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THE EFFECT OF ADDING SPECIFIC HIP STRENGTHENING EXERCISES TO CONVENTIONAL KNEE EXERCISES IN PATIENTS WITH PATELLO-FEMORAL PAIN SYNDROME

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ABSTRACT

Background: Patello femoral pain Syndrome is an over use injury and one of the commonest problems seen in adolescents who are physically active. Till date no study has been done comparing the effect of adding specific hip strengthening exercises (gluteus medius, gluteus maximus & lateral rotators) to conventional exercises in patients with Patello femoral Pain Syndrome (PFPS) while minimizing the effect of minimizing the activation of tensor fascia lata (TFL).

Methods: 30 subjects were randomly allocated using convenience random sampling into 2 Groups Group A and Group B with 15 subjects in each group. Readings were taken for Numeric Pain Rating Scale (NPRS), Manual Muscle Testing (MMT) for hip abductors, extensors and external rotators muscles quadriceps and hamstrings, and Anterior Knee Pain Scale (AKPS) on baseline and at the end of 4th week.

Results: Analysis of the data collected for NPRS, AKPS and MMT of Quadriceps, Hamstrings, Hip Abductors and Hip External Rotators of 30 subjects was done by statistical analysis tests using STATA and software version 11.2. Although improvement was seen in both the groups but group B improved better compared to group A.

Conclusion: Group B treatment protocol i.e. Hip specific strengthening (gluteus medius and gluteus maximus) in addition to conventional treatment in patients with patello-femoral pain syndrome, was found to be effective in reducing pain, improving functional status and increasing muscle strength than Group A treatment protocol i.e. Knee strengthening and stretching.

Keywords: Patello-femoral Pain syndrome (PFPS), 11-Point Numerical Pain Rating Scale (NRS), Anterior Knee Pain Scale (AKPS), Manual Muscle Testing (MMT)

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INTRODUCTION

Patello-femoral pain syndrome (PFPS) is one of the common problems among physically active individuals between the ages of 15 and 30[1]. The reported incidence in the clinical setting ranges from 21 to 40 %². PFPS is particularly common in adolescents, especially females, young adults. It is an overuse injury characterized by aching pain in the prepatellar area [2]. The term "PFPS" is often used interchangeably with "Anterior knee pain" or "Runner's knee" because it involves the patella and the retinaculum that excludes other intra articular and pre-patellar pathology [3].

It is an overuse injury characterized by aching pain in the prepatellar area. Several factors have been proposed to cause PFPS such as patellar mal-alignment[4,5] an increased Q-angle[6,4,7,8] quadriceps weakness[4,9], decreased flexibility of lower extremity[4,10], overuse[11] and muscle imbalance[9] which results in an increase in cartilage and subchondral bone stress[4,12].

Clinical presentation of patello-femoral pain syndrome include stiffness or pain or both on prolonged sitting with the knees flexed and pain with activities that load the patello-femoral joint such as climbing or descending stairs, squatting, jumping, running and by sitting with the knees flexed for prolonged periods of time[3].

Excessive hip internal rotation and lateral patellar displacement has been seen in patients with patello-femoral pain syndrome [5]. So to limit this excessive hip internal rotation, it appears appropriate to design rehabilitation program using therapeutic exercises that promote activity of the gluteus medius and gluteus maximus while minimizing recruitment of the TFL[13].

Recently, Fukuda et al noted that in sedentary women with PFPS the addition of hip strengthening exercise (gluteus medius, gluteus maximus and lateral rotators) program was more effective in improving function and pain than knee exercises alone[14].

A study by Selkowitz, the electro myographic assessment using fine wire electrodes was done and it is proved that there are 5 groups of exercises are helpful in activation of gluteal muscles (gluteus medius & gluteus maximus) while minimizing TFL activation [15].

These are:

- The clam.
- The side step.
- The unilateral bridge.
- Hip extension in quadruped on elbows with knee extending.
- Hip extension in quadruped on elbows with knee flexion.

MATERIALS AND METHODS

Design

A comparative study design was used for the study.

Subjects

30 Participants who satisfied the inclusion criteria were se-

lected and randomly allocated to either Group A-Conventional exercises or Group B-Conventional exercises + Specific Hip strengthening (gluteus medius, gluteus maximus and lateral rotators). Informed consent was taken from all the participants included in the study.

