Effectiveness of half squats and inner thigh strengthening exercise in patients with patellofemoral pain syndrome; randomized control trial

Noor Fatima, Nadeem Asghar*, Asim Raza*, Farooq Islam*, Afifa Tariq****

*Department of Rehabilitation Sciences, University of Chenab, Gujrat, Punjab, Pakistan

**University Institute of Physical Therapy, University of Lahore, Punjab, Pakistan

Abstract

Patellofemoral Pain Syndrome (PFPS), often known as runner's knee, is the most prevalent diagnosis for people experiencing knee pain behind, under, or surrounding the patella while running, kneeling, prolonged sitting, and climbing stairs.

Objective - To determine the effectiveness of half squats and inner thigh strengthening exercise in patients having Patellofemoral Pain Syndrome (PFS).

Methodology - Randomized Control Trial was conducted in 54 patients with patellofemoral pain syndrome from public and private hospitals and clinics of Jhelum through non probability convenient sampling. . Participants were randomly distributed into 2 groups: Group A: 2 months long, half squats and inner thigh strengthening exercises program; Group B: 2 months long, inner thigh strengthening exercises program. Demographic data, health status of participant was collected through SF-36 Questionnaire. KUJALA Scoring Questionnaire and NPRS were used for functional assessment of participants and level of pain. To measure knee strength and ROMs of paticipants, MRC scale and Goniometer were used, respectively. Data was analyzed through Statistical Package for Social Sciences (SPSS) version 24 and interpreted using independent t-test and two way repeated measures ANOVA.

Results – The addition of half squats to the inner thigh strengthening exercises improved the quality of life of participants in the intervention group A, a statistically significant decrease in pain and an increase in muscle strength and functional performance ($p<0.001$) was observed.

Conclusion – Adding half squats to inner thigh strengthening exercises programs for strengthening quadriceps muscles, the program was effective to reduce pain and improve knee functionality as well as quality of life in people with patellofemoral pain syndrome.

Keywords **-** Anterior Knee Pain Syndrome, Muscle Strength, Joint Range of Motion, Questionnaire, Assessment, Patient Outcomes, Clinical Trials, Exercise, Strengthening Programs, Pain, Patellofemoral

I. INTRODUCTION

Patellofemoral Pain Syndrome (PFPS), often known as runner's knee, is the most prevalent diagnosis for people with knee pain and most commonly arises in between ages of 15 and 30.[1] It is commonly characterized as discomfort all over the patella that appears either during or after heavy knee flexion and extension, as well as reduced function.[2] Overuse, injuries, muscular malfunction, tight lateral restrictions, patellar hypermobility, and inadequate quadriceps flexibility are all risk factors.[3] PFPS usually worsens with kneeling, prolonged sitting, and climbing stairs, and it is characterized in the absence of other diseases including patellar tendinopathy, chondral abnormalities, or patellofemoral osteoarthritis.[4] Women are thought to be 1.5 times more likely than males to suffer from PFPS, which is likely due to their greater Q angle and loss of lower - limb strength.[1]

Although the etiology is unknown, it is widely accepted in the clinical field that the major cause is lateral patella malalignment.[5] The inherent valgus of the lower limb, along with the prominent lateral force of the quadriceps, causes the patella to migrate to the side. This lateral patellar shift may cause PFPS by putting unequal pressures between the patella and the peripatellar tissues.[4]

A randomized clinical trial in Colombia showed that integrating core muscle strengthening exercises in the conservative management of PFPS improves its efficacy in reducing pain and improving these patients' quality of life.[6] Nascimento LR et al found that combining hip and knee strengthening is more efficient and preferable to knee training alone in reducing pain and enhancing activity in those with patellofemoral discomfort.[7]

Patellofemoral pain syndrome is a disorder that, if left untreated, can lead to a number of issues, including quadriceps weakness, patellar subluxation, knee osteoarthritis, and complications that could endanger the normal lifestyle of an individual. Additionally, there is relatively little information on quadriceps strengthening program and specific recovery protocol for individuals experiencing PFPS. Taking this into account, the objective of the present study was to determine the effectiveness of half squats vs inner thigh strengthening exercises in patients with Patellofemoral Pain Syndrome (PFPS).

