

## ORIGINAL ARTICLE

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## A STUDY TO COMPARE THE EFFECT OF CLOSED AND OPEN KINETIC CHAIN EXERCISE WITH KINESIO TAPING FOR PATELLO FEMORAL PAIN SYNDROME

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## ABSTRACT

**Background:** Patello femoral pain syndrome is dull, aching pain anterior to knee which frequently activity related may be present in one or both knees with difficulty in walking, running. The purpose of the study is to evaluate the effect of open kinetic chain exercise with Kinesio taping versus close kinetic chain exercise with kinesio taping for improving pain and functional mobility in subjects with unilateral patellofemoral pain syndrome.

**Methods:** An Experimental study design, 30 subjects with unilateral patellofemoral pain were selected and randomized 15 subjects into each two groups. Group-A received Open Kinetic chain exercise with Kinesio taping while Group-B received Close kinetic chain exercises with kinesio taping. The duration of intervention was 2 weeks. Outcome measure such as Functional mobility was measured using a Kujala questionnaire and pain was measured using a VAS scale before and after two weeks of intervention.

**Results:** Analysis using Independent 't' test and Mann Whitney U test found that there is statistically significant difference with  $p < 0.000$  when pre to post interventions means were compared within the groups. When post intervention means between the Group-A and Group-B were compared there is a significant statistical difference in VAS and functional mobility.

**Conclusion:** The present study concluded that both Open kinetic chain exercise with kinesio taping and close kinetic chain exercise with kinesio taping are effective in improving functional mobility and Pain. However close kinetic chain exercises with Kinesio taping shown greater percentage of effect in improving pain and functional mobility than open kinetic chain exercise.

**Keywords:** Patellofemoral pain, Close kinetic exercise, open kinetic exercise, Kinesio taping, VAS, Kujala Score, functional outcome.

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## INTRODUCTION

Patellofemoral pain syndrome is a broad term used to describe pain in the front of the knee and around the patella, or kneecap. Patellofemoral pain syndrome (PFPS) is common among females. The incidence in the general population is 25% in adolescents and adults. Incidence of this problem was reported to be 7% to 15%, most often involving the women and the youth.<sup>1</sup>

Patellofemoral pain is caused by numerous pathophysiological processes. A tightness of the soft tissue around the knee joint and a quadriceps muscle imbalance have frequently been described as the contributing factors in Patellofemoral pain. The abnormal relationship in the activation pattern of the vastus medialis obliquus (VMO) and vastus lateralis (VL) can alter the dynamics of the Patellofemoral joint (PFJ). This imbalance may lead to lateral tracking of the patella by the action of VL during knee extension.<sup>3</sup> Quadriceps femoris strengthening is the one of the treatment option for PFPS that usually performed through open and closed kinetic chain exercises.<sup>3</sup>

Open kinetic chain exercises (OKC) are performed in non-weight bearing with a free distal extremity. Open chain exercises can only be used traditionally with manual and mechanical resistance exercise routines with-out weight bearing activities.<sup>4,5</sup> Closed kinetic chain (CKC) exercises are multi-joint movements performed generally in weight bearing with a fixed distal extremity. Closed chain exercises are performed in functional postures with some degree of weight bearing and can involve concentric, eccentric, or isometric muscle action, they stimulate certain mechanoreceptors in and around joints more effectively than open-chain exercises, thereby stimulating muscle co-contraction and adding to joint stability.<sup>4,5</sup>

One successful approach in the treatment of patellofemoral pain involves taping of the patella, which facilitates the activation of vastus medialis oblique (VMO) muscle, the main transverse stabiliser of the patella, increases quadriceps strength, enhances neuromuscular recruitment, as well as relive pain.<sup>6,7</sup> It is theorized that the use of Kinesio tape can enhance joint stability by providing support to or around affected muscles, facilitate muscle contraction, the mechanism for which remains unknown.<sup>8-11</sup>