Inclusion criteria - male and female, subject in the age group between 15-30 years, both males and females, sedentary subjects were taken, positive patellar compression test, patients having anterior knee pain for least 2 or 3 months, muscle strength for quadriceps, hamstring, gluteus medius and gluteus maximus should be grade 3, pain increasing in any of 2 activities or more-ascending & descending stairs, squatting, kneeling, jumping, running, jogging, isometric contraction at 60° of knee flexion.

Exclusion criteria - Any neurological disorder such as stroke, Parkinsonism, etc, Injury to lumbosacral region, hip or ankle, any heart condition, patients using corticosteroids or anti inflammatory drugs, rheumatoid arthritis, pregnancy, patellar instability, history of knee injury.

INTERVENTION

Group A was given conventional exercises and Group B was given specific hip muscle strengthening (gluteus medius, gluteus maximus and lateral rotators) in addition to conventional exercises.

Group A: Control group [14]

- Stretching (hamstrings, quadriceps and iliotibial band), 3 repetitions of 30 sec.
- Seated knee extension from 90° to 45°, 3 sets of 10 repetitions.
- Squatting from 0° to 45°, 3 sets of 10 repetitions.
- Leg press from 0° to 45°, 3 sets of 10 repetitions.
- Prone knee flexion, 3 sets of 10 repetitions.
- Single-leg calf raises, 3 sets of 10 repetitions.

All the exercises were performed on alternate days for 4 weeks.

Group B: Experimental Group [14,15]

In addition to exercises given to control group following exercises were given:

- Clam in side lying with elastic resistance around thighs, 3 sets of 10 repetitions.
- Sidestep, 3 sets of 10 repetitions.
- Unilateral bridge, 3 sets of 10 repetitions.
- Hip extension in quadruped on elbows with knee extending, 3 sets of 10 repetitions.
- Hip extension in quadruped on elbows with knee flexed 3 sets of 10 repetitions.

All the exercises were given on alternate days for 4 weeks.

OUTCOME MEASURES

Pain was measured by 10 Point Numerical Pain Rating Scale, Muscle strength was measured by MMT and Functional status was measured by AKPS.

RESULTS

Analysis of the data collected for NPRS, AKPS and MMT of Quadriceps, Hamstrings, Hip Abductors and Hip External Rotators of 30 subjects were done by statistical

analysis tests using STATA and software version 11.2. The results were considered statistically significant at $p < 0.05$. T-test was used to analyse inter-group differences in NPRS, AKPS and MMT readings before and after performing the intervention. Paired sample t-test was used to compare the intra-group differences in NPRS, AKPS and MMT readings before and after intervention.

Between group comparison of Mean Age and Mean BMI

Between group analysis of these baseline characteristics showed that there was no significant difference in the Mean Age (0.96) and Mean BMI (0.52) of the subject in both groups that is $p > .05$.

Table 1: Between group comparison of Mean Age and Mean BMI

	Group A	Group B	p-value
Mean Age	24.40 ± 4.04	24.33 ± 3.79	0.96NS
Mean BMI	23.13 ± 2.23	23.11 ± 3.63	0.52NS

NS- Not Significant

Within Group Analysis of NPRS Score

Group A

The Mean value ± Standard Deviation of NPRS in Group A was 7.31 ± 0.74 on baseline and on last day of 4th week was 5.53 ± 0.63. The within group analysis of NPRS showed that there was a significant difference between baseline and last day readings in Group A. Paired sample t-test revealed that there was a significant decrease in NPRS score from baseline to last day of 4th week as $p < .05$.

Group B

The Mean value ± Standard Deviation of NPRS in Group B was 6.73 ± 1.09 on baseline and on last day of 4th week was 3.66 ± 1.04. The within group analysis of NPRS showed that there was a significant difference between baseline and last day readings in Group B. Paired sample t-test revealed that there was a significant decrease in NPRS from baseline to last day of 4th week as $p < .05$.

Table 2: Comparison of change in NPRS within group A

Group A	NPRS base-line	NPRS post treatment	p-value
Pair 1	7.13 ± 0.74	5.53 ± 0.63	0.001**

Pair 1 - Difference of mean score of NPRS from baseline to last day of 4th week.

