

Comparing the Effect of Open and Closed Kinetic Chain Exercises in Patients Suffering From Patellofemoral Pain Syndrome

Zahra Firoozkoobi Moghadam¹, Ahmad Ebrahimi Atri^{2*}, Seyed Ali Akbar Hashemi Javaheri³

¹Master Student of Sport Injuries and Corrective Exercise, International Branch of Ferdowsi University of Mashhad, Mashhad, Iran

²Associate Professor of Exercise Physiology, Faculty of Physical Education and Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

³Associate Professor of Therapeutic Exercises, Faculty of Physical Education and Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

*Correspondence to
Ahmad Ebrahimi Atri;
Email: atri@um.ac.ir

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Abstract

Introduction: Patellofemoral pain syndrome is one of the most prevalent problems in physically active people. The syndrome is a multifactorial disorder with different therapeutic approaches. Conservative treatment of the syndrome has been a crucial matter in different studies. Quadriceps muscle strengthening exercise is a recommended approach which is performed in forms of open and closed kinetic chain exercises. This study was designed to compare the efficacy of these exercises on this syndrome.

Methods: Totally 30 women suffering from the syndrome aged 30-40 were randomly allocated into three groups: open, and closed kinetic chain exercises, and control group, as groups A, B, and C, respectively. Groups A and B participated in 28 sessions of exercises in a period of four weeks and group C did not do any exercise in this period. Before and after the period, pain and function of the participants were assessed using visual analog scale (VAS) and Kujala patellofemoral scale, respectively. Data were analyzed using independent t test, dependent t test, and univariate variance analysis, while significance of data was determined at $P < 0.05$.

Results: The study indicated that open kinetic chain exercises (group A) for 4 weeks brought significant changes in relieving the pain along with improving the function ($P = 0.001$). Likewise, it was revealed a significant pain relief as well as function improvement in group B ($P = 0.001$). Comparing two groups illustrated that benefits of open kinetic chain exercises outweigh closed ones ($P = 0.001$).

Conclusion: Overall, both exercises were efficient in relieving pain as well as improving function, however open kinetic chain exercises were more contributory.

Keywords: Patellofemoral pain syndrome, Open kinetic chain exercises, Closed kinetic chain exercises, Pain, Function, PFPS.

Introduction

Patellofemoral pain syndrome is one of the most prevalent injuries in the knees, and is one of the most frequent orthopedic complaints in clinical fields.^{1,2} This multifactorial syndrome is known by a pain in knee which is increased by activities that exert pressure on the patellofemoral joint such as climbing, stepping down the stairs, squatting, and long periods of sitting.³⁻⁵ Since there are a wide variety of symptoms, making a definite diagnosis is pretty difficult. Malalignment of the lower extremity, increasing Q angle, muscular disequilib-

rium, decrease in the strength of vastus medialis oblique muscle, and ultimately overuse are some of the contributors of the disease. Although surgical procedures have been used successfully for these patients, conservative interventions are used widely especially in the first steps of the treatment.⁶ This kind of treatment entails 80%-90% of all.⁷

On the other hand, since there are plenty of biomechanical factors relating to this problem,^{8,9} various conservative interventions such as exercise therapy, taping, brace, foot prostheses, soft tissue manipulation, and

acupuncture have been suggested and evaluated for the treatment of this syndrome.¹⁰

Earlier studies reported satisfactory results regarding the exercise therapy in these patients.^{5,11-15} Such exercises are widely accepted for relieving pain and improving joint function.⁶ Frye et al indicated in a systematic review that despite reported effectiveness about these exercises in improving joint function and diminishing pain, there is no consensus about the most effective therapeutic approach as well as the best method of exercise therapy.⁵

One of the therapeutic approaches for this syndrome is quadriceps muscle strengthening exercises. Open and closed kinetic chain exercises are some examples among many different strategic approaches for quadriceps muscle strengthening.^{16,17} Chain exercises activate different parts of the extremity that provides situations which result in pressure production, extremity fixation, and ultimately pressure transport to the end of extremity.¹⁸ Closed chain exercises are multiple articular movements in which end of the extremity is fixed and occasionally related to weight bearing. By stark contrast, in open chain exercises, end of the extremity is not fixed and there is no weight bearing exercise.¹⁹ Witvrouw et al illustrated that there is no significant differences between two approaches. They concluded that both exercises are effective in muscle function improvement as well as pain alleviation,²⁰ however, Collins et al recommended closed kinetic chain exercises for just short-term periods.¹⁰

Considering the fact that there is no consensus about the best and most effective exercises for treatment of patellofemoral pain syndrome, and high prevalence of the disease in our community, this study aimed to compare two methods of kinetic chain exercises-open and closed-regarding their efficacy in alleviating pain and improving joint function in this syndrome.