No studies have been found to find the effect of on open kinetic chain (OKC) and closed kinetic chain (CKC) with Kinesio taping for PFPS. Therefore, the present study with research question, Whether the closed or open kinetic chain exercise combined with patellar kinesio taping does have an effect on

improving pain and functional disability in subjects with Patellofemoral pain syndrome? Hence, the purpose of the study is to know the combined effect of open or closed chain exercises with kinesio taping on improving pain and functional disability in subjects with Patello femoral pain syndrome. It was null hypothesized that the closed or open kinetic chain exercise combined with Kinesio taping will not have a significant difference on improving pain and functional disability in subjects with Patellofemoral pain syndrome.

## METHODOLOGY

An experimental study design, pre and post-test measurements with two groups- Group-A and Group-B. As this study involved human subjects the Ethical Clearance was obtained from the Ethical Committee of KTG College of Physiotherapy and K.T.G. Hospital, Bangalore as per the ethical guidelines of Bio-medical research on human subjects. This study was registered under Rajiv Gandhi University of Health Sciences for subject for registration for dissertation with registration number 09\_T031\_47179. Subjects included in the study were both males and females, patellofemoral pain from 3 to 6 in visual analogue scale, knee pain at least in two activities among stair ascend and descend, pain in prolonged sitting with knee flexed, squatting, running, jumping and kneeling.<sup>4,5</sup> Subjects were excluded with history of knee surgery, knee dislocation and sub-luxation, referral pain from spinal cord or nerve root, ligament rupture; articular capsule or meniscus injury, tendon and muscle rupture in lower extremity. Subjects were recruited and study was conducted at KTG Hospital, Bangalore. Subjects who meet inclusion criteria were recruited by Simple random sampling method using closed envelopes, randomly allocated subjects into two groups. Subjects who meet inclusion criteria were informed about the study and a written informed consent was taken. Total 30 Subject (n=30), 15 in each group was studied. Total duration of intervention per subject is for two weeks.

### **Procedure of Kinesio Patella Taping for both Group-A and Group-B:<sup>8-11</sup>**

Kinesio tape was applied to quadriceps femoris to provide proprioceptive stimulation for muscle weakness (origin to insertion/muscle technique) and the hamstring muscles were taped to relieve tightness (origin to insertion/muscle technique) and to allow natural patella movement in the femoral groove. 'Y' strip is used in both techniques where tension dispersed through and between two tails over target tissue. All subjects were instructed to keep tape for two days and return for review after 12 hours removing tape to reapply.

Instructions were given to subject to observe for any rash or allergy, if it's there asked to remove tape. Subject was also taught easy way of removing tape.

#### **Facilitation technique for Quadriceps Muscle:**

Subject was positioned in supine or sidelying with hip and knee neutral on treatment table and kinesiio tape was measured as required approximately subject's length of muscle. Y strip with long base anchored with no tension at belly of muscle. Same extremity is taken into hip extension position and knee flexion at the edge of the table and applied tape with 15-30% tension till musculotendinous junction. At musculotendinous junction separated tails to surround patella. Ended with no tension on skin at Tibial tuberosity and activated adhesive by rubbing palm on it.

#### **Inhibition technique for Hamstring Muscle**

Subject was positioned in standing or sidelying. Measured and cut the kinesiio tape approximately length of hamstring. Anchored lower third portion of tape approximately by leaving length for tails at musculotendinous junction with no tension on it. Subject positioned with hip flexion and knee extension and directed tape towards Ischial tuberosity with 15-30% tension. Medial tail of the Y strip crossed medial joint line of the knee and end with no tension at medial condyle. Lateral Tail of Y strip crossed the lateral joint line of knee and end with no tension at lateral Fibular head.

