

Effects of combined application of progressive resistance training and Russian electrical stimulation on quadriceps femoris muscle strength in elderly women with knee osteoarthritis

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Abstract. [Purpose] The aim of this study was to investigate the effects of combined application of progressive resistance training and Russian electrical stimulation on quadriceps femoris muscle strength in elderly women with osteoarthritis of the knee. [Subjects] Thirty women over 65 years of age diagnosed with knee osteoarthritis participated in the present study. The subjects were randomly assigned to a control group (n=10), a progressive resistance training group (n=10), or a Russian electrical stimulation group (n=10). [Methods] Each group was treated 3 times weekly for 8 weeks, and each session lasted 45 minutes. Muscle strength was assessed by measuring the peak torque of the quadriceps femoris muscle. Outcome measurements were performed at baseline and at the fourth and eighth weeks of the treatment period. [Results] All groups showed significant intragroup differences in the quadriceps femoris muscle peak torque after the treatment intervention. There were significant intergroup differences between the Russian electrical stimulation group and the other groups. [Conclusion] The results of this study suggest that combined application of progressive resistance training and Russian electrical stimulation can be effective in strengthening the quadriceps femoris muscle in elderly women with knee osteoarthritis.

Key words: Knee osteoarthritis, Progressive resistance training, Russian electrical stimulation

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INTRODUCTION

Osteoarthritis (OA) of the knee is the most common cause of chronic disability in people at older ages¹⁾. Weakness of the quadriceps femoris muscle (QFM) is one of the major characteristics of knee OA, and a reduced quadriceps strength has been shown to be associated with the presence of OA in the knee. Accordingly, many exercise programs place particular emphasis on strengthening this muscle group²⁾. It has been documented that muscle strength can be improved by progressive resistance training (PRT), and numerous studies have reported the benefits of PRT in individuals with knee OA by strengthening the QFM^{3, 4)}. Electrical stimulation (ES) is also commonly used by physical therapists in muscle strength rehabilitation⁵⁾. However, there have been few studies that have attempted to investigate the effects of simultaneous PRT and ES applications on muscle strength improvement. Therefore, this study was conducted to examine whether a combination of PRT and ES increases

the QFM strength in patients with knee OA.

SUBJECTS AND METHODS

Thirty women over 65 years of age diagnosed with knee OA through radiographic images were recruited in this study. The exclusion criteria were medical comorbidities precluding participation in an exercise program, implanted electrical devices, participation in an exercise program that may have caused an increase in muscle strength within last 6 months, and usage of any anti-inflammatory analgesics. All participants meeting the inclusion criteria were given verbal and written information on the study, and provided their informed consent. The protocol of this study was approved by Daegu University.

Subjects were randomized into a control (CON) group (n=10), a progressive resistance training (PRT) group (n=10), or a Russian electrical stimulation (RES) group (n=10). The control group received a general physical therapy treatment that consisted of hot packs, ultrasound application, and isometric knee extension exercise. Hot packs wrapped in a towel were placed on the osteoarthritic knee for 20 minutes. During 5 minutes of ultrasound treatment, continuous ultrasonic waves with a frequency of 1 MHz and 1 watt/cm² power were selected, and the transducer head was applied to the treatment region at right angles to ensure maximum absorption of the ultrasound energy⁶⁾. Isometric knee exten-

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sion exercise consisted of 3 sets of 10 contractions of the quadriceps femoris muscle (QFM) and lasted approximately 20 minutes. Each contraction was held for 5 seconds, and each set was separated by a 2-minute rest period to minimize fatigue. The exercise was performed with the subjects sitting on the edge of a treatment bed and leaning on a wall with a pillow placed behind their back. From a knee flexed position, the subjects extended their knee joint as far as possible and sustained the position to contract the QFM.

In the PRT group, the subjects received the same modalities (hot packs and ultrasound) and were treated using PRT instead of the isometric knee extension exercise. A ten repetition maximum (RM) was used for the resistance, and the amount of resistance was reevaluated every week. The subjects were positioned as described in the CON with sandbags loaded anterior to their ankle joint. The loads applied were set at 50%, 75%, and 100% of the 10 RM for each set.

The RES group was given electrical stimulation and the same treatment as the PRT group. ES was carried out using an Endomed 982 (Enraf-Nonius, Rotterdam, The Netherlands). The ES used in this study was Russian current: pulse frequency of 50 Hz, burst duration of 10 ms, symmetric pulses of sinusoidal form, with a duty cycle of 25% (5 seconds/20 seconds) and a pulse duration of 400 μ s. The anterior area of the thigh of the affected limb was cleaned with alcohol, and four self-adhesive electrodes were placed on the limb: one electrode on the rectus femoris, two electrodes on the proximal and distal area of the vastus lateralis, and one electrode on the vastus medialis⁷. After placing the electrodes on the subject's thigh, the subject was instructed to inform the maximum level of tolerance and contract the QFM while the PRT was performed. All groups were treated three times weekly for 8 weeks. The amount of time of each session was approximately 45 minutes for all groups.

For outcome measurements, subjects were encouraged to perform three maximum contractions on an isokinetic dynamometer (Biodex Multi-joint System 4 ProTM, Biodex Medical Systems, Shirley, NY, USA) after a 5-minute warm-up flexion and extension of the knee joint. The axis of rotation of the knee joint was carefully aligned with the axis of rotation of the dynamometer arm with the subjects stabilized in the dynamometer chair. The QFM isometric contractions from the affected limb were collected with the knee joints positioned at 90° and were sustained for 5 seconds with a 2-minute interval between contractions to prevent fatigue. The mean value of the three maximum contractions was used for data analysis. The outcome measurements were carried out at baseline and at the fourth and eighth weeks of the treatment period.