II. METHODOLOGY

This Randomized Control Trial was completed in duration of 8 weeks. This study was conducted on 54 participants who met the eligibility criteria and expressed their willingness to participate in the study. Inclusion criteria includes, participants aged 20 and above years

old and being diagnosed with PFPS, living in Jhelum city, having clinical signs of patellar pain while resting, sitting for an extended period, or doing any following activities: going up or down stairs, jumping, running, squatting, kneeling, experiencing pain when moving the kneecap or being afraid of moving it at all, experiencing crepitus when doing squats and reporting unilateral or bilateral patellofemoral joint alignment complaints. Exclusion Criteria includes, patellofemoral dislocation, subluxation, or osteoarthritis of the knee, participants having connective tissue problems, such as knee bursitis, torn meniscus, patellar tendinitis, or synovial plica syndrome, those patients who suffered from ligament or meniscal injuries a year ago or had any form of spinal, hip, or knee orthopaedic surgery in the last 5 years.[(6)] All Participants (n=54) were randomly divided into 2 groups; Interventional group (Group A, n=27), in which half squats and inner thigh strengthening exercises program was implemented, and the control group (Group B, n=27), where inner thigh strengthening exercises program was used. Before participating in the muscle strengthening exercise programs, all participants (n=54) signed an informed consent. Exercise sessions took place at private and public hospitals and clinics of Jhelum City. Likewise, they were asked to complete each muscle strengthening exercise program according to the group they were assigned to. Both exercise protocols lasted eight weeks and each session (45 to 60 minutes). Three sessions per week during eight weeks, for a total of 24 sessions and was monitored by a physical therapy specialist, who was in charge of verifying that each exercise was properly performed. Three assessments were taken from each participant; baseline, after 4 weeks and last on 8^{th} week. Assessment includes demographic data, quality of life, pain intensity, functional assessment of participant. Quality of life was assessed through SF-36 Questionnaire, level of pain was measured from Numeric Pain Rating Scale (NPRS), and Kujala Scoring Questionnaire was used to determine the functional assessment. Additionally, knee range of motion and knee strength were measured using Goniometer and MRC scale, respectively. Data were analyzed through Statistical Package for Social Sciences (SPSS) version 24. For descriptive analysis, mean and standard deviation were calculated for quantitative variables whereas frequency and percentages were used for qualitative variables. For the inferential statistics to find significance Independent t-test and two way repeated measure ANOVA were applied. All results were calculated at 95% confidence interval and p-value ≤ 0.05 was considered as a significant value.

III. RESULTS

Mean pain of participants after 8 weeks were 5.80(±2.89) (Table1). Mean range of motion of participants in knee flexion were 105.27(±8.08) and in knee extension after last assessment

were 1.30(±2.51) (Table2). Mean muscle strength in knee flexion were 3.42(±0.95) and that in knee extension were 3.65(± 1.0) (Table3). Mean functional assessment of participants from Kujala Scoring Questionnaire after 8 weeks were 75.07(± 18.45) (Table4). Mean physical functioning in Quality of life after 8 weeks were 62.37(± 0.91) (Table5). Between subject intercept value for Wilks'Λ = 0.001, P-value= <0.001, F-test value (15, 24) = 2086.47 and partial η^2 = 0.99 showing that that it's results were remarkably significant with 99% effect size. With respect to time periods, Wilks'Λ =0.09, F-value (28, 11) = 43.57 and partial η^2 =0.99 which means there was 99% effect size. With respect to time*interventions, Wilks'Λ = 0.053, F-value (28, 11) = 6.99 and partial η^2 = 0.94, which means their effect size was 94% in this case (Table6). For time*groups showed that both interventional and control with respect to time intervals had remarkable significance (p-value< 0.001), Wilk's Λ= 0.422, F-test value (28,126) = 2.427 and partial η^2 =0.35, having 35% effect size among each other in PFPS (Table7). . In Kujala Scoring Questionnaire, the comparison between both groups had mean difference of 3.72 lower to upper bound values for confidence interval were -9.41 to 16.86 and p-value = 0.56 showing non-significant effects. Emotional well-being of participants in quality of life, the comparison between both groups had mean difference of -14.62 lower to upper bound values for confidence interval were -26.64 to -2.60 and p-value = 0.018 showing significant effects (Table8). For Kujala Scoring Questionnaire, the mean difference is -11.043 with lower and upper bound values ranging -13.338 to -8.748. For emotional well-being of participants in quality of life after 8 weeks, the mean difference is -5.965 with lower and upper bound values ranging -8.190 to -3.740 (Table9).