#### **Open and Closed Kinetic Chain Exercise Programs<sup>4,5</sup>**

Before the beginning of the open and closed kinetic chain exercise programs, a 10-repetition maximum was determined. On the basis of that information patients were instructed to train at 60% of their maximum. A new 10-repetition maximum was established at the end of a week of training. In both training groups, each exercise was repeated 3 sets of 10 repetitions. The patients rested 1 minute after the conclusion of each set. In the open kinetic chain exercise protocol, each exercise was held isometrically for a count of 6 seconds with a 3-second rest between repetitions. Each exercise in the closed kinetic chain protocol was performed dynamically with a 3-second rest between repetitions.

In both training protocols the subjects were instructed to perform the conventional static quadriceps, hamstring, and gastrocnemius muscle stretching exercises after each training session. All subjects were instructed to perform three repetitions of a 30-second static stretch of exercised muscle groups. The subject were made to do one session under supervision when they visit in OPD

for every alternative days and advised to do exercises at home once in a day.

#### **Procedure of Intervention for Group A: (Open Kinetic chain exercise)<sup>4,5</sup>**

Along with taping the subjects in this group are treated with open kinetic chain exercises.

The open kinetic chain exercise program consisted of 1) maximal static quadriceps muscle contractions (quadriceps muscle setting) with the knee in full extension, 2) straight-leg raises with the patient supine, 3) short arc movements from 10° of knee flexion to terminal extension, and 4) leg adduction exercises in the lateral decubitus position.

#### **Quadriceps Isometrics:**

Subject positioned in supine or long sitting. Kept small towel about 1 inch roll below the knee of treatment extremity and asked the subject to press the knee on it, keeping it straight. Therapist positioned at the side of treatment extremity. Contraction should be hold for 6 sec and 10 repetitions performed in each set for three sets.

#### **Straight Leg Rising:**

In this exercise subject is lying on his back with the leg to be exercised in straight position and rest that foot of other leg while bending it at knee next to their straight leg. Tighten the quadriceps muscles of straight leg and lift the leg 10 inches off the floor, hold it for 6 seconds, then slowly lowered the leg back down.

#### **Terminal Knee Extension (Short arc Exercises):**

Subject is in supine lying and bolster is kept below both the knees. Subject has to take exercised leg into straight position. Hold the position for 6sec and bring back to start position.

#### **Hip adduction in decubitus position:**

Subject is in supine lying. Both knees bent as much as possible and feet joined together. Lowered down both legs simultaneously sideways and took it back to starting position.

#### **Procedure of Intervention for Group B: (Closed Kinetic chain exercise)<sup>4,5</sup>**

Along with taping the subjects in this group are treated with closed kinetic chain exercises.

The closed kinetic chain exercise program consisted of 1) Semi Squat and seated leg presses, 2) one-third knee bends on one leg and on both legs, 3) stationary bicycling, 4) rowing-machine exercises, 5) step-up and step-down exercises, and 6) progressive jumping exercises.

#### **Semi Squat**

Semi-squatting exercise is performed by eccentric phase (down) and in the concentric phase (up). Subject stands with wide stance – feet wider than

shoulder width, toes pointing forward; arms raised to chest height, palms facing. Then in next step keeping body upright; bend knees and hips to lower body, knees should not go in front of toes. Position was hold for 10sec and returned to starting position. Provided handle if patient was not able to balance himself.

### **Semi squat with hip adduction and internal rotation.**

This exercise performed in same way as semi squatting exercise. Only with difference in starting position where patient rotates his both legs internally without wide base and performed as above.

### **Step up and step down exercises.**

This exercise is performed on step or using block. Subject stands with normal base in front of step and then climb the step up and change the leg after climbing up then step down with opposite leg.

### **Outcome Measurements**

Outcome measurements such as pain using Visual Analogue Scale and functional disability using Kujala Patellofemoral Scoring System were measured pre and post intervention.

