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Original Article

Effects of the hold and relax-agonist contraction technique on recovery from delayed onset muscle soreness after exercise in healthy adults

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Abstract. [Purpose] This study was conducted to verify the effects of the hold relax-agonist contraction and passive straight leg raising techniques on muscle activity, fatigue, and range of motion of the hip joint after the induction of delayed onset muscle soreness in the hamstring muscle. [Subjects] Sixty subjects were randomly assigned to a hold relax-agonist contraction group and a passive straight leg raising group. [Methods] Subjects in the experimental group underwent hold relax-agonist contraction at the hamstring muscle, while subjects in the control group underwent passive straight leg raising at the hamstring muscle. [Results] Subjects in the hold relax-agonist contraction group showed a significant increase in hamstring muscle activity and hip joint angle and a significant decrease in muscle fatigue. In the passive straight leg raising group, the hip joint angle increased significantly after the intervention. In the hold relax-agonist contraction group, hamstring muscle activity increased significantly and muscle fatigue decreased significantly. [Conclusion] We conclude that the hold relax-agonist contraction technique may be beneficial for improving muscle activation and decreasing muscle fatigue.

Key words: Delayed onset muscle soreness, Hold relax-agonist contraction, Passive straight leg raising

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INTRODUCTION

Delayed onset muscle soreness (DOMS) resulting from exercise is triggered by selective and minute damage to the fast twitch fibers due to sudden eccentric high-intensity exercise[1)]. High-intensity exercise exhausts energy sources including glycogen within the muscles, causes muscle tension, and prevents the discharge of side products of energy metabolic processes such as lactic acid[1)]. Lactic acid accumulation causes pain in the joints and muscles of certain areas, a sense of tenderness, local edema and stiffness, restricted range of motion and decreased muscle strength, lack of endurance, and decreased muscle coordination[1)]. The hamstring muscle, which is very important in adjusting the human body's movement during gait, is one of the most commonly damaged areas. When the hamstring muscle flexibility increases, muscle pain after exercise decreases and muscle coordination improves. Therefore, maintaining normal muscle length through regular stretching exercises after precisely evaluating hamstring muscle flexibility in advance not only prevents muscle shortening but also reduces the risk of hamstring muscle injury and may enhance physical activity.

Physical therapy activities to increase hamstring muscle length include the passive straight leg raising (PSLR) and hold relax-agonist contraction (HR-AC) proprioceptive neuromuscular facilitation techniques. HR-AC is a positive contraction technique that may efficiently lengthen the muscles with a combination of reciprocal agonist and antagonist inhibition and autogenic protagonist inhibition[2)]. PSLR, which was first described by Frost in 1881, is currently one of the most representative neurological tests for the lower limbs. Used as a passive contraction technique, it can stretch the hamstring muscle simultaneously with the sciatic nerve[3)]. This study was conducted to verify the effects of the HR-AC and PSLR techniques on muscle activity, muscle fatigue, and range of motion of the hip joint after DOMS induction to the hamstring muscle.

SUBJECTS AND METHODS

Sixty healthy people without an orthopedic history provided informed consent prior to participating in this study. All procedures were reviewed and approved by the Institutional Ethics Committee of Eulji University Hospital. The subjects were randomly assigned to the HR-AC group (n = 30; 12 males, 18 females) and the PSLR group (n = 30; 15 men, 15 women) via a computerized random number generator to determine group allocation. Subject age, height, and weight were 20.2 ± 1.4 years, 169.7 ± 5.1 cm, and 59.8

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± 10.2 kg in the HR-AC group and 21.3 ± 1.2 years, 171.8 ± 9.3 cm, and 62.2 ± 5.4 kg in the PSLR group, respectively. To induce DOMS in the hamstring muscle, subjects in both experimental groups walked downhill on a 10° declined treadmill at a speed of 4 km/h for 30 minutes[4].

After DOMS induction, the HR-AC and PSLR techniques were applied to each experimental group. For the HR-AC technique, the subjects lay supine and relaxed with a straight posture on the treatment table. The investigator passively stretched the hamstrings until the subject first reported a mild stretching sensation and held that position for 7 seconds. Next, the subject maximally isometrically contracted the hamstrings for 7 seconds by attempting to push the leg back toward the table against the resistance created by the investigator. After the contraction, the subject relaxed for 5 seconds[2]. For the PSLR technique, subjects lay supine in a straight posture on the treatment table and relaxed. With the knees extended and the hip joint bent as much as possible within its range, the hip joints were increasingly bent until the hamstring muscle was stretched with light, tolerable pain and held there for 30 seconds[3]. After the passive stretching, the subject relaxed for 5 seconds. All stretching was performed on the dominant lower extremity and the sequence was repeated 20 times in both groups.

