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Effects of PNF Technique on Delayed Onset Muscle Soreness After Eccentric Exercise

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Abstract

This study examined the effects of hold-relax with agonist contraction (HR-AC) on the symptoms of delayed onset muscle soreness (DOMS) induced by intensive eccentric exercise of the non-dominant biceps brachii. Ten men (mean age=26.7 yrs, mean height=172.1 ㎝, mean weight=66.2 ㎏) and ten women (mean age=27.4 yrs, mean height=165.9 ㎝, mean weight=60.7 ㎏) who had not participated in a regular exercise program for the upper extremities in the previous six months were randomly assigned to one of two experimental groups: the HR-AC group, or the control group. We measured joint range of motion (ROM), maximal voluntary isometric contraction (MVIC), and muscle soreness before eccentric exercise, and 24, 48, and 72 hours after eccentric exercise. The subjects in the HR-AC group received the HR-AC technique in the non-dominant biceps brachii. The HR-AC technique was applied 24 and 48 hours after eccentric exercise. There was no significant difference between the HR-AC and the control group. However, the HR-AC group, compared to the control group, had a significant difference between the time points of the various parameters. Increased ROM ($p<.05$), decreased muscle soreness ($p<.05$), and reduced MVIC ($p<.05$) were found in the HR-AC group after 72 hours. Decreased ROM ($p<.05$) and MVIC ($p<.05$), and increased muscle soreness ($p<.05$) were observed in the control group. These findings suggest that the HR-AC technique effectively reduces muscle soreness and increases ROM 72 hours after eccentric exercise.

Key Words: Eccentric exercise; Hold-relax with agonist contraction; Maximal voluntary isometric contraction; Muscle soreness.

Introduction

Delayed onset muscle soreness (DOMS) results from micro-injury of the selective fast twitch fiber after intense unaccustomed eccentric exercise (Cheung et al, 2003). Muscle strain includes myofibrillar disruption, prolonged loss of muscle strength, decrements in motor control, changes in energy substrate levels, and the increase of muscle proteins in blood, such as creatine kinase (CK), lactate dehydronase (LDH), myoglobin, and myosin heavy chain fragments (Yu et al, 2003).

Several studies have demonstrated that proprioceptive neuromuscular facilitation (PNF) stretching techniques were more effective than static stretching for increasing the flexibility of the hamstring muscle (Etnyre and Abraham, 1986). The PNF stretching techniques are widely applied in the rehabilitation of patients with musculoskeletal system injury, as it reduces the resistance of the muscle in a pain free manner. Hence, If the PNF stretching techniques are

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applied in DOMS for alleviating its symptoms, they will be much more effective than static stretching (Prentice, 1999; Sullivan and Markos, 1995). In particular, an inhibition reflex circuit in hold-relax with agonist contraction (HR-AC) among the PNF stretching techniques can potentially reduce the limitation of the active joint range of motion (ROM) due to lack of muscle contraction, muscle coordination, or muscle power, as well as pain (Golhofer et al, 1998).

The HR-AC technique, one of the PNF techniques, combines autogenic inhibition and reciprocal inhibition to lengthen a muscle. During HR (isometric contraction), tendon tension registered by the golgi tendon organ is conveyed into the spinal cord by Ib afferents, stimulating interneurons that inhibit the α motor neurons to the same muscle, resulting in autogenic inhibition. During AC (concentric contraction), reciprocal inhibition decreases the activity of the α motor neuron in an antagonist when the α motor neuron in an agonist is active, allowing the agonist to act unopposed (Lundy-Ekman, 2002). Thus the HR-AC technique can effectively lengthen an agonist within pain.

Numerous studies have attempted to identify treatment strategies for DOMS, but few studies have applied the HR-AC technique. Therefore after DOMS was induced by eccentric exercise on the non-dominant biceps brachii muscle, the HR-AC technique was applied. The measurements include muscle soreness, range of motion (ROM) of the elbow joint, and maximal voluntary isometric contraction (MVIC). This study aims to determine the most effective treatment method to relieve the symptoms of DOMS.

Methods

Subjects

A total of 20 subjects (10 males, and 10 females) who had not participated in a regular exercise program for the upper extremities in the previous six months were randomly assigned to either the HR-AC or the control group. All the subjects provided informed consent after having the purpose and method of the study explained to them (Table 1).