**Pain:** The subject's VAS for pain was measured in both groups before and after intervention using a 10 cm VAS. Reliability of VAS for measurement for acute pain measured by the Interclass Co-efficient (ICC) appears to be high. This suggests VAS is sufficiently reliable to be used to assess pain.<sup>12</sup>

**Functional disability:** Functional disability was measured using Kujala scale. The Kujala Scale is 13 item knee specific self- support questionnaire. It documents response to six activities thought to be associated specifically with anterior knee pain syndrome (walking, running, jumping, climbing stairs etc), as well as symptoms through such as limp, inability to weight bear affected limb, swelling, abnormal patellar movements etc. The maximum score is 100 and lower scores indicate greater pain/disability. Scoring is hierarchical using various types of categorization including 'no difficulty -unable' and 'no pain- to sever pain'. It has good test-retest reliability. Validity has demonstrated by scale authors (Kujala et al 1993) and by Timm (1998).<sup>13</sup>

### **Statistical Methods**

Descriptive statistical analysis was carried out in the present study. Out Come measurements analyzed are presented as mean  $\pm$  SD. Significance is assessed at 5 % level of significance with p value was set at 0.05 less than this is considered as statistically significant difference. Paired 't' test as

a parametric and Wilcoxon signed rank test as a non-parametric test have been used to analysis the variables pre-intervention to post-intervention with calculation of percentage of change. Independent 't' test as a parametric and Mann Whitney U test as a non-parametric test have been used to compare the means of variables between groups with calculation of percentage of difference between the means. The Statistical software namely SPSS 16.0, Stata 8.0, MedCalc 9.0.1 and Systat 11.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

### **RESULTS**

The study carried on total 30 subjects (Table-1) shows that in Group A there were 15 subjects with mean age 47.93 years and there were 8 males and 7 females were included in the study. In Group B there were 15 subjects with mean age 52.67 years and were 8 males and 7 females were included in the study. There is no significant difference in mean ages between the groups.

When means were analyzed from pre intervention to post intervention within the groups (Table-2 & 3) shows that in both the groups there is a statistically significant change ( $p < 0.05$ ) in means of Visual analog score and Kujala score for functional disability with  $p < 0.000$  with negative percentage of change showing that there is decrease in the post means. There is clinical significant improvement with large effect size in both the groups.

When pre intervention means were compared between Group A and Group B there is no statistically significant difference in means of Visual analogue score for pain and Kujala score for functional disability and no clinical significant difference in pre intervention means with small effect size. When post intervention means were compared there is a statistically significant difference in means of Visual analogue score for pain and Kujala score for functional disability. There is a clinical significant difference in post means with medium and large effect size.

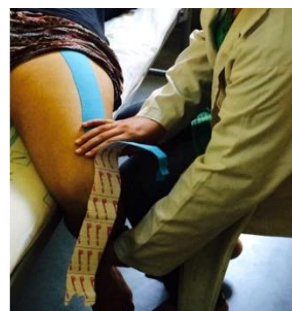


Figure-1: Quadriceps Taping



Figure-2: Taping applied both the sides



**Table 1:** Basic Characteristics of the subjects studied

Basic Characteristics of the subjects studied		Group A		Group B		Between the groups Significance <sup>a</sup>	
Number of subjects studied (n)		15		15		--	
Age in years (Mean ± SD)		47.93 ± 5.94 (38-59)		52.67 ± 5.88 (42-63)		p= 0.073 (NS)	
Gender	Males	8	53.33%	8	53.33%	--	
	Females	7	46.66%	7	46.66%		