Table 1: Descriptive analysis for Pain

Characteristics	Group of participants		
	Interventional Group (n=19)	Control Group (n=21)	Total
	Mean±S.D	Mean±S.D	Mean±S.D
Baseline pain assessment of participants	7.52±2.48	8.0±2.14	7.77±2.29
Pain assessment after 4 weeks of participants	6.31±2.78	7.42±2.44	6.90±2.63
Pain assessment after 8 weeks of participants	5.15±2.75	6.38±2.95	5.80±2.89

Table 2: Descriptive analysis for range of motion of knee in flexion and extension

Characteristics	Group of participants		
	Interventional Group (n=19)	Control Group (n=21)	Total
	Mean±S.D	Mean±S.D	Mean±S.D
Baseline knee flexion range of motion of participants (Degrees)	102.0±9.81	104.9±6.22	103.5±8.15
Knee flexion range of motion of participants after 4 weeks (Degrees)	102.6±9.77	105.2±6.36	104.02±8.1
Knee flexion range of motion of participants after 8 weeks (Degrees)	104.3±9.69	106.1±6.42	105.2±8.08
Baseline knee extension range of motion of participants (Degrees)	3.05±4.02	1.19±1.72	2.07±3.14
Knee extension range of motion of participants after 4 weeks (Degrees)	2.21±3.61	1.0±1.70	1.57±2.80
Knee extension range of motion of participants after 8 weeks (Degrees)	1.89±3.33	0.76±1.30	1.30±2.51

Table 3: Descriptive analysis for Kujala scoring Questionnaire

Characteristics	Group of participants		
	Interventional Group(n=19)	Control Group(n=21)	Total
	Mean±S.D	Mean±S.D	Mean±S.D
Baseline kujala scoring of participants	56.78±21.91	55.85±21.0	56.30±21.16
Kujala scoring of participants after 4 weeks	65.84±23.21	62.57±21.51	64.12±22.1
Kujala scoring of participants after 8 weeks	78.73±18.15	71.76±18.53	75.07±18.45

Table 4: Descriptive analysis for knee strength in flexion and extension

Characteristics	Group of participants		
	Interventional Group (n=19)	Control Group (n=21)	Total
	Mean±S.D	Mean±S.D	Mean±S.D
Baseline knee flexion strength of participants (0-5)	2.73±1.24	2.90±0.70	2.82±0.98
Knee flexion strength of participants after 4 weeks (0-5)	3.05±1.35	3.14±0.65	3.10±1.03
Knee flexion strength of participants after 8 weeks (0-5)	3.36±1.06	3.47±0.87	3.42±0.95
Baseline knee extension strength of participants (0-5)	3.15±1.25	3.14±0.65	3.15±0.97
Knee extension strength of participants after 4 weeks (0-5)	3.42±1.21	3.57±0.87	3.50±1.03
Knee extension strength of participants after 8 weeks (0-5)	3.57±1.16	3.71±0.84	3.65±1.0

