need for recovery methods that can improve athletes' well-being, reduce the risk of injury, and enable them to return to normal training as soon as possible [8,9]. Many sports scientists have conducted studies to promote athletes' recovery, the findings of which suggest various methods, including cold-water immersion, whole-body cryotherapy, massage, compression garments, foam rolling, neuromuscular electrical stimulation, and nonsteroidal anti-inflammatory drugs as potential management options [10–12].

Topical sports creams (TSCs) containing phytochemical extracts are among the most popular items sold by the general public [7,13]. According to a few studies, TSCs are effective in decreasing post-exercise muscle pain and promoting recovery [13,14]. Hill and Sumida [14] reported that the application of a menthol/methyl salicylate cream after exercise was effective in relieving pain in elbow flexor muscles. Manimmanakorn *et al*. [13] also stated that the application of a cream containing *Zingiber cassumunar* to quadriceps muscles immediately after exercise significantly reduced muscle pain compared to a placebo cream.

Cymbopogon schoenanthus (*CS*) is a desert species that grows in dry stony, which has been traditionally used to treat various diseases due to its strong aroma and excellent medicinal value [15,16]. Several studies have suggested using *CS* to treat pain because it has anti-inflammatory and anti-oxidative functions [16–18]. Such functions are expected to cause potential improvements in various recovery markers after exercise; however, there has been no study that has tested this hypothesis. In addition, sports cream-related studies have focused only on changes in pain after exercise, and observations of physiological changes related to fatigue are limited. Therefore, this study aimed to examine the effects of the acute application of a TSC containing *CS* after exercise-induced muscle fatigue on acute recovery markers, such as muscle strength, muscle pain, blood flow, and skin temperature. We hypothesized that TSC contain-

ing *CS* would accelerate the recovery of muscle strength, reduce muscle pain and skin temperature, and increase blood flow.

2. Materials and Methods

2.1 Subjects

Ten taekwondo athletes (five males and five females) were included in this study. The physical characteristics of the participants were as follows: mean age, 19.70 ± 1.49 years; mean height, 176.00 ± 7.13 cm; mean weight, 69.30 ± 10.52 kg; and mean body mass index (BMI), 22.4 ± 2.66 kg/m^2. The physical characteristics of the male and female participants are presented in Table 1. The subjects in this study regularly trained 4–5 days a week, and the average athlete career was 8 years. The number of subjects necessary for the study was calculated using the G*Power software (ver. 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany), with the following settings: alpha, 0.05; power, 0.8; and effect size = 0.5. As a result of the calculation, the required sample size for this study was 8. However, the dropout rate was considered, and 10 individuals were recruited. In addition, previous studies were used as references to calculate the number of participants [19]. This study used a crossover design with 2-week intervals and randomly assigned the subjects into two clinical trial groups (Fig. 1): the TSC and placebo cream (PC) groups. The subjects exercised five times a week and did not have any current musculoskeletal injury or were medicated for any medical reason. To ensure that the subjects met the inclusion criteria, they completed a health screening questionnaire. Those who completed the questionnaire provided a detailed explanation of the study objectives and procedures. The participants voluntarily signed an informed consent form approved by the Research Ethics Committee of Konkuk University.

Table 1. Physical characteristics of subjects.

	Male (n = 5)	Female (n = 5)	Total (n = 10)
Age (years)	20.20 ± 1.64	19.20 ± 1.49	19.70 ± 1.49
Height (cm)	181.60 ± 2.70	176.00 ± 7.13	176.00 ± 7.13
Weight (kg)	75.00 ± 8.57	69.30 ± 10.52	69.30 ± 10.52
BMI (kg/m^2)	22.72 ± 2.83	22.24 ± 2.68	69.30 ± 10.52

Data are presented as mean ± standard deviation (SD); BMI, body mass index.