Pearson Chi-Square

**Table 2:** Analysis of pain and Functional Disability within Group-A and Group-B (Pre to post test analysis)

	Pre intervention (Mean ± SD)	Post intervention (Mean ± SD)	Percentage change	Z value <sup>b</sup> (Non parametric significance)	t value a (Parametric)	Parametric Significance (2-tailed) P value	95% Confidence interval of the difference		Effect Size (r)
	min-max	min-max					Lower	Upper	
Group A									
Visual analog scale score in cm	8.22 ± 0.81 (6.8-9.5)	2.48 ± 0.88 (1.0-4.3)	-69.82%	-3.410 P = 0.001**	20.000	P < 0.000**	5.130	6.362	+ 0.959 (Large)
Functional disability using Kujala Score	50.47 ± 6.23 (40 - 60 )	85.87 ± 3.58 (80 -90)	70.14%	-3.424 P = 0.001**	-25.286	P < 0.000**	-38.403	-32.397	+ 0.961 (Large)
Group B									
Visual analog scale score in cm	8.50 ± 0.92 (7.0 - 10.0)	1.80 ± 0.72 ( 0.5- 3.2 )	-78.82%	-3.415 P = 0.001**	24.095	P < 0.000**	6.109	7.303	+ 0.971 (Large)
Functional disability using Kujala Score	49.00 ± 5.39 (40- 58)	94.33 ± 3.39 (90-100)	92.51%	-3.438 P = 0.001**	-45.190	P < 0.000**	-47.485	-43.182	+ 0.981 ( Large)

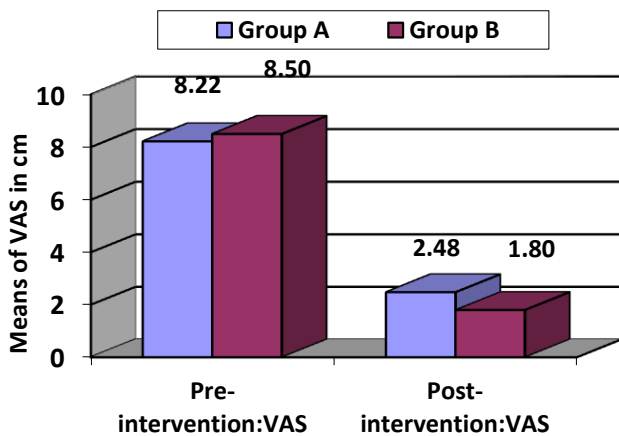
\*\* Statistically Significant difference p < 0.05; NS- Not significant; a. Pared t test. b. Wilcoxon Signed Ranks Test

**Table 3:** Comparison of means of pain and functional disability between Group-A and Group-B (PRE and POST INTERVENTION COMPARISION)

	Group A (Mean ± SD)	Group B (Mean ± SD)	Percentage of difference	Z value <sup>b</sup> (Non parametric)	t value a (Parametric)	Significance (2-tailed) P value	95% Confidence interval of the difference		Effect Size r
	min-max	min-max					Lower	Upper	
PRE INTERVENTION									
Visual analog scale score in cm	8.22 ± 0.81 (6.8-9.5)	8.50 ± 0.92 (7.0 - 10.0 )	3.34%	Z= -.601 P=0.548	1.362	P =0.182(NS)	- 0.3831	1.9365	+ 0.159 (Small)
Kujala score for functional disability	50.47 ± 6.23 (40 - 60 )	49.00 ± 5.39 (40- 58)	-2.95%	Z= -1.734 P=0.83	1.849	P =0.073 (NS)	-0.424	8.857	+ 0.125 (Small)
POST INTERVENTION									
Visual analog scale score in cm	2.48 ± 0.88 (1.0-4.3)	1.80 ± 0.72 (0.5- 3.2)	-31.77%	Z= -2.549 P=0.011**	2.638	P = 0.013**	0.1613	1.2487	+ 0.389 (medium)
Kujala score for functional disability	85.87 ± 3.58 (80 -90)	94.33 ± 3.39 (90-100)	9.38%	Z= -2.260 P=0.024**	0.569	P = 0.573 (NS)	-8.031	14.264	+ 0.772 (Large)