Electromyography equipment (MP150; Biopac Inc, USA) was used to measure hamstring muscle activity and fatigue. While in a prone position, the subjects flexed the knees to contract the hamstring muscle. Maximal voluntary isometric contraction (MVIC) was derived using average electromyography signal volume for 3 seconds excluding the first and last seconds during the 5-second muscle contraction[5]. A lactic acid analyzer (Accutrend; RDGH, Germany) was used to measure the lactic acid level in the blood, which was collected from the capillaries of the tip of the second finger using a capillary tube and analyzed. A goniometer was used to measure the hip joint angle while the subjects maintained extension of the knee joints and flexed them to a maximal degree. The measured areas were based on the midline between the greater trochanter and the trunk and the greater trochanter and the lateral epicondyle of the femur.

Data analysis was performed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). Mean and SD were calculated for each variable. Before the intervention, differences in the general characteristics of the experimental and control groups were compared using independent t-tests and χ^2 tests. Comparisons of variables before and after training within each group were made using paired sample t-tests. Comparisons of pre- and post-test differences in variables between the experimental and control groups were performed using the independent t-test. Intergroup effect sizes were calculated using the Cohen[6] d coefficient. An effect size < 0.2 reflects a negligible mean difference; 0.2−0.5, a small difference; 0.5−0.8, a moderate mean difference; and > 0.8, a large difference. Statistical analysis was performed at a 95% confidence level, and p values < 0.05 were considered statistically significant.

Table 1. Comparison of the results of the experimental and control group (n = 60)

	EG (n=30)	CG (n=30)
Muscle activity (μV)^{a,b}		
Pre	88.24±3.66$^{\#}$	88.74±5.84
post	97.10±5.36*	90.54±6.16
Muscle fatigue (mol/dL)^{a}		
pre	7.34±5.84	6.30±5.27
post	3.44±3.06*	4.12±3.30
Hip joint angle (°)		
pre	120.1±8.27	128.15±7.70
post	121.95±6.73*	130.85±7.67*

EG: Hold and relax-agonist contraction group; CG: Passive straight leg rise group
$^{\#}$mean±SD
*Significant difference from pre-test, p < 0.05
^{a}Significant difference in gains between the two groups, p < 0.05
^{b}Effect size greater than > 0.70

RESULTS

The HR-AC group showed significant increases in hamstring muscle activation and hip joint angle as well as significantly decreased muscle fatigue compared to the pre-intervention results (p < 0.05). In addition, the PSLR group showed significant increments in the angle of the hip joint compared to the pre-intervention results (p < 0.05). A significant difference in the post-training increase in hamstring activation and a significant decrease in muscle fatigue was observed between the HR-AC group and the PSLR group (p < 0.05). In addition, the effect size for gains in the HR-AC group and PSLR group was very strong for muscle activity (effect size = 1.13) (Table 1).

DISCUSSION

This study examined changes in muscle activity, lactic acid concentration in the blood, and range of motion when HR-AC and PSLR were applied separately after DOMS induction in the hamstring muscle in healthy subjects. Our results showed that the HR-AC technique more effectively increased muscle activity and decreased muscle fatigue than the PSLR technique. In a previous study comparing HR-AC and PSLR techniques with athletes as the subjects, no significant difference was found between the two methods. In another study applying nerve mobilization, the HR-AC technique, and the PSLR technique to 100 healthy adults for 8 weeks, PSLR was reported the most effective[7]. Handle et al.[8] reported that use of the HR-AC technique resulted in greater enhancements of hamstring muscle activity and flexibility than that with the PSLR. During HR-AC, isometric contraction triggers autogenic inhibition that inhibits α-motor neurons of contracted muscles and synergists in interneurons and activates antagonists by transmitting tendon tension by I b afferent nerve fibers to the anterior horn of the spinal cord.

During AC, concentric contraction causes reciprocal inhibition that activates the α-motor neurons of contracted muscles and synergists and inhibits antagonists[9–12]. Decoster et al.[13], who introduced diverse stretching techniques in a literature review, reported that it was difficult to determine the most effective stretching technique. The results of the current and previous studies differed because of differences in the number of times stretching techniques were applied, experimental periods, subjects, and measurement timing. Therefore, in the clinical field, subjects' personal characteristics should be considered in the selection and application of an appropriate stretching technique.

The limitations of this study are as follows. First, the subjects were healthy people; therefore, it is difficult to generalize our results. Second, the short-term effects during the early period were measured according to each technique and continuous effects were not analyzed. Third, the force applied to the hamstring was not quantified when each stretching technique was applied by a physical therapist. Future research should include the establishment of a standardized method for the selection of an appropriate stretching technique according to individual subjects by complementing the above-mentioned problems.

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