2.2 Exercise-Induced Muscle Fatigue

In this study, isokinetic dynamometers (Humac Norm 776, CSMi, Stoughton, MA, USA) were used to measure exercise-induced muscle fatigue. Before exercise, the researcher asked the subjects to identify their dominant arm and instructed them to exercise their non-dominant arm. Considering the aspects of familiarity and adaptation, a non-dominant arm was selected. Each subject externally rotated their arm by approximately 45° with their arm flexed to 90° at the elbow in a sitting position in a dynamometer chair. While maintaining this position, the subjects comfortably grasped the handles of the tool in the scaption position. To induce fatigue, they performed alternating external and internal rotations of the shoulder. In the first round, the subjects exercised ten times at a speed of 100°/s. Then, in the following three rounds, the exercise was done 10 times at a speed of 60°/s. There was a 30 s break between each round. When maximum voluntary isometric contraction (MVIC) did not reduce by ≥40% after exercise, it was assumed that fatigue was not induced, and the subjects performed an additional two to four rounds of four to eight times of alternating internal and external shoulder rotations using the same methods. This definition of inducing fatigue was used in agreement with a few previous studies that used the same [20,21]. Throughout the exercise, standardized verbal encouragement was consistently provided to encourage the study subjects to exert maximum effort during the fatigue protocol. The researcher verbally encouraged by saying "Try your best" to the subjects during each round so that the subjects would perform muscle contractions with their maximum force at every repetition. Exercise-induced muscle fatigue protocol and procedure were performed following previous studies [21,22].

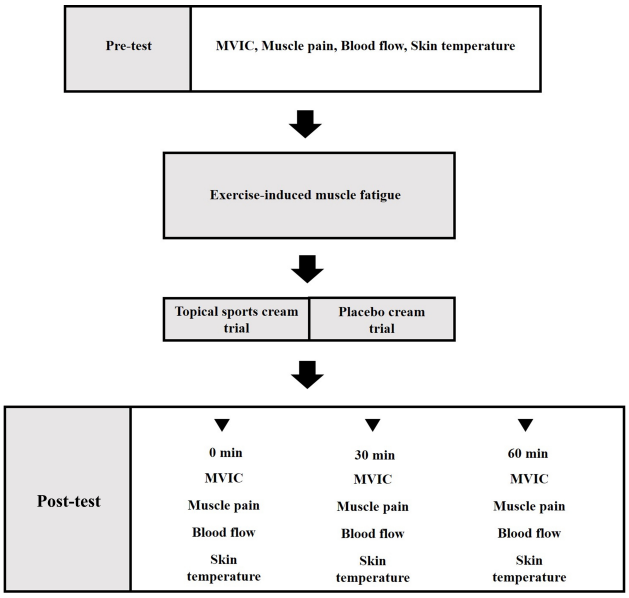

Fig. 1. Experimental procedure. MVIC, maximum voluntary isometric contraction.

2.3 Application of Topical Sports Cream

In this study, a TSC containing *CS* (MEGA POWER SPORTS CREAM, OS BIO, Cheongju, Korea) was applied, like a massage cream, to muscles around the subjects' shoulder (especially infraspinatus and supraspinatus muscle) upon completion of exercise intended to cause exercise-

Table 2. Changes in maximum voluntary isometric contraction (MVIC) after topical sports cream.

	Group	Pre	Post min	Post 30 min	Post 60 min	p	$\eta_p{}^2$
MVIC (Unit: N)	TSC (n = 9)	15.53 ± 8.67	7.69 ± 4.22	12.49 ± 7.61	13.09 ± 7.27	0.130	0.107
	PC (n = 10)	16.60 ± 8.02	7.18 ± 2.99	9.23 ± 3.86	11.12 ± 4.27		

Data are presented as mean ± standard deviation (SD). TSC, topical sports cream; PC, placebo cream; MVIC, maximum voluntary isometric contraction.

induced muscle fatigue. Approximately 5 g of the sports cream was applied. After each individually packaged sports cream (5 g) produced by the manufacturer was opened, it was applied to each participant. The cream was applied for approximately five minutes. The control cream contained the same ingredients, except for *CS* and was applied in a similar manner.

2.4 Maximum Voluntary Isometric Contraction

MVIC was measured in the same way as exercise using isokinetic dynamometers. As MVIC is isometric, concentric and eccentric external rotations were performed five times at 60° with 3 s between each movement; the average value was used. Moreover, for MVIC, the researcher verbally encouraged the subjects by saying, "Try your best", so that they would exercise with their maximum force. MVIC was measured before, 10 min after, 30 min after, and 60 min after exercise.

2.5 Muscle Pain Assessments

A visual analog scale (VAS) was used to measure muscle pain in this study. VAS has been used in many recovery studies [23,24] and has been reported to have excellent reliability and test-retest reliability as determined by intraclass correlation coefficients [25,26]. The VAS was anchored as "no pain" (score of 0) on the left and "worst pain imaginable" (score of 10) on the right. To measure the VAS score, the subjects drew a horizontal line over their self-perceived level of pain. In this study, the level of pain in the infraspinatus and supraspinatus muscles was measured separately. After the researcher palpated the infraspinatus and supraspinatus muscles of each subject, they were asked to measure the level of pain they felt.