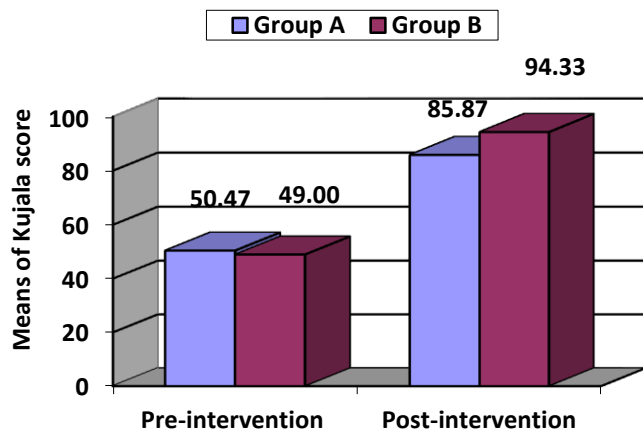
\*\* Statistically Significant difference p < 0.05; NS- Not significant a. Independent t test b. Mann-Whitney Test

**Graph-1:** Comparison of means of VAS between Group-A and Group-B (PRE AND POST INTERVENTION)



The above graph shows that there is no statistically significant difference in means of VAS for pain when pre-intervention were compared between Group A and Group B, when post intervention means were compared there is a statistically significant difference between groups

**Graph-2:** Comparison of means of functional disability between Group-A and Group-B (PRE AND POST INTERVENTION)



The above graph shows that there is no statistically significant difference in means of functional disability when pre-intervention means were compared between Group-A and Group-B, when post intervention means were compared there is a statistically significant difference between groups.

**DISCUSSION**

In this study, finding from the analysis it was found that there is a statistically and clinically significant improvement in pain and functional mobility in both groups- OKC with KT (Group-A) and CKC with KT (Group-B) after two weeks of intervention in subjects with patellofemoral pain. However, Group-B subjects shown greater percentage of reduction in pain and improvement in functional disability than Group-A.

Improvement in Pain and functional disability in both the groups could be because of kinesio taping that has been proved that it lifts skin below the tape and increase space between skin and muscle reducing localized pressure, promoting circulation and lymphatic drainage. Theoretically, it reduces pain swelling and muscle spasm.<sup>7-11</sup> Also it stimulates mechanoreceptors and deliver motor signals to CNS, increased stimulation may increases motor unit firing. Increase space and improved circulation could lead to improve muscle performance.<sup>11</sup> Many studies showed kinesio taping improve patellar alignment including quadriceps retraining (especially VMO the main transverse stabiliser of the patella), hip musculature strengthening.<sup>6</sup> Marc Campolo et.al, in their study found that both Kinesio and Mc Connell taping is effective in reducing pain during stair climbing activities in subjects with unilateral anterior knee pain.<sup>8</sup> Whittingham Martin, et.al., found that 4 weeks combination of daily patella taping and exercises was successful in improving pain and function in individuals with Patellofemoral pain syndrome. The combination of patella taping and exercise was superior to the use of exercise alone.<sup>14, 16-19</sup>

In Group A, the improvement in pain and functional disability could be due to open kinetic chain exercises with kinesio taping. Open kinetic chain exercises such as leg extension exercises have been the traditional means of strengthening the quadriceps muscle that has shown increase in activation of VMO and VL during open kinetic exercises.<sup>5,19</sup> Erik Witvrouw, et al., This study examined long term 5-year follow-up. They found the open kinetic chain group showed significantly less complaints compared to the closed kinetic chain group.<sup>5,19</sup>

In Group B, the improvement in pain and functional disability could be due to Closed kinetic chain exercises with kinesio taping. Closed chain exercises are performed in functional postures with some degree of weight bearing and can involve concentric, eccentric, or isometric muscle action. In addition to loading muscles, closed-chain exercises also load bones, joints, and non-contractile soft tissues such as ligaments, tendons, and joint capsules, because closed chain activities are done in weight bearing, they stimulate certain mechanoreceptors in and around joints more effectively than open-chain exercises, thereby stimulating muscle co-contraction and adding to joint stability.<sup>4</sup>

