

Effect of combined resistance exercise of knee-extension with hip adduction on dynamic balance performance in healthy male adults - a newly developed knee-extension resistance exercise

保健医療学専攻・理学療法学分野・応用理学療法学領域

学籍番号： 14s3008

氏名： WANG HONGZHAO

研究指導教員：丸山 仁司 教授 副研究指導教員：小野田 公 助教

Key words: Knee-extension with hip adduction, muscle hypertrophy, dynamic balance

[Background and purpose] Balance and stability have a functional role for vocational purposes, recreation, daily tasks or injury prevention and rehabilitation. It would be beneficial to identify if a particular exercise program or technique could maximize dynamic and static balance. The literature examining progressive resistance exercise and balance performance is characterized by an extreme un-uniformity in populations, training program and balance outcome variables making clear comparisons between studies difficult. Few studies have closely examined whether the resistance exercises determine a positive balance outcome, an aspect critical to the design of optimal exercise program to enhance balance. Combined resistance exercise of knee-extension with hip adduction (The following is abbreviated as CREK/HA) is a newly developed physical fitness exercise focused on open kinetic chain (The following is abbreviated as OKC) knee extension. This study examines the CREK/HA designed to improve knee extensors hypertrophy on improving balance performance in healthy male adults.

Study 1 Changes of vastus medialis oblique and rectus femoris after combined resistance exercise of knee-extension with hip adduction on muscle thickness in healthy male adults

[Subjects and methods] The subjects were 18 healthy men (age 32.3 ± 4.5 (y), height 169.6 ± 5.6 (cm), weight 63.4 ± 7.1 (kg)) who were divided into two groups randomly, namely a CREK/HA group (n=8) and a control group (n=10). To identify changes of vastus medialis oblique (The following is abbreviated as VMO) and rectus femoris (The following is abbreviated as RF) on muscle thickness after the exercise interventions (In CRKE/HA both ankle and hip adduction resistance were performed, ankle resistance performed only in control group), an Ultrasound was used. Two-way analysis of variance and multiple comparisons (Bonferroni) were used to test for statistically significant differences, and the factors were the exercise intervention and groups. If a significant interaction was found, the paired *t*-test was performed to compare between before and after the intervention. The level of statistical significant was set as $p = 0.05$.

[Results] Significant improvement in muscle thickness of VMO and RF was observed both in the CREK/HA and control groups. There were increases in VMO/RF ratio for the CREK/HA group.

Study 2 Combined resistance exercise of knee-extension with hip adduction improves performance on the star excursion balance test in healthy male adults

[Subjects and methods] The subject's characteristics were the same as Study 1. The CREK/HA group performed CREK/HA. In control group subjects performed their daily activity only. The dynamic balance was measured by star excursion balance test (The following is abbreviated as SEBT).

[Results] After participation in a CREK/HA, subjects demonstrated a significant improvement in the SEBT composite score on the right limb and left limb. Further analysis identified for the significant improvements for the SEBT in the anterior, posteromedial, and posterolateral directions on both the right and left limb in the CRKE/HA group.

Study 3 Electromyography analysis of vastus medialis oblique/rectus femoris in combined resistance exercise of knee-extension with hip adduction

[Subjects and methods] The subjects were 7 healthy men (age 21.6 ± 1.5 (y), height 173.6 ± 6.0 (cm), weight 66.0 ± 3.9 (kg)) who all participated the CREK/HA and commonly used knee-extension resistance (The following is abbreviated as CUKR). The EMG signals of VMO and RF muscles were digitized.

[Results] Independent *t*-test showed the VMO/RF ratio of mean amplitude for normalized EMG was significantly larger in the CREK/HA task compared with CUKR.

[Ethics approval] This study was performed in accordance with the approval of Huaian Sports School Ethics Committee in Jiangsu Province.

[Discussion] Significant improvement in muscle thickness of VMO and RF was observed both in the CREK/HA and control groups. Resistance exercise is generally expected to bring an increase in muscle strength and mass. Moreover, muscle thickness is related to muscle strength. Thus, it may be related to muscle EMG characteristics. There were increases in the CREK/HA group in VMO/RF ratio of muscle thickness that was suggested that the VMO was preferentially hypertrophied to a greater degree of its maximum voluntary contraction ability on muscle thickness than the remaining components of knee extensors after CREK/HA in healthy male adults.

Prior to training both the CREK/HA and the control groups of the subjects demonstrated similar performance on the SEBT in all measured variables. Following a CREK/HA, the SEBT composite score significantly improved in the exercise group compared to that in the control group, who did not participate in a CREK/HA. There were no differences in composite score between limbs in the control group or in the CRKE/HA group. Improvements in the SEBT composite score in the CREK/HA group appeared to be dependent on improvements in the anterior reach, the posteromedial reach, and the posterolateral reach as indicated by the independent reach analysis. It seems to imply that knee extension strength may be improved by exercise intervention and the CREK/HA is effective for unilateral dynamic balance although the type of movement required both multi-limb and multi-articular during the SEBT. When one sees the SEBT being performed, it is visually obvious that each direction places different demands on the lower extremity. Improvements in the anterior, posteromedial, and posterolateral directions are likely the result of improved eccentric and isometric contractions of the knee extensors of the supporting limb, neuromuscular control and dynamic balance, because the distance reached in the three directions would be greatly affected by the amount of knee flexion and ankle dorsiflexion of the support limb. There was a significant change in dynamic balance in the anterior direction in both legs. The anterior component of the SEBT is mostly quadriceps dependent, demonstrated by significant quadriceps EMG activation during task. To perform the anterior excursion, subjects leaned backward, extending the trunk, to maintain their balance. Gravity acting on the upper body creates a large knee-flexion moment, which must be controlled by an extension moment produced by the quadriceps. Earl JE and Hertel J indicated that VMO activity was found to be greater during the anterior excursion than during any other direction in EMG activity.

[Conclusion] These results showed that the CREK/HA is effective on knee extensors hypertrophy and performance of SEBT in healthy male adults.

[References]

1).Earl JE, Hertel J. Lower-extremity muscle activation during the star excursion balance tests. *J. Sports Rehabil.* 2001;10(2):93-104.