2.6 Blood Flow

Heart-brachial pulse wave velocity (hbPWV) was measured to observe changes in blood flow after the application of TSC. hbPWV refers to the pulse wave velocity (PWV) from the heart to the carotid and radial arteries and was measured for 3 min using a PowerLab analog to digital converter (PowerLab8/45, Ad Instruments Ltd, NSW, Australia). LabChart 8.0 software (LabChart8, Ad Instruments Ltd., NSW, Australia) was used to analyze and calculate each wave of the measured hbPWV [27]. hbPWV was measured before, 10 min after, 30 min after, and 60 min after exercise.

2.7 Skin Temperature

Skin temperature was measured from areas around the shoulder using an infrared hand-held thermometer (UT305R, UNI-TREND TECHNOLOGY CO., LTD., Guangdong, China) a total of five times: two times before, and once every 10 min, 30 min, and 60 min after the exercise; the average value was used for analysis.

2.8 Statistical Analysis

All data are presented as mean ± standard deviation (SD). Repeated–measures analysis of variance (ANOVA) was used to examine the significant interaction effect between time and group. The Mauchly sphericity test was used to check the assumptions of homogeneity of variance, and if violated, the adjustment degree of freedom was adjusted using the Greenhouse-Geisser value. If there were significant interactions, a post-hoc analysis was performed using the independent *t*-test. Statistical analysis was performed using IBM SPSS Statistics software (version 19.0., IBM Corp., NY, USA). All statistical significance levels were set at $p \leq 0.05$.

3. Results

3.1 Change in Maximum Voluntary Isometric Contraction after Topical Sports Cream

The change in MVIC over time after the application of TSC for exercise-induced muscle fatigue is shown in Table 2. Immediately after exercise, MVIC was significantly reduced in both groups, and it was observed that it recovered again afterwards (main effect of time, $p < 0.001$, $\eta_p{}^2 = 0.635$). However, no significant interaction effect was found in MVIC between time and group after the application of topical sports cream ($p > 0.05$).

3.2 Change in Muscle Pain after Topical Sports Cream

Changes in muscle pain over time after the application of TSC for exercise-induced muscle fatigue are shown in Table 3. In the infraspinatus muscle, muscle pain significantly increased immediately after exercise and was highest after 30 min of exercise (main effect of time, $p < 0.001$, $\eta_p{}^2 = 0.878$). The supraspinatus muscle also significantly increased muscle pain immediately after exercise, and a similar level was observed until 60 minutes of exercise (main effect of time, $p < 0.001$, $\eta_p{}^2 = 0.902$). However, no significant interaction effect was found in pain from the infraspinatus and supraspinatus muscles between time and

Table 3. Changes in muscle pain after topical sports cream.

	Group	Pre	Post min	Post 30 min	Post 60 min	p	η_p^2
Infraspinatus (Unit: mm)	TSC (n = 9)	0.00 ± 0.00	44.33 ± 14.45	54.00 ± 11.52	53.44 ± 12.28	0.284	0.071
	PC (n = 10)	0.00 ± 0.00	46.50 ± 9.51	46.50 ± 10.75	46.00 ± 9.07		
Supraspinatus (Unit: mm)	TSC (n = 9)	0.00 ± 0.00	56.11 ± 12.07	53.44 ± 10.42	53.88 ± 16.06	0.746	0.024
	PC (n = 10)	0.00 ± 0.00	51.10 ± 12.69	52.90 ± 17.52	55.20 ± 17.20		

Data are presented as mean ± standard deviation (SD); TSC, topical sports cream; PC, placebo cream.

Table 4. Changes in blood flow and skin temperature after topical sports cream application.

	Group	Pre	Post min	Post 30 min	Post 60 min	p	η_p^2
HbPWV (Unit: cm/s)	TSC (n = 9)	295.42 ± 18.25	279.76 ± 20.29	284.91 ± 24.36	287.02 ± 25.28	0.032*	0.157
	PC (n = 10)	307.84 ± 22.52	301.00 ± 23.65	304.77 ± 39.90	284.82 ± 29.13		
Skin temperature (Unit: °)	TSC (n = 9)	36.70 ± 0.21	36.87 ± 0.21	36.72 ± 0.13	36.64 ± 0.27	0.118	0.108
	PC (n = 10)	36.54 ± 0.17	36.66 ± 0.24	36.68 ± 0.11	36.67 ± 0.18		

Data are presented as mean ± standard deviation (SD); * $p < 0.05$; TSC, topical sports cream; PC, placebo cream; hbPWV, heart-brachial pulse wave velocity.

group after application of TSC ($p > 0.05$).