The present study shows that between Group A and Group B statistically and clinically shown significant improvement in pain and functional

mobility following one week of intervention. Improvement in functional mobility is attributed to the engagement of more muscle activation and strengthening of VMO in Close Kinetic exercises than Open Kinetic chain exercises. Various positions of the lower extremity affect the muscle activity of the vastus medialis obliquus (VMO) differently during both open and closed kinetic chain exercise conditions among patients with Patellofemoral pain syndrome (PFPS). Patients who presented with symptoms consistent with PFPS completed a series of open kinetic chain and closed kinetic chain exercises in which VMO activity was measured and compared. In open kinetic exercise, maximum VMO activity was achieved with terminal knee extension with medial tibial rotation. During closed kinetic exercises, squats with external rotation were preferred for maximum VMO activation.<sup>15, 20,21</sup>

Kinesio Taping was added to both the group as it is an effective strategy to reduce pain and correct alignment of muscles affected by muscle dysfunction in patellofemoral pain.<sup>11</sup> Improvement in the outcome parameters also could be due to Kinesio taping. Therefore the study lacks comparison with control group who received only kinesio taping.

Hence, the present study found that one week of Open Kinetic Chain with Kinesio taping and Close kinetic exercise with kinesio taping found statistically no significant difference on improvement of pain and functional mobility for subjects with patellofemoral pain. Therefore the present study accepts the null hypothesis.

### **Limitations of the Study**

The findings in this study are based on the subjects having anterior knee pain for more than month, difficulty in walking, stair climbing more than one week. Therefore, effects cannot be generalized with walking and stair climbing difficulty which is less than month. Moreover the study was carried for one week. So long term effects of both exercises with KT cannot be predictable. Only functional mobility and pain were measured.

### **Recommendation for Future Research**

Present study is lacking with control group who received only Kinesio taping so further studies with control group suggested. Study on long term effects of both type of exercises with kinesio taping are needed. Further study should also be done to compare the effect with different types of kinesio taping methods added with other techniques used in the management of PFPS. Further study should needed measuring effect using other outcome measurements.

## **CONCLUSION**

The present study concludes that the two weeks of combined OKC with KT and CKC with KT found statistically and clinically significant effect on improving pain, Functional mobility. CKC with KT group shown slightly greater percentage of reduction in pain and significantly greater percentage of functional mobility than OKC with KT.

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**Conflicts of interest:** None

## **REFERENCES**

1. H. Minoonejad, R. Rajabi, E. Ebrahimi-Takamjani, M.H. Alizadeh, A.A. Jamshidi, A. Azhari and E. Fatehi. Combined Open and Closed Kinetic Chain Exercises for Patellofemoral Pain Syndrome: A Randomized Controlled Trial. *World Journal of Sport Sciences*. 2012; 6 (3): 278-285.
2. Eda Akbas, Ahmet Ozgur Atay, Inci Yuksel. The effects of additional kinesio taping over exercise in the treatment of patellofemoral pain syndrome. *Acta Orthopaedica et Traumatologica Turcica*. 2011; 45(5):335-341.
3. Ann-Katrin Stensdotter, Paul W. Hodges, Rebecca Mellor, Gunnevi Sundelin and Charlotte Ha` Ger-Ross. Quadriceps Activation in Closed and in Open Kinetic Chain Exercise. *Medicine and Science in Sports and Exercise*. 2004; 35 (12): 2043-2047.
4. Erik Witvrouw, Lieven Danneels, Damien Van Tiggelen, Tine Marieke Willems and Dirk Cambier .Open Versus Closed Kinetic Chain Exercises in Patellofemoral Pain- A 5-Year Prospective Randomized Study. *Am. J. Sports Med*. 2004; 32(5):1122-30.
5. Erik Witvrouw, Roeland Lysens, Johan Bellefans, Koen Peers and Guy Vanderstraetenb. Open Versus Closed Kinetic Chain Exercises for Patellofemoral Pain. *Am J Sports Med*. 2000; 28 (5): 687-694.
6. Health and Taping Techniques <http://www.physioadvisor.com.au/11343550/patella-taping-mcconnell-taping-physioadvisor.htm>
7. TH Nakagawa et al. The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain syndrome: A randomized controlled pilot study. *SAGE Publications. Clinical Rehabilitation*. 2008; 22: 1051–1060.
8. Marc Campolo, Babu J, Dmochowskak, Scariah S, Varughese J. Comparison of two taping