Table 5: Descriptive analysis for SF-36 Questionnaire

Characteristics	Group of participants		
	Interventional Group (n=19)	Control Group (n=21)	Total
	Mean±S.D	Mean±S.D	Mean±S.D
Baseline physical functioning of participants (percentage)	44.47±34.63	37.85±26.19	41.0±30.28
Physical functioning of participants after 4 weeks (percentage)	52.63±30.24	48.80±24.02	50.62±26.87
Physical functioning of participants after 8 weeks (percentage)	65.78±28.44	59.28±23.67	62.37±25.91
Baseline physical health of participants (percentage)	46.05±48.77	40.47±36.63	43.12±42.36
Physical health of participants after 4 weeks (percentage)	55.26±42.96	54.76±33.18	55.0±37.63

Physical health of participants after 8 weeks (percentage)	61.84±37.60	70.23±33.18	66.25±35.15
Baseline emotional problems of participants (percentage)	49.12±50.14	66.67±44.72	58.33±47.59
Emotional problems of participants after 4 weeks (percentage)	59.64±43.85	73.01±41.66	66.66±42.7
Emotional problems of participants after 8 weeks (percentage)	64.91±39.24	77.7±37.02	71.66±38.16
Baseline energy/fatigue of participants (percentage)	45.78±26.73	59.76±20.52	53.12±24.4
Energy/fatigue of participants after 4 weeks (percentage)	54.73±25.95	68.09±18.93	61.75±23.24
Energy/fatigue of participants after 8 weeks (percentage)	66.05±22.14	75.0±15.57	70.75±19.26
Baseline emotional wellbeing of participants (percentage)	64.21±22.72	84.0±21.42	74.60±23.95
Emotional wellbeing of participants after 4 weeks (percentage)	70.94±19.99	86.28±18.18	79.0±20.35
Emotional wellbeing of participants after 8 weeks (percentage)	80.21±16.83	88.95±15.74	84.80±16.65
Baseline social functioning of participants (percentage)	54.60±33.3	64.28±22.1	59.68±28.09
Social functioning of participants after 4 weeks (percentage)	69.73±27.10	70.83±18.25	70.31±22.59
Social functioning of participants after 8 weeks (percentage)	80.26±20.54	81.54±16.11	80.93±18.12
Baseline pain of participants (percentage)	42.10±26.23	44.04±21.11	43.1250±23.39
Pain of participants after 4 weeks (percentage)	54.47±23.74	50.23±18.57	52.25±21.01
Pain of participants after 8 weeks (percentage)	67.50±21.04	61.30±20.83	64.25±20.90
Baseline general health of participants (percentage)	67.10±24.51	74.28±23.09	70.87±23.74
General health of participants after 4 weeks (percentage)	67.63±24.17	74.28±23.09	71.12±23.54
General health of participants after 8 weeks (percentage)	73.15±23.16	77.61±21.88	75.50±22.32
Baseline health change of participants (percentage)	35.52±25.43	38.09±18.74	36.87±21.91

Health change of participants after 4 weeks (percentage)	35.52±25.43	38.09±18.74	36.87±21.91
Health change of participants after 8 weeks (percentage)	35.52±25.43	38.09±18.74	36.87±21.91

Table 6: Multivariate tests

Effect			Value	F-value	Hypothesis df	Error df	p-value	Partial Eta Squared
Between Subjects	Intercept	Wilks' Lambda	0.001	2086.478[b]	15.000	24.000	<0.001*	0.99
	Groups	Wilks' Lambda	0.476	1.758[b]	15.000	24.000	0.105	0.52
Within Subjects	Time	Wilks' Lambda	0.009	43.573[b]	28.000	11.000	<0.001*	0.99
	Time * Groups	Wilks' Lambda	0.053	6.996[b]	28.000	11.000	0.001*	0.94

*= remarkable significance

Table 7: Tests of within-subjects effects

Within Subjects Effect		Value	F-value	Hypothesis df	Error df	p-value	Partial Eta Squared
Time	Wilks' Lambda	0.036	19.130[c]	28.000	126.000	<0.001*	0.81
Time * Groups	Wilks' Lambda	0.422	2.427[c]	28.000	126.000	<0.001*	0.35