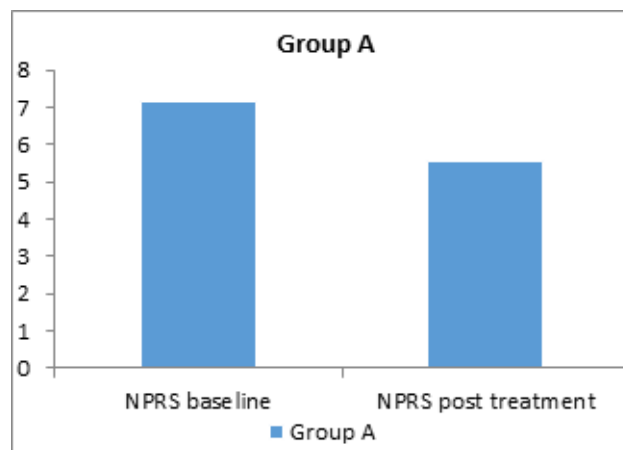
** $p < .001$ (Highly significant)

Table 3: Comparison of change in NPRS within group B

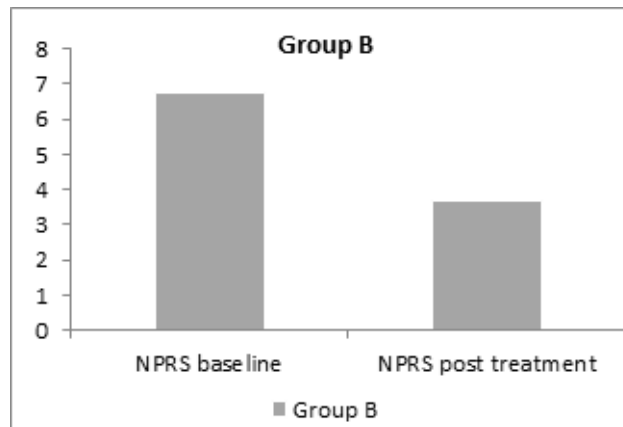
Group B	NPRS base-line	NPRS post treatment	p-value
Pair 1	6.73 ± 1.09	3.66 ± 1.04	0.001**

Pair 1 - Difference of mean score of NPRS from baseline to last day of 4th week.

** $p < .001$ (Highly significant)



Graph 1: Comparison of change in NPRS within group A



Graph 2: Comparison of change in NPRS within group B

Between group analysis of NPRS score

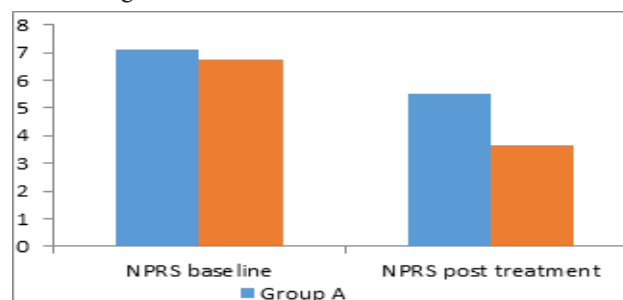
The Mean Value ± Standard Deviation of NPRS for subjects in group A was 7.13 ± 0.74 on baseline and on last day of 4th week was 5.53 ± 0.63 but Mean Value ± Standard Deviation of NPRS for subjects in group B was 6.73 ± 1.09 on baseline and on last day of 4th week was 3.66 ± 1.04. Between groups analysis of NPRS showed there was no significant difference between group A and group B on baseline ($p > 0.05$) but there was significant difference between both the groups on last day of 4th week ($p < .001$).

Table 4: Between group comparison of NPRS

	Group	Mean	p-value
NPRS baseline	A	7.13 ± 0.74	0.25 ^{NS}
	B	6.73 ± 1.09	
NPRS post treatment	A	5.53 ± 0.63	.001**
	B	3.66 ± 1.04	

** $p < .001$ (Highly significant)

NS – Not Significant



Graph 3: Between group comparison of NPRS

Within group analysis of Anterior Knee Pain Scale score (AKPS)

Group A

The Mean value \pm Standard Deviation of AKPS in Group A was 59.4 ± 4.4 on baseline and on last day of 4th week was 66.2 ± 4.8 . The within group analysis of AKPS showed that there was a significant difference between baseline and last day readings in Group A. Paired sample t-test revealed that there was a significant improvement in functional status on the last day of 4th week that is $p < .05$.

