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Research Article

Efficacy of Electromyographic Biofeedback Strength Training on Quadriceps Femoris Muscles In Pattelofemoral Pain Syndrome

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ABSTRACT

The aims of this study were to evaluate the effectiveness of Electromyographic-biofeedback as an add-on therapy with isometric contraction exercise on quadriceps strength and pain in patient with pattelofemoral pain syndrome. Thirty patients (9 men and 21 women) with pattelofemoral pain syndrome. Patients were randomly placed into two groups: biofeedback group (n=15) and a control group (n=15). The biofeedback group received electromyographic-biofeedback guided isometric contraction exercise program for 5 days a week for 3 week, whereas the control group received aisometric contraction exercisesprogram only. Isometric quadriceps strength improved significantly at the end of 3 week, compared with the pretreatment values in both the groups. On between group comparisons, the isometric quadriceps strength in biofeedback group, at the end of 3 week and after 2 week follow-up i.e. on 5th week were significantly higher than those of control group ($p<0.05$). The addition of electromyographic-biofeedback toisometric exercise program has been shown to produce greater gains in isometric quadriceps strength, thereby reduce pain than isometric exercise alone over a 3 week period. This study may provide a rationale for the clinical use of electromyographic-biofeedback.

Keywords: Electromyographic-biofeedback, Isometric exercise, pattelofemoral pain syndrome (PFPS)

1. INTRODUCTION

Patellofemoral pain syndrome can be defined as retropatellar or peripatellar pain resulting from physical and biochemical changes in the patellofemoral joint. Patients with patellofemoral pain syndrome have anterior knee pain that typically occurs with activity and often worsens when they are descending steps or hills. It can also be triggered by prolonged sitting [1]. The PFS etiology is still unknown and multifactorial. It includes valgus knee, shortening of the hamstrings, biggers Q angles and patellar malalignment. In spite of the diverse factors associated with PFS, there is a general consensus that the malalignment of the knee extensor mechanism would be the major cause of Patellofemoral pain [2, 3]. Considered as a dynamic stabilizer of the patella, the action of the quadriceps femoris muscle influences its position because it is a great muscle with large size which has differences in fiber orientation, as seeing as vastusmedialis (VM), and vastuslateralis [4-7], who may lead to pain when muscle forces are related to maltracking of the patella. An abnormal tracking pattern may be suggested by the imbalance of the activity of vastuslateralis (VL) and vastusmedialis (VM), especially its obliqus portion (VMO), which is the most important dynamic stabilizers of the patellofemoral joint [8-10]. Reduced strength of VMO or abnormal relationship in the timing of activation pattern of the VMO and VL can alter the dynamics of patellofemoral joint and therefore predisposes PFS.

The initial treatment plan should include quadriceps strengthening and temporary activity modification. The use of EMG-biofeedback as an adjunct therapy to standard exercise regime for increasing muscle strength has been investigated in several studies. Adamovich et al., [11] studied the effects of EMG-biofeedback on static contraction of quadriceps muscles. The experimental group, which received auditory and visual EMG-feedback while exercising, demonstrated significantly greater strength gains than the control group, which received no form of feedback. Similarly, Lucca and Recehlutti [12], Waly et al., [13], and Khalil et al., [14] found that isometric exercise coupled with EMG-biofeedback lead to significantly greater gains in strength than did isometric exercise alone.

So the present study was intended to evaluate the effectiveness of EMG-biofeedback as an add-on therapy with standard exercise on quadriceps strength and pain in patient with pattelofemoral pain syndrome.

2. MATERIAL AND METHODS

2.1. Subjects

A total of 30 (9 men and 21 women) patients with pattelofemoral pain syndrome were included in the study.The inclusion criteria were males and females aged between 20-55 years with insidious onset of anterior knee pain unrelated to traumatic incident within the last 6 months, and who also experienced anterior knee pain in at least 2 of the following activities: ascending stairs, descending stairs, squatting, kneeling, prolonged sitting, jumping.