Eccentric Exercise

The maximum weight that a participant was able to lift with his or her non-dominant arm for 1 repetition through the full range of motion on dumbbells was defined as the 1 repetition maximum (1 RM). DOMS was initiated in the participant's non-dominant arm by having the participant lower 60% of 1 RM in sets of 15 repetitions while maintaining an 8 sec rate of descent for each repetition. sixty sec of rest were provided between sets. The exercise ended when the participants were no longer able to maintain an 8 sec rate of descent.

Range of Motion

Extended and flexed elbow joint angles were assessed three times using the three dimension motion analysis system CMS70P[1)] calibrated at the fully extended elbow joint angle. The mean value of the three times was used for the ROM. The ROM was determined by the difference between the flexed and extended elbow joint angle. Before eccentric exercise, extended and flexed elbow joint angles were measured

Table 1. Descriptive statistics for study subjects height, weight and age (N=20)

	HR-AC group		Control group	
	Males (n_1=5)	Females (n_2=5)	Males (n_3=5)	Females (n_4=5)
Age (yrs)	25.2±4.5[a]	26.8±5.1	28.2±3.5	28±4.2
Weight (㎏)	62.2±3.1	53.1±6.4	70.2±6.0	51.1±6.5
Height (㎝)	171.3±3.7	57.9±3.3	172.8±2.6	158.9±1.6

[a]Mean±SD.

1) Zebris Mdizintechnik, GmbH, Isny, Germany.

in the full joint range; after eccentric exercise, they were measured at the pain point. ROM was evaluated before and for 3 days after eccentric exercise.

Maximal Voluntary Isometric Contraction

Maximal voluntary isometric contraction (MVIC) of the biceps brachii muscle was measured by force transducer[2] connected to a computer via the MP100 system with the Acqknowledge 3.7.3 software program (BIOPAC System Inc., CA, U.S.A.) for the subsequent analysis.

Subjects were seated on an N-K table[3] with the shoulder fixed and the elbow flexed to 80° a wrist band worn by the subject was attached to the force transducer. Subjects were asked to perform three maximal isometric contractions for 3 sec and then to rest for 5 min; the highest force of the three values was used for the analysis. MVIC was evaluated before and 72 hours after eccentric exercise.

Muscle Soreness

Biceps brachii muscle soreness on flexion and extension of the elbow joint was evaluated by a Visual Analogue Scale (VAS) that had a 100-㎜ line with "no pain" on one end (0 ㎜) and "extremely painful" on the other (100 ㎜). Subjects were asked to mark their subjective scale of soreness on the line under the supervision of the examiner. VAS was evaluated before and for 3 days after eccentric exercise.

Holding-Relax With Agonist Contraction Technique

Treatment was performed in a total of 5 sets, 24 hours and 48 hours after eccentric exercise.

At first, the examiner fixed the subject's shoulder using his hand. The elbows of subjects with DOMS were passively extended up to pain, and then were concentrically resisted by the examiner under the pain threshold without protective muscle splinting (minimal~moderate) for 7 sec.

The subjects then breathed in and out deeply 2~3 times to make the biceps brachii muscle release. The subjects' triceps muscles were actively extended up to pain, being concentrically resisted by the examiner under the pain threshold. This sequence was repeated 5 times on each subject in the experimental group. A 30 sec rest period was administered for each session. Each session was begun at the renewal elbow joint range (Prentice, 1999; Sullivan and Markos, 1995).

Statistical Analysis

Two-way analysis of variance (ANOVA) was used to test for differences between the HR-AC and the control group, as well as in terms of sex for body weight, age, and height. Analysis of variance with repeated measures was used to test differences in the ROM, MVIC, and muscle soreness before and at 24 hours, 48 hours, and 72 hours after eccentric exercise between the HR-AC and the control group. In particular the difference between the time points of the various parameters was tested using Bonferroni post-hoc testing. Statistical significance was set at α=.05. Statistical analyses were performed using SPSS 12.0.

Results

Range of Motion

ROM was significantly higher in the HR-AC group 48 and 72 hours after eccentric exercise ($p<.05$), while there was no difference in the control group (Table 2). There was no significant difference between the HR-AC and the control group.