Group B

The Mean value \pm Standard deviation of AKPS in Group B was 64.8 ± 9.8 on baseline and on last day of 4th week was 79.6 ± 8.4 . The within group analysis of AKPS showed that there was a significant difference between pre and post readings in Group B. Paired sample t-test revealed that there was a significant improvement in functional status on last day of 4th week that is $p < .05$.

Table 5: Comparison of change in AKPS score within group A

Group A	AKPS baseline	AKPS post treatment	p-value
Pair 1	59.4 ± 4.4	66.2 ± 4.8	0.001**

Pair 1 - Difference of mean score of AKPS from baseline to last day of 4th week.

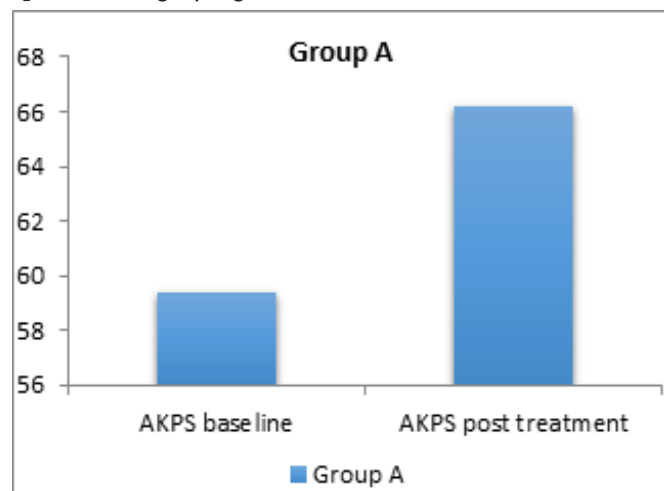
** $p < .001$ (Highly significant)

Table 6: Comparison of change in AKPS within group B

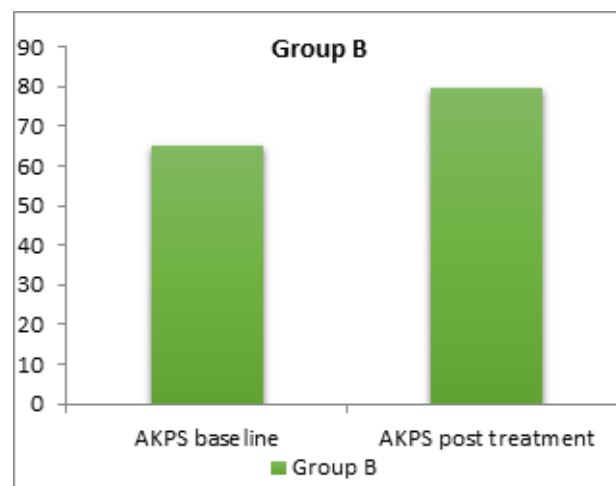
Group B	AKPS baseline	AKPS post treatment	p-value
Pair 1	64.8 ± 9.8	79.6 ± 8.4	0.001**

Pair 1 - Difference of mean score of NPRS from baseline to last day of 4th week.

** $p < .001$ (Highly significant)



Graph 4: Comparison of change in AKPS score within group A



Graph 5: Comparison of change in AKPS within group B

Between group analysis of Anterior Knee Pain Scale score (AKPS)

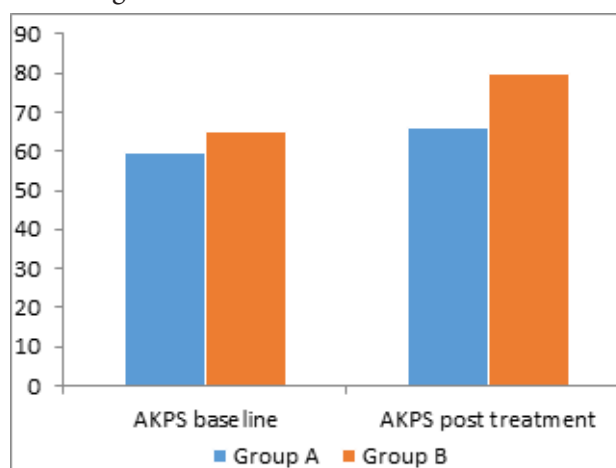
The Mean Value \pm Standard Deviation of AKPS score for subjects in group A was 59.4 ± 4.4 on baseline and on last day of 4th week was 66.2 ± 4.8 but mean value \pm standard deviation of AKPS for subjects in group B was 64.8 ± 9.8 on baseline and on last day of 4th week was 79.6 ± 8.4 . Between groups analysis of AKPS showed there was no significant difference between group A and group B on baseline ($p > 0.05$) but there was significant between both the groups on last day of 4th week ($p < 0.05$)

