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RESEARCH ARTICLE

EFFECTS OF HIP ABDUCTORS AND LATERAL ROTATORS STRENGTHENING IN ADDITION TO QUADRICEPS STRENGTHENING IN PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME: A RANDOMIZED CONTROLLED CLINICAL TRIAL

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ABSTRACT

Purpose: To investigate the influence of additional strengthening of hip abductor and lateral rotator musculature on pain and function in sedentary people with Patellofemoral pain syndrome (PFPS).
Methods: 120 sedentary patients between 18 and 40 years of age, with a diagnosis of PFPS, were distributed randomly into 3 groups: 40 patients in the knee exercise group, who received a conventional treatment that emphasized stretching and Strengthening of the knee musculature; 40 patients in the knee and hip exercise group, who performed exercises to strengthen the hip abductors and external rotators in addition to the same exercises performed by those in the knee exercise group; and 40 patients who received only stretching and no strengthening. The patients were instructed to maintain their normal daily activities. An 11-point numerical pain rating scale (NPRS) was used to assess pain and the anterior knee pain scale (AKPS) were used to assess function, preintervention and post intervention.
Results: After 6 weeks of treatment, the control group, pre and post-test value for AKPS ($p<0.001$), NPRS ($p<0.001$) shows a statistical significance and even in the experimental group, pre and post-test value for AKPS ($p<0.001$), NPRS ($p<0.001$) shows a statistical significance in pain and function, but comparing both the experimental group, AKPS ($p=0.002$), LEFS ($P<0.001$), NPRS ($P<0.001$) showed better result than a control group. But, when we considered minimal clinically important differences, only the knee and hip exercise group demonstrated Mean improvements in AKPS and pain scores that were large enough to be clinically meaningful.
Conclusion: Physiotherapy programs focusing on Knee strengthening exercises supplemented by hip abductor and lateral rotator musculature–strengthening exercises were more effective than knee exercises alone in improving function and reducing pain in sedentary people with PFPS.

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most commonest and challenging knee pathologies encountered in the physical therapy outpatient clinic. It is frequently seen in adolescents and younger adults. It is higher for women than for men (2:1) (Almeida *et al.,* 1999; Bizzini *et al.,* 2003; Bolgla *et al.,* 2008). The most typical symptom of PFPS is a diffuse peripatellar and retropatellar pain, typically provoked by ascending or descending stairs, squatting, cycling and sitting with flexed knees for prolonged periods of time. The exact cause for PFPS is still unknown but has been proposed to be multifactorial.

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The most commonly accepted hypothesis of the cause of PFPS is that abnormal patellar tracking increases PFJ stress and causes subsequent wear on the particular cartilage (Mascal *et al.,* 2007). Historically, PFPS has been linked with quadriceps muscle impairement (Powers, 2003; Nijs *et al.,* 2006). But more recent research regarding PFPS has focused on strength deficits of the proximal hip musculature as a contributor to this disorder causing femoral adduction and medial rotation during weight-bearing activities abnormal patellar tracking (Bolgla *et al.,* 2008; Mascal *et al.,* 2003; Powers, 2003). The majority of published material on conservative treatment of PFPS has focused on Patellar bracing, Taping, Exercise, stretching and use of foot orthoses to attempt to alleviate pain and restore patients to full-functioning status (Witvrouw *et al.,* 2000). The Quadriceps strengthening exercises have been repeatedly demonstrated to

be an effective intervention for individuals with PFPS (Mascal *et al.,* 2003; Boling *et al.,* 2006). But based on the recent studies, several articles have reported associations between hip strength and knee pain, including studies that suggest hip strengthening may improve knee pain. Especially poor eccentric hip abductors and lateral rotators muscles control can result in femoral adduction and medial rotation during weight-bearing activities, leading to a predisposition to lateral patellar tracking (De Marche Baldon *et al.,* 2009; Magalhaes *et al.,* 2010). Although there are numerous studies showing weakness of the hip musculature in females with PFPS, there is currently very limited information on the effectiveness of hip strengthening exercises to decrease pain and improve function in these individuals. Thus, the purpose of this study was to evaluate, whether strengthening the hip abductors and lateral rotators in addition to the knee musculature would be superior to strengthening the knee musculature alone or no strengthening at all for outcomes of pain and function in sedentary patients with PFPS.