Maximum Voluntary Isometric Contraction

MVIC was significantly decreased in the experimental groups before eccentric exercise and 72 hours after eccentric exercise ($p<.05$) (Table 3). There was no significant difference between the HR-AC and the control group.

2) TSD121C, BIOPAC System Inc., CA, U.S.A.
3) Preston, NJ, U.S.A.

Table 2. Variation of ROM through time sequence (Unit: °)

Groups	24 hours after~before exercise	48~24 hours after exercise	72~48 hours after exercise
HR-AC[a]	-16.8*	7.2	4.1*
Control	-24.9*	-3.4	5.9

[a]HR-AC: holding-relax with agonist contraction.
*p<.05

Table 3. Variation of MVIC through time sequence (Unit: kg)

	HR-AC[a] group	Control group
72 hours after~before exercise	2.8*	4.8*

[a]HR-AC: holding-relax with agonist contraction.
*p<.05.

Table 4. Variation of muscle soreness through time sequence (Unit: mm)

Groups	24 hours after~before exercise	48~24 hours after exercise	72~48 hours after exercise
HR-AC[a]	58*	-12	-24*
Control	61*	5	-12

[a]HR-AC: holding-relax with agonist contraction.
*p<.05.

Muscle Soreness

Muscle soreness was significantly decreased in the HR-AC group 48 and 72 hours after eccentric exercise (p<.05), while it was not in the control group (Table 4). There was no significant difference between the HR-AC and the control group.

Discussion

Since 1900, when Sherrington defined the basic concepts of muscle facilitation and inhibition, these concepts have been the basis for the PNF techniques. These concepts have been used as a reason for increased ROM and decreased resistance of the muscles through muscular relaxation (Olivo and Magee, 2006). According to some authors (Etnyre and Abraham, 1986), the PNF techniques, especially those involving reciprocal inhibition, such as the AC and the contract relax-antagonist contract (CRAC), provide the greatest potential for muscle lengthening, due to increased suppression of the motor pool.

The objective of this study was to investigate the effectiveness of the HR-AC technique. The HR-AC group was significantly increased in the ROM of the elbow joint and decreased in muscle soreness from 72 hours after eccentric exercise. That is, the ROM of the elbow joint was increased from 85.1° at 24 hours to 96.4° at 72 hours after eccentric exercise and muscle soreness decreased from a score of 58 at 24 hours to a score of 22 at 72 hours after eccentric exercise. When some studies compared the CR and the CRAC techniques to static stretching on hamstring flexibility, the PNF techniques significantly increased the ROM of the hip joint (Etnyre and Abraham, 1986; Funk et al, 2003), reinforcing the result of this study. The target contraction PNF procedure resulted in a greater muscle torque production, compared to the static stretch. The reason for the achievement of a greater ROM with the target contraction PNF procedure was that the subjects had an altered stretch perception, allowing them to go to a greater muscle length and generate more torque, before they felt the onset of pain (Magnusson et al, 1996). In the PNF procedures, an increased tolerance to stretch, as opposed to a change in viscoelastic

properties, has also been used to explain acute increases in ROM observed with static stretching (Magnusson et al, 1998).

However, we found a 2.8 kg decrease in muscle strength as a result of the HR-AC technique. Marek et al (2005) also reported that when the static stretch and the CR technique were performed on the subjects' hamstrings, the muscle's electrical activity and muscle strength were decreased. They suggested 2 hypotheses to account for the stretching-induced decrease in muscular force-producing capacity: (1) mechanical factors, such as alterations in the viscoelastic properties of the musculotendinous unit, and (2) neurologic factors, such as decreased motor unit activation.

As a result of this study, there was no significant difference between the HR-AC and the control group. However, the HR-AC group, compared to the control group, had significant difference between the time points of the various parameters. That is, the HR-AC technique demonstrated progressive recovery in the ROM or muscle soreness, but was not effective in muscle strength. In further studies, the therapeutic strategy should be established to reduce all the symptoms of DOMS.

Conclusion

The HR-AC technique on the symptoms of DOMS was not effective when compared to the control group. However, the HR-AC technique increased the ROM of the elbow joint, and decreased muscle soreness from 72 hours after eccentric exercise, while subjects in the control group did not show the ROM or muscle soreness recovery. These findings suggest that the HR-AC technique reduces effectively muscle soreness and increases ROM from 72 hours after eccentric exercise.

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