Table 1. Details of Subjects

	Group A	Group B
No. of Subjects	15	15
Age (Mean±SD)	54.40±7.73	55.27±7.08
Weight (Mean±SD)	64.93±5.61	65.86±4.34
Height (Mean±SD)	155.26±4.41	155.20±3.40
BMI (Mean±SD)	26.93±2.08	27.34±1.35

2.2. Study design

A different subject pretest-posttest experimental group design was selected for testing the hypothesis, where a baseline reading was taken prior to the intervention, rest measurements were taken at the end of 2nd week, 3rd week and after two week follow-up i.e. at the end of 5th week. These reading were then compared to find out the effect on independent variables. The outcome measure or dependent variables, selected for this study were pain, and quadriceps muscles strength. These variables were measured using VAS scale, and electronic strain gauge respectively.

2.3. Procedure

The subjects were screened first according to the inclusion and exclusion criteria. The subjects were randomized to experimental and control groups, each consisting of 15 patients. An informed consent was obtained from the subjects.

Group A (Experimental group) EMG-biofeedback guidedisometric exercise and paraffin wax bath.

Group B (control group): Sham EMG- biofeedback along with isometric exercise and paraffin wax bath.

2.4. Measurement of isometric strength

The isometric strength of quadriceps femoris was measured at baseline (before the treatment) and recorded as STN0, at the end of 2nd week recorded as STN2, at the end of 3rd week recorded as STN3 and at the end of 5th week recorded as STN5. During the testing subject was made to sit on the quadriceps table with the knee joint in 60 degrees of flexion. Thigh was stabilized with a belt; the shin pad was adjusted at 5.1cm (2 in) superior to the medial malleolus. The fulcrum of the lever arm was aligned with the most inferior aspect of the lateral epicondyle of the femur. Strain gauge was attached to the distal end of the quadriceps table arm. Subject was given verbal encouragement in order to motivate the subject to attain maximum effort during the 5-second contraction. Each test includes 3 consecutive 5-second trials with 30 second rest between trials. The mean of readings was used for the purpose of analysis.

2.5. Measurement of pain intensity

The subject was asked to mark along the line of VAS scale to denote his level of pain. The distance from mark 0 was calculated in cm and was recorded. The readings were taken at baseline (before the treatment) and marked as V0, at the end of 2nd week marked as V2, at the end of 3rd week marked as V3 and at the end of 5th week as V5.

2.6. Intervention

Experimental group received the EMG-biofeedback guided isometric exercise program. The other group received the isometric exercise program along with sham EMG-biofeedback, without any instruction regarding muscle recruitment. Both the group received paraffin wax bath (temperature 52° C) for 20 minute prior to exercise.

Paraffin wax bath (PWB) was given prior to the exercise session with patient in sitting position at the wax unit with knee joint in extended position. The patient was asked to expose the area to be treated. Seven consecutive coatings of paraffin wax were applied, using a standard paint brush, over the treatment area. The waxed area was then immediately wrapped in layer of plastic for 20 minute. At the end of treatment the paraffin wax was removed by asking the patient to do gentle flexion and extension of knee joint. Paraffin wax bath was applied for 3 week (5 days/week).

2.7. Biofeedback training

Biofeedback training was performed with a Myomed 932, a two channel EMG machine. Clear and full screen displayed the EMG signal with a curve was obtained for both the VastusMedialis Oblique (VMO) and Vastuslateralis (VL).

2.8. Electrode placement

Before the electrode placement the subject was asked to shave the part and then the part was thoroughly washed by alcohol solutions to clean the area and to reduce the skin resistance. Skin adhesive surface electrodes have been used. Two electrodes were placed 4 cm superior and 3 cm medial to supero-medial border of patella, that is to record the recruitment of VMO. Other electrodes were placed at the junction of the middle and lower third of the thigh, slightly medially and angled downwards and lateraly for Vastuslateralis. The two active electrodes from each channel were placed as close together as possible along the directions of the fibers of each muscle. Reference electrode was placed below the tibial tubercle.

2.9. Exercise procedure

Group A: Three sets of exercise were given for three weeks, for five days a week. The subjects was explained about the procedure and asked to watch the muscle activity and try to increase the activity level of VMO and Vastuslateralis while performing the exercises. After each 5 second hold the subjects was then asked to take rest for 10 second. The training session were held for 5 days a week for three weeks. Before each session the subject was asked to contract the quadriceps muscle maximally three times while the activity level of the VMO and Vastuslateralis was monitored by EMG-biofeedback device. The average of these three maximum contractions was lowered by 20% for each muscle to determine their threshold levels. During the training session, subjects were instructed to contract the VMO and Vastuslateralis above its threshold level and to maintain the audible signal for 5 sec.