METHODS

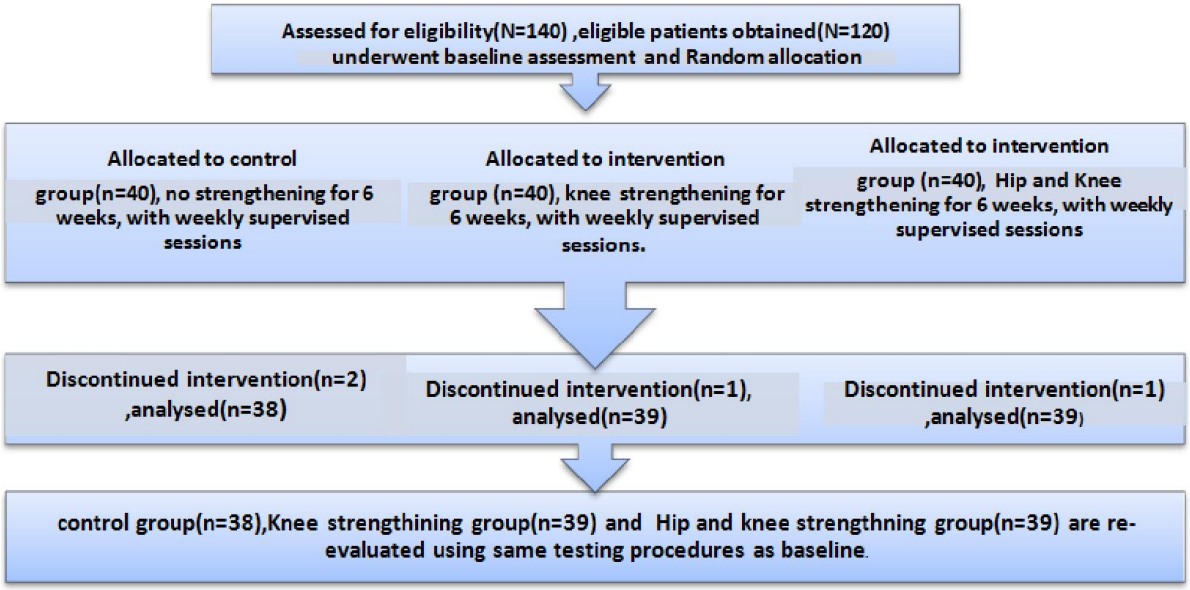
120 Subjects with PFPS of both sexes, between 18 and 40 years of age were selected from the population group satisfying the inclusion and exclusion criteria. Informed consent was obtained from the subjects before recruitment into the study. PFPS patients are diagnosed and referred from the Department of Orthopaedics, K.S Hegde Charitable hospital, Mangalore. Inclusion criteria;

Location of symptoms (peripatellar and/ or retropatellar) and the reproduction of pain with activities from at least 3 of the follow -ascending/descending stairs, squatting, kneeling, and prolonged sitting, insidious onset of these symptoms being unrelated to a traumatic incident, pain persistent for at least 1 month , presence of pain on palpation of the patellar facets;on stepping down from a 25-cm step/ double-legged squat, all patients in this study will be sedentary according to the criteria of ACSM. Exclusion criteria; History of patellar fracture/dislocation/knee surgery, pregnancy, Signs of nerve root compression, previous surgery around knee joint, systemic disorder, hip or lumbar referred pain, tenderness over the patellar tendon, iliotibial band, or pes anserinus tendons, a positive finding on any special tests aimed to identify knee ligament or meniscal injuries or other intra-articular pathologic conditions. They were randomly assigned into 3 groups: 40 participants not receiving treatment in the control (CO) group except stretching, 40 participants in the knee strengthening (KS) group, and 40 participants in the Hip and knee strengthening (HKS) group, protocol explained in table 1, 2, and 3.one patients in the KS group, one patient in the HKS group and two patients in control group did not complete the study.

Evaluation

Self-Administered Anterior Knee Pain Scale (AKPS) and 11 point numeral pain rating scale (NPRS) were used during pre-treatment and post treatment (after 6 weeks of treatment).Self-Administered Anterior Knee Pain Scale (AKPS) it is a13-item questionnaire that contains questions related to various levels of knee function and Response scores are summed. Total score is 100 and higher scores indicate greater function and lower levels of pain. kujala.pdf

11 point numeral pain rating scale (NPRS)- The NPRS is an 11-point scale that ranges from 0 (no pain) to 10 (worst imaginable pain) and subjects were instructed to circle pain level.



The flow chart below explains the distribution of data

RESULTS

Descriptive statistic

Baseline and Demographic Data

Overall, all the groups are having greater proportion of females than males. In total 120 subjects 22 are male and 98 are female.

Table 1. Control group (CO) treatment protocol

Activity	Duration
Stretching (all exercise session) • Sitting hamstring stretch • Sitting patellar mobilization • Standing quadriceps stretching • Standing calf stretching • Standing iliotibial band stretch	3repetitions/30-seconds hold

The table no 6 shows that in control group mean age of the subject is 25.85±6.71, in HKS group it is 28.27±6.24, whereas, KS group 23.10±5.78. From the above table (Table 7) it is clear that, the calculated "t" value is 21.32, which is greater than the 't' table value 2.01 (degrees of freedom = 52) and the p value is < 0.05.