Table 7: Between group comparison of AKPS score

	Group	Mean	p-value
AKPS baseline	A	59.4 ± 4.4	0.096 ^{NS}
	B	64.8 ± 9.8	
AKPS post treatment	A	66.2 ± 4.8	.001**
	B	79.6 ± 8.4	

** $p < .001$ (Highly significant)

NS – Not significant



Graph 6: Between group comparisons of AKPS score

Within group analysis of MMT

Group A

The within group analysis of MMT showed that there was a significant difference between baseline and last day readings in Group A. Paired sample t-test revealed that there

was a significant improvement in muscle strength of Quadriceps and Hamstrings on the last day of 4th week that is $p < .05$ and there was no significant improvement in muscle strength of Hip Abductors and external rotators on the last day of 4th week that is p -value is not significant.

Group B

The within group analysis of MMT showed that there was a significant difference between pre and post readings in Group B. Paired sample t-test revealed that there was a significant improvement in muscle strength of Quadriceps Hamstrings, Hip abductors and external rotators on last day of 4th week that is $p < .05$.

Table 8: Comparison of change in MMT within group A

Group A	MMT base-line	MMT post treatment	p-value
Quadriceps	3.00 ± .000	4.33 ± .617	.001**
Hamstrings	3.00 ± .000	4.33 ± .617	.001**
Hip Abductors	3.00 ± .000	3.00 ± .000	N.S
Hip External Rotators	3.00 ± .000	3.00 ± .000	N.S

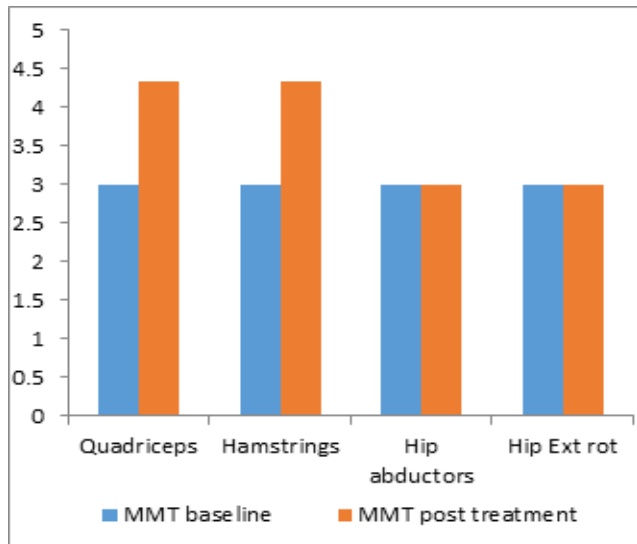
** $p < .001$ (Highly significant)

NS – Not Significant

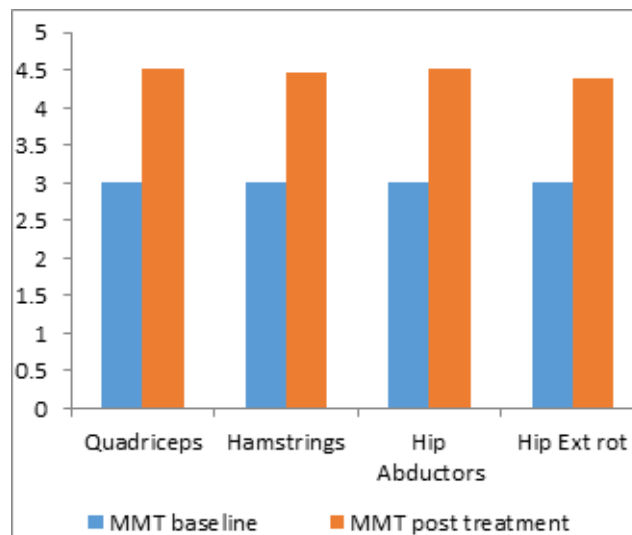
Table 9: Comparison of change in MMT within group B