2.9.1. Isometric quadriceps exercise

Patient was positioned in supine lying. A roll of towel was put beneath the knee. The patient was instructed to maximally activate their thigh muscles above its threshold level in order to straighten their knee and maintain the audible signal for 5 sec. This exercise was of 3 sets of 10 repetitions each.

2.9.2. Terminal knee extension exercise

The knee extension exercise was performed with the patient in a sitting position with the knee flexed from 30 to 0 degrees. The patient was instructed to maximally activate their thigh muscles above its threshold level in order to straighten their knee and to maintain the audible signal for 5 sec. This exercise was of 3 sets of 10 repetitions each.

2.9.3. Straight Leg Raising (SLR) exercise

Patient was positioned in supine lying. The patient was instructed to perform a maximum isometric quadriceps contraction prior to the lifting phase of exercise. Then subject was instructed to lift the leg and to maintain the audible signal for 5 sec. This exercise was of 3 sets of 10 repetitions each.

Group B**:** Same set of exercise were given to Group B also but the electrodes was placed away from the VMO and Vastuslateralis, and reference electrode was placed below the tibial tuberosity. Here the patients were doing exercises without any instruction to recruit VMO and Vastuslateralis muscle.

2.10. Statistical Analysis

Statistical analysis was done using SPSS 15.0 Software. An independent t-test was used to compare the changes in isometric quadriceps strength and VAS in both the groups at baseline, 2nd week, 3rd week and after two week follow up i.e. at 5th week. Repeated measures of analysis of variance (ANOVA) with Bonferroni test was used to study the changes in isometric quadriceps strength and VAS in each group at 2nd week, 3rd week and after two week follow up i.e. at 5th week.

3. RESULTS

Isometric strength

The baseline reading i.e. STN0 for both the groups was statistically insignificant (p=0.60). On comparing the STN2 between two groups an insignificant difference was obtained (p=0.23). On comparing at the end of treatment session i.e. STN3 between two groups a significant difference was obtained (p=0.010). Again when comparing after two week follow-up i.e. on 5th week (STN5) between two groups a significant difference was obtained (*p*=0.000).

Table 2. Comparison of strength between the groups

	Group A (Mean±SD)	Group B (Mean±SD)	Independent t-test	
			T	p
STN0	9.07±1.87	9.42±1.86	0.51	0.60
STN2	11.93±2.08	11.05±1.80	1.22	0.23
STN3	13.33±1.89	11.54±1.70	2.72	0.011
STN5	13.68±1.99	11.06±1.56	4.00	0.000

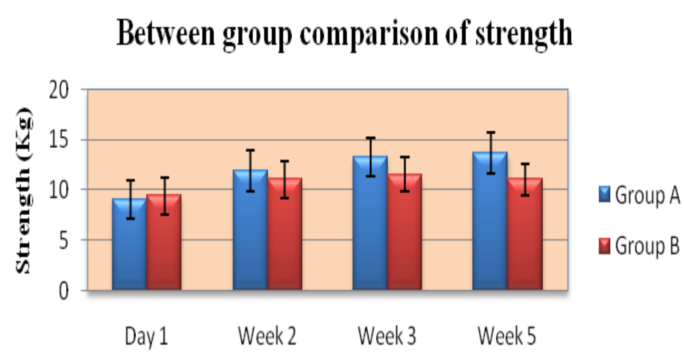

Fig 1. Comparison of strength between the groups Pain intensity

Table 3. Comparison of VAS between the groups

	Group A (Mean±SD)	Group B (Mean±SD)	Independent t-test	
			T	p
V0	6.13±0.81	6.06±1.03	0.19	0.846
V2	3.46±0.99	4.33±1.04	2.3	0.027
V3	1.53±0.74	2.93±0.88	4.8	0.000
V5	1.20±0.94	2.66±0.61	4.8	0.000

For both the groups the baseline value i.e. V_0 was statistically insignificant (p=0.846). The reading at 2nd week (V_2) found to be statistically significant between groups (p=0.027). The reading at the end of treatment session i.e. on 3rd week (V_3) also found to be statistically significant between two groups (p=0.000) (Table 3). The final reading after two week follow-up i.e. at 5th week (V_5) were also found to be statistically significant between two groups (p=0.000).