Methods

This case-control study was done on females who referred to a physiotherapy clinic diagnosed with patellofemoral pain syndrome in Zabol, Iran. Among these patients, 30 subjects were allocated randomly into 3 groups: group A for performing open kinetic chain exercises (10 subjects), group B for closed kinetic chain exercises (10 subjects), and group C as control group (10 subjects). Inclusion criteria were: being aged between 30 and 40, absence of tendon and/or meniscus problem in knees (based on the report of the physician), minimum visual analog scale (VAS) score of three as well as Kujala score of 50, positive grind test along with other clinical tests, and confirmation of diagnosis of patellofemoral pain syndrome by a specialist.

All of the participants filled a questionnaire out about demographic data and signed a written consent. Then, severity of pain in patients was measured using VAS. Function of the joints was assessed using Kujala disability specific questionnaire as well. At next step, groups A and B were treated by 28 sessions of treatment during a period of 4 weeks. Each session lasted about 45-60 minutes. The

control group (group C) continued their daily routine as previous without any special physical activity. After termination of this period, all of the cases and controls filled out abovementioned questionnaire again. All of the three groups had the same medication protocol. They were trained for their daily activity, diet and sport. It was emphasized that the patients follow this daily routine.

Kujala questionnaire was introduced first by Kujala in 1993 for evaluating function of the knee in patients who suffer from patellofemoral pain syndrome. The questionnaire consists of 10 objective and subjective questions with minimum score of zero (loss of function) and maximum of 100 (perfect function). This questionnaire was translated into Persian by Negahban et al.²¹ Its validity and reliability were confirmed with intragroup correlation scale in test and retest (ICC=0.96) and Cronbach α of 81%, respectively.

VAS was used to measure perception of the pain. The scale is a 10 centimeter horizontal band in which one extreme is zero (no pain) along with other extreme which is 10 (the most severe pain). Patients were asked to mark one point in this 10 centimeter line based on the severity of pain. This scale is the most reliable scaling system for measuring pain that is widely used in pain related researches. Its validity and reliability is confirmed.

Regarding the open and closed kinetic chain exercises, both of the groups A and B had warm up and cool down exercises for about 5-10 minutes. The exercises in the first half of sessions were much easier than the second half with less severity and duration as well as repetition. Therefore, patients had much more time for rest in early stages. Gradually, exercises were more severe considering increased patients' ability and more pressure. In first two weeks each main exercise was repeated 10 times, while the contractions lasted 10 seconds. Then in last two weeks, time of each contraction was increased to 20 seconds.

Data were analyzed using SPSS version 22.0. Independent *t* test, dependent *t* test, and univariate variance analysis were conducted in significance level of less than 0.05.

Results

Demographic characteristics of the patients are shown in Table 1. There were no significant difference among the groups regarding the age, height, and weight.

Results indicated that pain relief and joint function improvement was significant in groups A and B with open and closed kinetic chain exercises ($P=0.001$). Comparing two groups illustrated that benefits of open kinetic chain exercises outweigh closed ones in relieving pain and improving joint function ($P=0.001$) (Table 2).

Discussion

The study showed that a period of open or closed kinetic chain exercises on quadriceps muscle has a significant effect on relieving pain and improving joint function. Comparing two methods of exercises illustrated significant higher efficiency for open kinetic chain exercises.

Results of previous studies are compatible with the find-

Table 1. Mean and Standard Deviation of Age, Height, and Weight in Three Groups of Open, Closed, and Control

Variable	Open Kinetic Chain Group	Closed Kinetic Chain Group	Control Group	P Value
Age (y)	39.60 ± 3.40	40.50 ± 2.36	38.90 ± 3.07	0.73
Height (cm)	163.50 ± 2.83	162.10 ± 4.45	160.30 ± 5.53	0.84
Weight (kg)	69.61 ± 6.78	66.39 ± 3.31	69.30 ± 5.53	0.60
BMI (kg/m ²)	26.33±1.67	25.20±1.32	25.46 ± 1.41	0.62

Abbreviation: BMi, body mass index.