Table 2. Knee strengthening group treatment protocol

Activity	Duration
Stretching (all exercise session) •Sitting hamstring stretch •Sitting patellar mobilization •Standing quadriceps stretching •Standing calf stretching •Standing iliotibial band stretch	3repetitions/30-seconds hold
•Isometric quadriceps contractions while sitting with 90^0 of knee flexion.	2 sets of 10 repetitions/ 10-second hold
•Straight-leg raise in supine position	3 sets of 10 repetitions
•Mini squats to 40^0 of knee flexion	3 sets of 10 repetitions
•Wall slides (0–60^0 of knee flexion)	3 sets of 5 repetitions
•Steps-up and steps-down from a 20-cm step	3 sets of 10 repetitions
•Forward lunges (0–45^o of knee flexion)	3 sets of 30-second hold each exercise
•Balance exercises: unilateral stance on the floor and on an trampoline , with opened and closed eyes	

Table 3.Hip and Knee strengthening group treatment protocol

Activity	Duration
Same as Knee strengthening group, hip strengthening is added, below mention exercise weight is progressed based on DAPRAE method.	
• In side lying with the hips and knees slightly flexed with free weight, the patient will be passively taken to abduction -lateral rotation then patient has to eccentrically drop the hip towards adduction and medial rotation direction.	2 sets of 15 repetitions 2 sets of 15 repetitions
• Side-lying patient will be passively taken to abduction controlled hip adduction with extended knee	

Table 4. Describes the overall age group

Gender	N	Mean age	Std. Deviation
Male	22	24.9412	6.08740
Female	98	26.0543	6.75267

Table 6. Describes the mean age for all the three groups

Group	Mean age	Std. Deviation
CO	25.8500	6.71660
HKS	28.2667	6.24328
KS	23.1000	5.78045
Total	25.7389	6.57349

Table 7. Difference in AKPS sore before and after the intervention among control group by using Paired t' test

Control group , n =38		Mean	SD	Mean difference	"t" value	p value
AKPS	Pre	69.48	16.18	16.05	21.32	<0.00
	Post	85.53	15.19			1

Paired t test within groups

Hence, there is a difference in mean AKPS score (16.05) before and after the interventions at 5% level of significance. It was observed that the mean post test score (85.53 ± 15.19) is higher than the pre-test score (69.48 ± 16.18). Thus the control group is effective in improving knee functions among the subjects with PFPS.

Table 8. Difference in NPRS sore before and after the intervention among control group by using Wilcoxon sign rank test

Control group, n=38		Mean	SD	Median	IQR	p value
NPRS	Pre	3.43	1.54	3.00	2 to 4	<0.001
	Post	1.95	1.47	1.00	1to 3	

The Table 8 shows that there is difference in the median value of NPRS in control group pre (3.00) and post (1.00), the p <0.05 at 5% level of significance. The mean pre-test score (3.43 ±1.54) was higher than post test score (1.95 ± 1.47) .it indicates that the control group are effective in reducing pain.

Table 9. Difference in AKPS sore before and after the intervention among hip and knee Strengthening(HKS) group by using Paired t' test

HKS group, n=39		Mean	SD	Mean difference	"t" value	p value
AKPS	Pre	50.26	10.22	33.45	29.71	<0.001
	Post	83.72	6.99			

From the above table (Table no 9) it is clear that, the calculated "t" value is 29.71, which is greater than the't' table value 2.01 (degrees of freedom = 54) and the p value is < 0.05. It was observed that the mean post test score (83.72 + 6.99) is higher than the pre-test score (50.26 ± 10.22). Thus the HKS group intervention is effective in improving knee functions among the subjects with PFPS

Table 10. Difference in NPRS sore before and after the intervention among hip and knee strengthening (HKS) group by using Wilcoxon sign rank test

HKS group, n=39		Mean	SD	Median	IQR	p value
NPRS	Pre	3.43	1.54	3.00	2 to 4	<0.001
	Post	1.95	1.47	1.00	1 to 3	

The Table 10 shows that there is difference in the median value of NPRS in HKS group pre (3.00) and post (1.00), the p <0.05 at 5% level of significance. The mean pre-test score (3.43 ±1.54) was higher than post test score (1.95 ± 1.47) .it indicates the treatment are effective in reducing pain.

Table 11. Difference in AKPS sore before and after the intervention among knee strengthening(KS) group by using Paired t' test

KS group, n=39		Mean	SD	Mean difference	"t" value	p value
AKPS	Pre	55.27	14.98	26.38	20.49	<0.001
	Post	81.65	15.91			

From the above table (Table no 11) it is clear that, the calculated "t" value is 20.49, which is greater than the "t" table value 2.02 (degrees of freedom = 54) and the p value is < 0.05.