Group B	MMT base-line	MMT post treatment	p-value
Quadriceps	3.00 ± .000	4.53 ± .516	.001**
Hamstrings	3.00 ± .000	4.46 ± .516	.001**
Hip Abductors	3.00 ± .000	4.53 ± .516	.001**
Hip External Rotators	3.00 ± .000	4.40 ± .507	.001**

** $p < .001$ (Highly significant)



Graph 7: Comparison of change in MMT within group A



Graph 8: Comparison of change in MMT within group B

Between group analysis of MMT

Between groups analysis of MMT for Quadriceps and Hamstrings showed there was no significant difference between Group A and Group B on baseline as well as on last day of 4th week, $p > 0.05$.

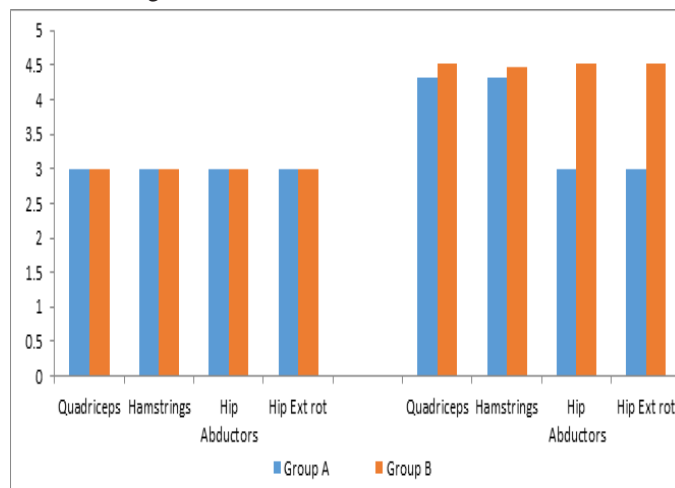
Between groups analysis of MMT for Hip abductors and external rotators showed there was a significant difference between group A and group B on the last day of 4th week, $p < 0.05$.

Table 10: Between group comparison of MMT

MMT		Group		p- value
		A	B	
Mean Baseline	Quadriceps	3.00 ± .000	3.00 ± .000	Nil
	Hamstrings	3.00 ± .000	3.00 ± .000	Nil
	Hip Abductors	3.00 ± .000	3.00 ± .000	Nil
	Hip Ext Rot	3.00 ± .000	3.00 ± .000	Nil
Mean Post treatment	Quadriceps	4.33 ± .617	4.53 ± .516	0.27 ^{NS}
	Hamstrings	4.33 ± .617	4.46 ± .516	0.58 ^{NS}
	Hip Abductors	3.00 ± .000	4.53 ± .516	.001**
	Hip Ext Rot	3.00 ± .000	4.53 ± .516	.001**

** $p < .001$ (Highly significant)

NS – Not Significant



Graph 9: Between group comparison of MMT

DISCUSSION

Patello-femoral pain syndrome (PFPS) is one of the common problems among physically active individuals between the ages of 15 and 30 [1]. It is an overuse injury characterized by aching pain in the prepatellar area.

The study compared the effectiveness of adding specific hip strengthening exercises to conventional knee exercises in patients with Patello femoral pain syndrome. The subjects in this study had similar baseline values of all dependent variables suggesting that all groups had homogenous distribution of patients. The results of this study revealed that although both treatment techniques were effective in reducing pain, improving muscle strength and improving functional status but statistically there was a significant difference between both the groups at the end of 4th week suggesting that Group B treatment protocol i.e. the specific hip strengthening exercises (hip abductors and external rotators) to conventional treatment protocol in patients with patello-femoral pain syndrome is a better treatment option than conventional treatment alone in patients with PFPS.

The results of our study are in accordance with the results of previous studies. According to McMullen et al (1990), isometric quadriceps exercises such as straight leg raises can facilitate quadriceps activation without stressing the patello-femoral joint and minimizes patello-femoral joint reaction forces, because the patella has no contact with the femoral condyles in the full extension position [16].

Kaya et al (2012) suggested that the prescription of the quadriceps strengthening exercise for the patients with PFPS must be well-designed because the contact area between the patella and the femur changes throughout knee flexion and extension. In closed kinetic chain exercises, movement at one joint produces predictable movements at all other joints. Weight bearing closed kinetic chain activities may increase joint compressive force and thus enhance joint stability [17].