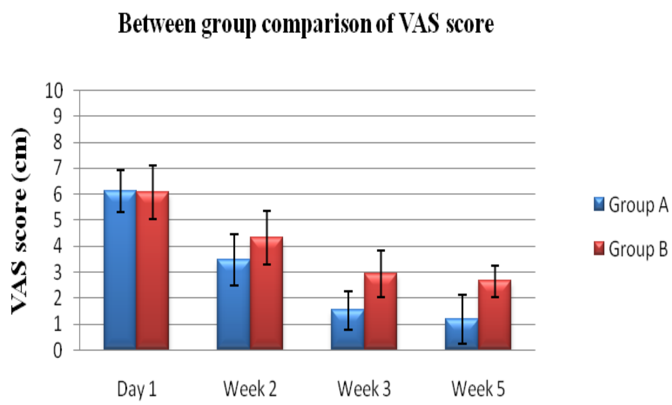

Fig 2. Comparison of VAS between the groups

4. DISCUSSION

The purpose of study was to assess the effectiveness of EMG biofeedback as an adjunct to strength training of quadriceps muscle in order to increase strength of quadriceps muscle and thereby reducing pain. The results of the study demonstrated that a combination of EMG-biofeedback and isometric exercises brought greater gains in isometric quadriceps strength and pain intensity. These effects were largely gained during the 3 weeks of treatment period. Gained improvement was also maintained over a period of 2 weeks follow-up i.e. at the end of 5th week.

Improvement in Isometric quadriceps strength

The data showed that 3 week of training period brought significant improvement in both the groups at 2nd and 3rd week. Post test inter group comparison showed significant improvement in EMG-biofeedback group at 2nd, 3rd and 5th week.

The study result can be explained on the basis of finding of Waley et al., [13] and Khalil et al., [14]. They investigated the physiological basis underlying increases in muscle strength associated with the use of feedback and found that muscle strength increases could be attributed to; 1) an increase in the average firing rate; 2) an increase in the motor unit recruitment; and 3) occurrence of synchronization of the active motor unit. As such, the increases in strength associated with feedback appear to be the result of changes in both motor unit firing rate and recruitment patterns.

Admovich et al., [11] studied the effect of EMG-biofeedback on static contraction of quadriceps muscle demonstrated significantly greater strength gains than the control group.

Similarly, Lucca et al., [12] and Khalil et al., [14] found that greater gains in strength with EMG-biofeedback than did exercise alone. Another study done by Croce et al., [15] showed that a training program that uses EMG-biofeedback with isokinetic exercise produces significant gains in maximal strength of leg extensor muscles. Thus significant differences in improvement in isometric quadriceps strength in biofeedback group in present study can be justified on the basis of above past studies on strength training.

Improvement in pain intensity

The data showed that the 5 week period of intervention brought significant reduction in knee pain in both group at 2nd, 3rd and 2 week after follow-up i.e. at 5th week. The significant reduction of pain in both groups may be attributed to improved quadriceps strength. The findings are consistent with previous investigators who have reported that exercise can reduce pain of PFS patients. Falconer et al., [16] and Fisher et al., [17] found same positive effects of exercise programme on pain. Centin et al., [18] in their study concluded that exercise and physical agents can reduce pain and improve function and health status in patients with knee OA.

Spence et al., [19] investigated the effect of EMG-biofeedback on pain and they concluded that the EMG-biofeedback group significantly decreased pain.

The results of this study indicate that the adjunctive therapy of EMG-biofeedback was an effective means for reducing pain. The analysis of difference between two groups, showed statistical significant improvement at 2nd, 3rd and 2 week follow-up i.e. at 5th week. The findings are consistent with previous investigators who have reported that EMG-biofeedback could be a useful alternative for musculoskeletal pain. This study is further supported by Yip and Ng [20], they investigated the effect of EMG-biofeedback on patellofemoral pain and concluded that tendency toward pain relief was greater with EMG-biofeedback group.

The major limitation of this study was the small sample size consisting of only 30 subjects in the study. Double blind study would have improved the reliability of the measurement and results. Inclusion of isokinetic device could have given the more reliable information of the muscle strength than strain gauge.

5. CONCLUSION

The addition of electromyographic-biofeedback to isometric exercise program has been shown to produce greater gains in isometric quadriceps strength, thereby reduce pain than isometric exercise alone over a 3 week period. This study may provide a rationale for the clinical use of electromyographic-biofeedback.

6. ACKNOWLEDGEMENT

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