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The Effects of Closed Kinetic Chain Exercise Using EMG Biofeedback on Functional Characteristics of PFPS Patients` Lower Extremity Muscles

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Abstract. This study aimed to examine the effects of closed kinetic chain exercise using electromyography (EMG) biofeedback for selective strengthening of the vastus medialis oblique (VMO) on functional characteristics of lower extremity muscles in patellofemoral pain syndrome (PFPS) patients. The subjects of this study were 30 PFPS patients and they were equally and randomly assigned to a control group (I), a closed kinetic chain exercise group (II), or an EMG biofeedback closed kinetic chain exercise (III). They received intervention three times per week (for 30 minutes per each time) for six weeks. EMG was used for measurement. According to the study result, there were significant differences groups II and III compared to group I in median frequency (MDF) and the VMO/the vastus lateralis (VL) muscle activity ratios (p<.05). According to the result, PFPS patients' improvement in muscle control and response ability using EMG biofeedback during closed kinetic chain exercise enhanced their muscle functions.

Keywords: PFPS, EMG Biofeedback, Muscle Function, Pain

1 Introduction

Patellofemoral pain syndrome (PFPS) is defined as pain appearing in the anterior or posterior knees during kneeling or squatting [1]. In a study which compared vastus medialis oblique (VMO)/ vastus lateralis (VL) muscle activity ratios in PFPS patients and normal subjects during voluntary isometric knee extension, Makhsous et al. [2] reported that PFPS patients' muscle activity ratios were lower than those of normal subjects. Such imbalance between the VMO and VL further increases pressure on the interface of the patellofemoral joint and triggers pain [3]. Therefore, for balance between and stability of the VMO and the VL, training for selective strengthening of the VMO is very important [4]. Closed kinetic exercise like squat exercise as a treatment method for PFPS patients is an effective and safe exercise method because it provides minimal stress on the patellofemoral joint within functional range [5]. Clinically, biofeedback is usefully employed in motor learning exercise and rehabilitation process by providing information on their muscle activity mostly while

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patients perform their task [6]. Yilmaz et al. [7] applied muscle strengthening exercise in combination with electromyography (EMG) biofeedback to knee osteoarthritis patients for three weeks and reported improvement in their muscle strength. However, although closed kinetic chain exercise has been much used for rehabilitation and training of PFPS patients until recently, research which examined improvement of muscle control and response ability through self-control of muscle activity using EMG biofeedback during closed kinetic chain exercise aimed at heightening treatment efficiency is very insufficient. This study intends to examine improvement in muscle control and response ability of PFPS patients by having them self-control muscle activity using EMG biofeedback during close kinetic chain exercise on functional characteristics of their lower extremity muscles.

2. Subjects and methods

2.1 Subjects

The characteristics of the subjects are shown in Table 1. The subjects not have a history of orthopedic or neurosurgical disease and who voluntarily consented to participate in this study. Closed kinetic chain exercise using EMG biofeedback was applied to PFPS patients for six weeks.

Table 1. General characteristics of each group

	Group Ⅰ(n=10)	Group Ⅱ(n=10)	Group Ⅲ(n=10)
Age(Years)	21.80±1.22	21.40±0.96	20.80±0.91
Height(㎝)	161.81±5.05	159.90±4.17	156.75±6.09
Weight(㎏)	55.18±3.35	53.91±2.74	51.72±4.16
BMI(㎏/㎡)	22.28±4.99	21.58±2.84	20.77±2.19

Value are given as mean±standard deviation
Group Ⅰ : control, Group Ⅱ : closed kinetic chain exercise, Group Ⅲ : closed kinetic chain exercise using EMG biofeedback

2.2 Exercise and EMG analysis

EMG biofeedback (Mymed 132, Enraf Nonius, Netherlands) was employed to maximally induce selective muscle activity of the VMO during closed kinetic chain exercise [8]. So that the subjects were able to identify EMG biofeedback signals easily, the monitor was placed in front of them. They conducted the exercise three times per week, for 30 minutes per each time, with contraction time at 10 seconds and resting time at 20 seconds. Surface EMG (MP150, Biopac system, USA) was used to collect and process EMG signals from the VMO and the VL of the subjects. Measurement was taken when the subjects in a squat position sat on an experimental chair with the upper body fixed and extended the knees against manual resistance [9].

Analysis of EMG signals was made using Acqknowledge 4.1 software program (Biopac, USA) and root-mean-square (RMS) amplitude and median frequency (MDF) of the signals were analyzed.

2.4 Data analysis

All data from this study were analyzed using the SPSS 12.0 statistics program. Differences among the groups in changes in EMG values were analyzed using analysis of variance and covariance (ANCOVA). Bonferroni test was conducted as post-hoc analysis. In order to verify significance of all statistical analyses, the significance level was set at $\alpha=0.05$.

3 Results

3.1 Changes of MDF during a squatting position

There were significant differences in changes in MDF values among the groups during a squatting position ($p<.05$) and according to Bonferroni post hoc test results, there were significant changes in Groups II ($p<.01$) and III ($p<.01$) compared to Group I.

3.2 Changes of VMO/VL muscle activity ratios during a squatting position

There were significant differences in changes in VMO/VL muscle activity ratios among the groups ($p<.05$), and according to Bonferroni post hoc test results, there were significant changes in Groups II ($p<.01$) and III ($p<.01$) compared to Group I.

4. Discussion

Callaghen et al. [10] reported that two different electrical stimulations to PFPS patients' quadriceps femoris muscle (QFM) resulted in significant decrease in muscle fatigue. In the present study, MDF values significantly increased in all the three groups after the intervention and the degree of fatigue of the closed kinetic chain exercise group using EMG biofeedback significantly decreased relative to the closed kinetic chain exercise group. Powers [11] reported that VMO/VL muscle activity ratios of PFPS patients were lower than those of normal subjects. Dursun et al. [8] applied universal treatment and treatment in combination with EMG biofeedback to 60 PFPS patients for improvement in balance between the VMO and VL, and reported that VMO/VL muscle activity ratios significantly increased in the group which received treatment in combination with EMG biofeedback compared to the control group. In the present study, all the groups' VMO/VL muscle activity ratios became close to 1:1 after the intervention, but the muscle activity ratios significantly increased in the closed kinetic exercise group which used EMG biofeedback than in the closed kinetic exercise group. This is considered because EMG biofeedback enabled self-control of muscle activity and improved muscle control and response ability, thereby more effectively influencing decrease in muscle fatigue and improvement in muscle activity ratios than the other interventions.

The above results show that when the subjects self-control muscle activity using EMG biofeedback which provides biometric information on the muscles on a real-time basis for efficient treatment, their muscle control and response ability and muscle functions improve.

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