*=Remarkable significance

Table 8: Pairwise comparisons

Measures			Mean Difference (I-J)	p-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
NPRS	Interventional Group	Control Group	-0.937	0.250	-2.560	.687
ROMF	Interventional Group	Control Group	-2.462	0.344	-7.668	2.744
ROME	Interventional Group	Control Group	1.402	0.112	-.342	3.146

MRCF	Interventional Group	Control Group	-0.122	0.692	-.740	.496
MRCE	Interventional Group	Control Group	-0.090	0.773	-.720	.539
KSQ	Interventional Group	Control Group	3.726	0.569	-9.410	16.862
QoLPF	Interventional Group	Control Group	5.647	0.521	-12.010	23.305
QoLPH	Interventional Group	Control Group	-0.773	0.949	-24.843	23.298
QoLEP	Interventional Group	Control Group	-14.593	0.276	-41.303	12.117
QoLEF	Interventional Group	Control Group	-12.093	0.082	-25.790	1.605
QoLEWB	Interventional Group	Control Group	-14.623*	0.018*	-26.644	-2.603
QoLSF	Interventional Group	Control Group	-4.020	0.575	-18.397	10.356
QoLPain	Interventional Group	Control Group	2.830	0.679	-10.890	16.550
QoLGH	Interventional Group	Control Group	-6.099	0.411	-20.958	8.761
QoLHC	Interventional Group	Control Group	-2.569	0.716	-16.776	11.638

*= remarkable significance

Table 9: Pairwise Comparison for tests of Within-Subjects effects

Measure			Mean Difference (I-J)	p-value	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
NPRS	1	2	0.891*	<0.001*	0.525	1.257
		3	1.994*	<0.001*	1.466	2.522
	2	3	1.103*	<0.001*	0.766	1.440
ROMF	1	2	-0.506*	<0.001*	-0.804	-0.209
		3	-1.777*	<0.001*	-2.266	-1.287
	2	3	-1.271*	<0.001*	-1.681	-0.860
ROME	1	2	0.516*	<0.001*	0.216	0.816
		3	0.793*	0.001*	0.305	1.282
	2	3	0.277	0.062	-0.010	0.564
MRCF	1	2	-0.277*	0.001*	-0.458	-0.096
		3	-0.602*	<0.001*	-0.800	-0.403
	2	3	-0.325*	<0.001*	-0.515	-0.134
MRCE	1	2	-0.346*	<0.001*	-0.537	-0.155
		3	-0.496*	<0.001*	-0.697	-0.295
	2	3	-0.150*	0.040*	-0.296	-0.005
KSQ	1	2	-7.883*	<0.001*	-10.010	-5.757
		3	-18.926*	<0.001*	-21.551	-16.302
	2	3	-11.043*	<0.001*	-13.338	-8.748
QoLPF	1	2	-9.555*	<0.001*	-12.278	-6.833
		3	-21.372*	<0.001*	-25.490	-17.254
	2	3	-11.817*	<0.001*	-14.625	-9.009
QoLPH	1	2	-11.748*	<0.001*	-18.487	-5.009

		3	-22.776*	<0.001*	-31.233	-14.319
	2	3	-11.028*	<0.001*	-16.272	-5.783
QoLEP	1	2	-8.435*	0.017*	-15.655	-1.214
		3	-13.445*	0.001*	-21.859	-5.031
	2	3	-5.010*	0.040*	-9.849	-0.172
QoLEF	1	2	-8.640*	<0.001*	-11.128	-6.153
		3	-17.751*	<0.001*	-21.472	-14.029
	2	3	-9.110*	<0.001*	-11.813	-6.407
QoLEWB	1	2	-4.511*	0.001*	-7.273	-1.749
		3	-10.476*	<0.001*	-14.394	-6.559
	2	3	-5.965*	<0.001*	-8.190	-3.740
QoLSF	1	2	-10.840*	<0.001*	-14.471	-7.208
		3	-21.460*	<0.001*	-27.471	-15.448
	2	3	-10.620*	<0.001*	-14.484	-6.756
QoLPain	1	2	-9.282*	<0.001*	-12.419	-6.145
		3	-21.328*	<0.001*	-25.209	-17.448
	2	3	-12.046*	<0.001*	-15.151	-8.942
QoLGH	1	2	-0.263	0.401	-0.693	0.167
		3	-4.693*	<0.001*	-6.723	-2.663
	2	3	-4.430*	<0.001*	-6.318	-2.542