- techniques Kinesio and McConnell and their effect on anterior knee pain during functional activities. *International journal of sports physical therapy*. 2013; 8(2): 105–110.
9. Cario Alano De Almeida, F Locks Neto, Anita Barros, Carlos Amorim, Liane De Brito Macedo. Kinesio tape does not alter neuromuscular performance of femoral quadriceps or lower limb function in healthy subjects randomised, double blind, controlled clinical trial. *Journal of manual therapy*. 2013; 18 (1):1-5.
  10. Vercelli, Francesco Sartori, C Foti, L Colletto, D Virton, G Ronconi, G Ferriero. Immediate effect of Kinesiotape application on maximal strength of dominant leg Quadriceps. *Clinical journal of orthopaedic sport medicine*. 2012;22(4):319- 326.
  11. Scott R. Freedman, Lori Thein Brody, Michael Rosenthal, and Justin C. Wise, PhD Short-Term Effects of Patellar Kinesio Taping on Pain and Hop Function in Patients With Patellofemoral Pain Syndrome. *Sports Health: A Multi-disciplinary Approach*. 2014; 6 (4): 294-300.
  12. Polly E. Bijur, Wendy Silver, E. Johan Galladhar. Reliability of the Visual Analog Scale for Measurement of Acute Pain. *Academic Emergency Medicine*. 2001; 8 (12): 1153-1157.
  13. Tugba Kuru, Elif Elcin Dereli, Ayse Yaliman. Validity of the Turkish version of the Kujala patellofemoral score in patellofemoral pain syndrome. *Acta Orthopadica et Traumatologica Turcica*. 2010; 44(2): 152-156.
  14. Whittingham M, Palmer S, Macmillan F. Effects of taping on pain and function in patellofemoral pain syndrome: a randomized controlled trial. *Journal of Orthop Sports Phys Ther*. 2004 ; 34(9):504-10.
  15. O'Sullivan SP, Popelas CA. Activation of vastus medialis obliquus among individuals with patellofemoral pain syndrome. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*. 2005, 19(2):302-304.
  16. Aminaka, Naoko; Gribble, Phillip A. Patellar taping, patellofemoral pain syndrome, lower extremity kinematics, and dynamic postural control. *Journal of Athletic Training*. 2008; 43 (1), 21 – 8.
  17. Ernst GP, Kawaguchi J, Saliba E. Effect of patellar taping on knee kinetics of patient with Patellofemoral pain syndrome *Journal of Orthop Sports Phys Ther*. 1999; 29(11):661-7.
  18. L Herrington, C J Payton. Effects of Corrective Taping of the Patella on Patients with Patellofemoral Pain. *Physiotherapy*. 1997, 83 (11): 566–572.
  19. Sallie M Cowan, Kim L. Bennell, and Paul W. Hodges. Therapeutic patellar changes the timing of vasti muscle activation in patient with Patellofemoral pain syndrome. *Clinical Journal of Sport Medicine*. 2002; 12:339–347.
  20. Michael James Callaghan, Huseyin Ozkan, Fatih Ozdag, Ozgur Ahmet Atay, Inci Yuksel and Mahmut Nedim Doral. The Effect of an Exercise Program in Conjunction with Short-Period Patellar Taping on Pain, Electromyogram Activity and Muscle Strength in Patellofemoral Pain Syndrome. *Sports Health*. 2010;12(5). 410-6.
  21. Tang SF, Chen CK, Hsu R, Chou SW, Hong WH, Lew HL. Vastus medialis obliquus and vastus lateralis activity in open and closed kinetic chain exercises in patients with patellofemoral pain syndrome: an electromyography study. *Arch Phys Med Rehabil*. 2001; 82(10):1441-5.

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