Nakagawa et al (2008) et al in his study suggested an association between hip muscle weakness or motor control impairment and the patello-femoral pain syndrome. Poor hip control may lead to abnormal patellar tracking, increasing patello-femoral joint stress and causing wear on the articular cartilage. 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 as the femur medially rotates underneath the patella. A possible treatment for the patello-femoral pain syndrome could include optimizing hip abductors and lateral rotators muscle function to control these femur motions and prevent or reduce greater lateral forces acting on the patella [2].

Fukuda et al (2012) have shown an association between hip muscle weakness, especially of the abductors and lateral rotators and changes in kinematic patterns of the lower extremity. Some evidence suggests that these strength defi-

cits may lead to excessive medial rotation and adduction of the femur, which in turn may lead to excessive dynamic valgus alignment of the knee in symptomatic patients with PFPS when compared to controls. Mechanically, weakness of the hip musculature could lead to increased femoral adduction, flexion, and medial rotation during dynamic weight-bearing activities, which would increase the lateral patello-femoral joint vector, leading to patellar facet overload. It is noted that most major muscle groups at the hip control movements in 2 or 3 planes (sagittal, frontal, and transverse). The gluteus maximus, for example, can produce hip abduction, and lateral rotation. For this reason, they developed a protocol composed of strengthening exercises for hip abductor, lateral rotator muscles.

However, it is well documented that the recurrence rate of PFPS can be as high as 91%. These findings would suggest that, although a conventional knee-stretching and -strengthening program may produce successful short-term outcomes, the inclusion of hip strengthening may be needed to prevent recurrence of future symptoms [14].

Selkowitz (2013) in his study investigated that which exercises would best activate the Gluteus Medius and Superior Gluteus Maximus while minimizing TFL activity. He stated that abnormal hip kinematics (i.e, excessive hip adduction and internal rotation) has been linked to certain musculoskeletal disorders. The TFL is a hip abductor, but it also internally rotates the hip. As such, it may be important to select exercises that activate the gluteal hip abductors while minimizing activation of the TFL. So if the goal of rehabilitation is to preferentially activate the gluteal muscles while minimizing TFL activation, then the Clam, Sidestep, Unilateral Bridging, Quadriceps with Knee Extension, and Quadriceps with Knee Flexion exercises appear to be most appropriate. This is based on the fact that all of these exercises produced significantly greater normalized EMG in both the Gluteus Medius and the Superior-Gluteus Maximus muscles relative to the TFL [15].

The results of the study indicated that although both treatment groups resulted in significant improvements in pain, muscle strength and functional status, the Group B treatment protocol i.e. Addition of specific hip strengthening exercises of Gluteus maximus and Gluteus medius to conventional treatment protocol was statistically better compared to group where only conventional treatment was given.

CONCLUSION

The study compared the effectiveness of adding specific hip strengthening exercises to conventional knee exercises in patients with Patello-femoral pain syndrome and it is concluded that Pain decreased significantly in group B as compared to group A, Functional status improved significantly in group B as compared to group A and Muscle strength increased significantly in group B as compared to group A.

Group B treatment protocol i.e. "Hip specific strengthening (gluteus medius and gluteus maximus) in addition to conventional treatment in patients with patello-femoral pain syndrome", was found to be effective in reducing pain, im-

proving functional status and increasing muscle strength than Group A treatment protocol i.e. "Knee strengthening and stretching".

Hence it is concluded that Group B treatment protocol is effective therapeutic option in the treatment of patients with Patello femoral pain syndrome.

Limitations of study

1. The sample size was small.
2. There was no follow-up.
3. Study was done only on patients with sedentary life-style; sports people were not included in the study.

Relevance to clinical practice

The study provides therapists with the evidence on which to base their judgement of the effectiveness of adding specific hip strengthening exercises to conventional knee exercises in patients with patello-femoral pain syndrome.

The results of the study indicated that the addition of specific hip strengthening exercises to conventional knee exercises brings better results in patients with patello femoral pain syndrome.

Future Research

1. Future research can be done with large group of samples.
2. Research have found that PFPS is more common in sportsmen and women of any age, so in future, research can be carried out by taking subjects who are involved in sports activities.

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