Table 2. Comparing Mean of Some Pain and Function Indexes in Groups of Open, Closed, and Control

Variable	Group	Stage		Intragroup Changes		Intergroup Changes	
		Pre-test	Post-test	t	P	F	P
Pain	Open kinetic chain	7.90±0.99	4.5±1.08	-20.82	0.001	70.54	0.001
	Closed kinetic chain	5.9±0.87	4.3±0.94	-9.79	0.001		
	Control	4.3±1.15	4.1±0.87	0.68	0.50		
Function	Open kinetic chain	65.7±4.78	77.9±5.50	-19.39	0.001	105.07	0.001
	Closed kinetic chain	63.5±3.43	69.8±2.78	-9.94	0.001		
	Control	61±3.82	60.1±3.41	1.36	0.2		

ings of our study. Witvrouw et al²² evaluated effects of long term open and closed kinetic chain exercises on patients with patellofemoral pain. They reported that both exercises resulted in sustained positive effects on patients. Similarly, Minoonejad et al²³ showed satisfactory results about relieving pain and increasing knee flexion in stepping stairs up and down. One of the possible reasons for this similarity in the results might be using the same exercise protocols.

In contrast, the results of Peeler et al²⁴ study showed different results. They studied effects of exercise therapy on the function of patellofemoral pain syndrome. Some of the possible reasons might be different duration of therapeutic period (3 weeks in the study of Peeler et al), number of sessions per week, and sample size.

As stated earlier, in this study, two methods of open and closed kinetic chain exercises were evaluated for their efficiency in alleviating pain along with improving joint function in patients with patellofemoral pain syndrome.²⁵ One of the possible reasons for alleviating pain and improving function with open and closed kinetic chain exercises is the fact that strengthening quadriceps muscle especially vastus medialis obliquus (VMO) muscle results in suitable and coordinated contraction of the muscle; therefore it would correct tracking of the patella and diminish forces on the knees. This would lead to joint function improvement and pain decrease.²⁶ In order to confirm this hypothesis, it should be emphasized that mechanism of pain in patellofemoral pain syndrome is weakness of quadriceps muscle along with muscle imbalance especially in VMO muscle.²⁷ Besides, agonistic contraction of hamstring and quadriceps muscles during closed kinetic chain contractions leads to better function of knee joint as well as tibiofemoral joint.²⁸

Explaining possible mechanism of improving function and decreasing pain in open kinetic chain exercises, it

should be considered that these types of exercises result in the isolation of quadriceps muscle; so it can be contracted solely and it can strengthen the muscle.²⁹ Quadriceps strengthening improves joint function. Since deficiency in neuromuscular system is another main problem in Patellofemoral Pain Syndrome patients,³⁰ another possible mechanism in effectiveness of open and closed kinetic chain exercises might be the effectiveness of these exercises in improving neuromuscular system of knee joint as well as in increasing proprioception in the joint.

Improving the neuromuscular system and muscle strengthening can mend pattern of muscle activity along with fixed stability of knee joint and ultimately can diminish forces on the joint.³¹

Increase in muscle spindle sensitivity would progress the afferent neurons' information to central nervous system about position of the joint. Such exercises can increase proprioception and joint function.³² These factors would improve joint function in patellofemoral pain syndrome patients.

Another result of the study was the fact that open kinetic chain exercises were more effective than close ones in alleviating pain as well as improving joint function in patellofemoral pain syndrome patients. Another study showed that closed kinetic chain exercises had more effect in increasing proprioception.³³ As mentioned earlier open kinetic chain exercises improve solely contraction of quadriceps²⁹ and this might be a possible reason for being more effective comparing to closed ones in our study.

Our study had some limitations. All the three groups were trained for their daily activity, diet, and sport and it was emphasized that the patients follow this daily routine. However, we could not follow these variables properly since our data reference was claim of the patients. Therefore we could not confirm that all of the groups were matched for their daily activity, diet and sport during

the study period. Another limitation was that we did not evaluate the efficacy of the exercises based on the sex, age, body mass index (BMI), function score, Q angle, and severity of the pain in first visit. Authors suggest more work considering these variables and factors in their studies.

Conclusion

Two methods of open and closed kinetic chain exercises were effective in alleviating pain along with improving joint function in patellofemoral pain syndrome patients. Besides, in comparison of these two methods, open kinetic chain exercises had more positive effects rather than closed ones.

Ethical Approval

Ethical committee of Zabol University of Medical Sciences, Zabol, Iran, approved the study under the code number of zbm.u.1.REC.1395.50.

Competing Interests

Authors declare that they have no competing interests.

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