Statistical analyses were performed using SPSS version

12.0. A one-way analysis of variance (ANOVA) was used to evaluate differences between groups in baseline characteristics (age, height, and weight). A repeated measures two-way ANOVA was used to compare differences between groups over time. The level of significance was set at 5% ($p < 0.05$) with Scheffé's method used for multiple comparisons. Results are expressed as the mean value \pm standard deviation (SD).

RESULTS

Baseline characteristics are presented in Table 1. There were no significant differences between the three groups in any of the measured characteristics. The results for all outcome measures are summarized in Table 2. In all groups, there were significant intragroup differences in the peak torque of the QFM in the fourth and eighth weeks of the treatment period. Post hoc analysis revealed significant intergroup differences in parameters between the RES group and the other groups.

DISCUSSION

Patients with knee OA often exhibit a gradual decline in muscle strength⁸. Quadriceps femoris muscle weakness has been demonstrated to correlate with knee pain and functional disability⁹. McAlindon et al. have reported that the strength of the QFM has been shown to be an important predictor of walking speed and functional performance in patients with knee OA¹⁰. It has been also reported that one aim of physical therapy intervention for patients with OA is to increase the strength of the musculature surrounding the knee joint¹¹.

The purpose of the present study was to evaluate whether an intervention of PRT combined with Russian current stimulation has beneficial effects on strengthening the QFM in elderly women with knee OA. In this study, two-way repeated measures ANOVA revealed that the peak torque of the QFM increased in the control group after receiving

Table 1. Baseline characteristics of the subjects

	Experimental condition		
	CON (n=10)	PRT (n=10)	RES (n=10)
Age (years)	68.4 \pm 1.5	67.9 \pm 2.0	68.2 \pm 2.1
Height (cm)	153.4 \pm 4.2	154.9 \pm 3.2	154.4 \pm 3.8
Weight (kg)	51.7 \pm 2.5	56.5 \pm 5.3	56.8 \pm 5.3

Values are means \pm SD. CON: control group; PRT: progressive resistance training group; RES: Russian electrical stimulation group.

Table 2. Outcome measures

	CON (n=10)			PRT (n=10)			RES (n=10)		
	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8
QFM Peak Torque (Nm)	123.4 \pm 2.4	124.5 \pm 2.1*	125.5 \pm 2.5*	123.1 \pm 3.6	125.9 \pm 3.5*	132.0 \pm 3.6*	125.1 \pm 3.6	144.9 \pm 11.3*	167.2 \pm 11.7*

Values are means \pm SD. *p significant vs. baseline ($p < 0.05$). CON: control group; PRT: progressive resistance training group; RES: Russian electrical stimulation group; QFM: quadriceps femoris muscle

the general physical therapy treatment. These findings are in accordance with the results of earlier experimental studies. In a previous study by Anwer et al.¹²⁾, it was demonstrated that quadriceps muscle strength in patients with knee OA was improved after a 5-week isometric exercise program. Similarly, Miyaguchi et al.¹³⁾ reported a significant increase in muscle strength after 8 weeks of isometric quadriceps exercise in knee OA patients.

The results of the current study also showed significant improvements in strength of the QFM in the PRT group, and some authors have suggested that a PRT program can increase muscle strength in women with knee OA¹⁴⁾. In a randomized controlled trial of Jusha et al.¹⁵⁾, it was indicated that PRT can strengthen the QFM in patients with early onset of knee OA and that PRT can be a vital component of knee OA management.

ES causes an increase in the muscle strength with changes in the muscle fibers and the capillary system¹⁶⁾. ES is an alternative and potentially more effective means than volitional exercise alone of increasing the force of muscles in appropriate patients¹⁷⁾. In several studies, it has been reported that the most commonly used ES to increase muscle strength is that via Russian current¹⁸⁾. In the trial by Taspinar et al.¹⁹⁾, however, the results indicated that Russian current was not sufficient alone to strengthen the QFM, and it has been suggested that training programs including voluntary muscle contraction must be considered for strengthening muscles. Furthermore, some authors argue that muscles cannot be strengthened to their full potential if they cannot be activated sufficiently to overload the muscle and therefore recommend a combination of ES and muscle strength training²⁰⁾. In our study, the results showed significant intergroup differences in QFM peak torque between the RES group and the other groups. These findings are consistent with those of Paillard et al.⁵⁾. According to their review article, training programs using ES superimposition (application of an electrical stimulation during a voluntary muscle contraction) could increase the overall contraction force of muscles.

The results of this study are subject to several limitations. First, although women are more likely to have OA than men²¹⁾ and females have significantly lower quadriceps strength than males even when strength is normalized to weight²²⁾, the gender of the participants in this study was limited to females. Accordingly, the results of this study might not be generalizable to the overall individuals with knee OA. Second, the knee OA duration or knee OA severity was not identified as a baseline characteristic of the subjects. Lastly, muscle peak torque was the only parameter examined in this study. Therefore, it is suggested that further studies are required to ascertain the effects of combined application of PRT and RES on parameters such as functional abilities and pain in patients with knee OA.

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