It was observed that the mean post test score (81.65 ± 15.91) is higher than the pre-test score (55.27 ± 14.98). Thus the intervention in KS group is effective in improving knee functions among the subjects with PFPS.

Table 12. Difference in NPRS sore before and after the intervention among knee strengthening (KS) group by using Wilcoxon sign rank test

KS group, n=39		Mean	SD	Median	IQR	p value
NPRS	Pre	4.21	1.41	4.00	3 to 6	<0.001
	Post	1.53	1.22	1.00	1 to 2	

The Table 12 shows that there is difference in the median value of NPRS in KS group pre (4.00) and post (1.00), the p <0.05 at 5% level of significance. The mean pre-test score (4.21 ±1.41) was higher than post test score (1.53 ± 1.22) .it indicates the treatment are effective in reducing pain.

Table 13. Differences between the group-(ANOVA) Descriptive statistics for AKPS score

Group, n=116	Mean(pre-post)	SD	F value	p value
CO group	16.05	5.82	65.81	<0.001
HKS group	33.45	8.71		
KS group	26.38	9.97		

The table no 13 from each subject the differences of post and pre (post-pre) AKPS score was obtained .This score was compared among the three groups by using one way .From the table it is clear that the p value is less than < 0.05 hence there is a difference among the groups at 5% level of significance. In HKS group the mean is (33.45±8.71), which is lower than the mean of KS group (26.38 ± 9.97) and control group (16.05 ± 5.82) it indicates among the HKS group the functional improvement of the knee joint is more effective followed by those subjects among the KS group and control group respectively.

Table 14. Differences between the group-(ANOVA) Descriptive statistics for AKPS score

Comparison	Mean difference	S.E difference	P value
HKS and CO	17.4	1.53	<0.001
KS and CO	10.33	1.53	<0.001
HKS and KS	7.07	1.53	<0.001

One way ANOVA results using multiple comparisons by Tukey revealed that there was a difference in AKPS score (pre-post) among the groups. To identify between which groups there is a difference (multiple comparisons) Tuckey test was used (Table 14). For each comparison the p value is less < 0.001 it indicates there is a difference in mean AKPS among HKS and control group is (17.5), KS and control is (10.33), followed by HKS and KS (7.07).

Table 15. NPRS Mann-Whitney Test, Frequencies

Group	Mean	SD	Median	IQR	P value
CO	1.48	0.57	1.0	1 to2	<0.00
HKS	3.35	0.95	4.0	2.25 to 4.0	
KS	2.68	0.77	3.00	2 to 3	

All the three groups have showed significant improvement for all the outcome scale, when the further analysis within each group was done using paired t test for AKPS score for the abductor and external rotator muscles, whereas NPRS value was analysed using Wilcoxon sign rank test, all the three group showed an improved in pain and function. In addition, comparisons between the groups were carried out using one way ANOVA for AKPS values. Whereas, Mann-Whitney test was performed for the NPRS values. This result shows that, all the groups have improved in all the outcome scale causing reduction in pain and function, but the Hip and knee strengthening group has shown an upper hand on AKPS score and NPRS value compared to knee strengthening group and control group.

DISCUSSION

The results of the present study demonstrated that a 6-week intervention either consisting of knee-strengthening exercises or knee-strengthening exercises supplemented by hip-strengthening exercises both led to improved function and reduced pain in sedentary population with PFPS. For most outcome measures, greater improvement was noted in the group combining knee and hip exercises, the importance of hip abductor and lateral rotator muscle strengthening in the treatment of PFPS has received increased attention in recent years. This approach is based on several studies that have demonstrated weakness of the hip abductors and lateral rotators in patients with PFPS (Mascal *et al.,* 2003; Magalhaes *et al.,* 2010).The eccentric hip strengthening was supported by Rodrigo de at all (2009) eccentric hip abduction mean peak torque was 28% lower in the PFPS group than in the control group (Theresa Helissa Nakagawa, 2011). A similar study done by Kimberly l. dolak at all (2012) showed that the patients with PFPS, initial hip strengthening may allow an earlier dissipation of pain than exercises focused only the quadriceps (Dolak *et al.,* 2011). Accordingly, some authors have also speculated that simple daily activities were sufficient to lead to poor knee and hip kinematics, leading to a reduction of the patellofemoral contact area and increased joint stresses (Erik and Jason, 2011). Therefore in this study, these concepts were applied to sedentary population with PFPS. This study witnessed more percentage of young and sedentary females with PFPS, possibly due to the commonly noted hip muscle weakness that may change lower limb kinematics (Magalhaes *et al.,* 2010).

Conclusion

Physiotherapy programs focusing on Knee strengthening exercises supplemented by hip abductor and lateral rotator musculature–strengthening exercises were more effective than knee exercises alone in improving function and reducing pain in sedentary people with PFPS.

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