3.3 Change in Blood Flow and Skin Temperature after Topical Sports Cream Application

Changes in blood flow and skin temperature over time after the application of T for exercise-induced muscle fatigue are shown in Table 4. Blood flow significantly decreased in both groups immediately after exercise ($p < 0.01$, $\eta_p^2 = 0.256$). However, a significant interaction effect was found in blood flow between time and group after the application of TSC ($p = 0.032$, $\eta_p^2 = 0.157$). The main effect of time on skin temperature was not significant ($p > 0.05$, $\eta_p^2 = 0.140$). In addition, no significant interaction effect was found in skin temperature between time and group after application of topical sports cream ($p > 0.05$, $\eta_p^2 = 0.018$).

4. Discussion

This study aimed to examine the effects of the acute application of TSCs containing *CS* after exercise-induced muscle fatigue on acute recovery markers. According to the results of this study, TSCs containing *CS* were found to be effective in increasing blood flow after exercise. The characteristics of sports creams can be considered the cause of this change. Sports cream is a blood-circulation-promoting cream that produces heat [28]. Previous studies have shown a significant increase in tissue blood flow when heat wraps are used [29]. Several recent studies have suggested that heat is a recovery strategy after repeated muscle contractions [30,31]. These studies reported that increased muscle blood flow can cause improved replenishment of muscle energy stores, improved function of blood vessels and mitochondria, and decreased muscle pain [30,31]. Repeated muscle contraction exercises that cause fatigue can ultimately contribute to premature fatigue, reducing the driving pressure of oxygen diffusion from capillaries to myocytes [32]. Based on these findings, it is suggested that an increase in blood flow after applying sports cream can potentially have a positive effect on recovery.

However, in this study, there was no change in muscle pain after the application of sports cream. Considering that muscle pain is observed high 24–48 hours after exercise [33], the timing of muscle pain observed in this study was very short, so it would have been difficult to properly confirm the change in muscle pain after sports cream application. Therefore, it is necessary to observe changes in muscle pain by increasing the observation time in future studies. Interestingly, there was no significant change in the tissue temperature, even though the blood flow rate increased. The cause of this change is unknown. A similar change was observed in a previous study. One study reported that the application of gel to local areas of muscle increased skin blood flow, but had no effect on the local heating response [34]. Accordingly, the changes in blood flow and skin temperature may not match. We found early evidence from this study that blood flow can be increased by sports cream, but it is not yet known how these changes actually affect recovery after exercise. The role of these changes in blood flow in recovery should be further investigated in future research.

The application of TSC after exercise did not cause any significant changes in MVIC during the recovery period. This result is contrary to the results of Johar *et al.*'s [7] study, which reported that the application of TSC to elbow flexor muscles after exercise resulted in a reduction of muscle pain as well as enhanced production of tetanic forces. However, this study differs from theirs [7] in a few respects. First, a different exercise-related protocol was used. More importantly, their study focused on menthol-based cream. Their findings were supported by a recent study [35] that reported the effectiveness of methanol in promoting strength recovery after exercise-induced muscle damage.

This study has several limitations. First, the observation period for acute recovery markers after exercise was short. Although pain occurs immediately after exercise, it

significantly increases 1–2 days after exercise. Hence, future studies should observe changes in these markers for a longer period. Second, TSC was applied only once after the exercise. A single application may have been insufficient to yield significant changes in the various indicators. Future studies should focus on increasing the frequency of applications. Finally, the exercise in this study included only the upper body muscles, and it remains unknown whether pain reduction is equally effective for the lower body muscles.

5. Conclusions

In this study, the acute application of TSC containing *CS* after exercise-induced muscle fatigue increased blood flow during the recovery period effectively. However, careful interpretation of these results is still necessary. This is because TSC has no effect on the changes in MVIC in this study, although fatigue is typically more closely related to MVIC reduction. Nevertheless, the results of this study are still in the early stages of development. In addition, the mechanism underlying this effect is not yet fully understood. More diverse studies should be conducted in the future.

Author Contributions

Study design—WY, JK; Data collection—WY, JK; Data analysis—WY, JK; Writing original draft—WY, JK; Manuscript review and editing—WY, JK. All authors read and approved final manuscript.

Ethics Approval and Consent to Participate

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Konkuk University (IRB No.7001355-202201-HR-509).

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Conflict of Interest

The authors declare no conflict of interest. JK is serving as one of the Guest editors of this journal. We declare that JK had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Hugo Sarmento.

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