*= remarkable significance

IV. DISCUSSION

Angel Yaez-lvarez et al found statistically significant differences in the between-groups comparison and in the interaction of the experimental group before and after treatment in terms of pain perception (P = 0.000; 2 = 0.63) and function outcomes scores (P = 0.000; 2 0.39 and 0.51 for lower limb functional scale and Kujala scores, respectively), whereas patients in our study reported a decrease in pain perception.[8]

The inclusion of half squats in inner thigh strengthening exercises increases quadriceps muscle strength, quality of life, functional outcome ($p<0.001$), and a significant reduction in pain, whereas Luisa Fernanda Prieto-Garca et al, The addition of core muscle strengthening exercises to the traditional treatment improved the quality of life of participants in the intervention group A, where a significant reduction in pain, with a statistically significant difference in the total score of the Kujala scale ($p=0.025$) was observed.[6]

Anis Jellad et al demonstrated in a randomized crossover study that combining strengthening of the hip external rotators and abductors with stretching of the hip internal rotators in conjunction with a standard rehabilitation program provided significantly better pain and function improvement ($p<0.05$) in patients with PFPS than a standard rehabilitation program alone, while we concluded that participants in the interventional group reported more decrease in pain and in function ($p<0.001$) as compared to that in control group in our study.[9]

Significant gains were identified in both groups ($p<0.01$), with between-group differences in both outcomes favouring the intervention ($p<0.05$), whereas Behnaz Tazesh et al demonstrated significant improvements in both groups ($P=0.001$). In both outcomes, there were substantial between-group differences in favor of the intervention (Pain: 12.4, CI 95%: 7.1-17.8, $P =0.001$; Function: 6.4, CI 95%: 2.2-10.5, $P = 0.003$).[7]

Participants in our study demonstrated a statistically significant decrease in pain and an increase in muscle strength and functional performance when compared to the control group ($p<0.05$), whereas L. Herrington et al demonstrated that individuals in both exercise groups demonstrated a statistically significant decrease in pain and an increase in muscle strength and functional performance when compared to the control group ($P<0.05$). All assessments revealed no statistically significant differences in result between the two workout groups ($P>0.05$).[13]

Limitations: Non-probability sampling was utilized in this investigation. At some hospitals and clinics, the patient-to-staff ratio was poor. Because exercise-related knowledge was lacking in numerous areas, several individuals did not appear following the initial evaluation. We do not assess knee strength with a knee dynamometer. The confounding variables were not corrected.

Recommendations: At this study, the patient-to-staff ratio was low in several centers. Studies must be conducted to determine the data collecting pool based on patient ratio. A longer follow-up time is most likely required to achieve better results. For more precise results,

future studies should look at using a Knee Dynamometer instead of the MRC scale to measure knee strength. While the Visual Analog Scale was used in the majority of the research to estimate pain levels, the McGill Pain Questionnaire and Anterior Knee Pain Scale were also commonly utilized to assess pain. To achieve better results, studies should be undertaken out using probability sampling.

v. CONCLUSION

Adding half squats to inner thigh strengthening exercises programs for strengthening quadriceps muscles, the program was effective to reduce pain and improve knee functionality as well as quality of life in people with patellofemoral pain syndrome.

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AUTHORS

First Author: Noor Fatima, Student, University Institute of Physical Therapy, University of Lahore, Lahore, Punjab, Pakistan,

Second Author: Nadeem Asghar, MS-SPT, Lecturer, Department of Rehabilitation Sciences, Allied Health Sciences, University of Chenab, Gujrat, Punjab, Pakistan,

Third Author: Asim Raza, PhD (Scholar Public Health), M.Phil. (Epidemiology and Public Health), M.Sc. (Biostatistics), Assistant Professor (Epidemiology and Biostatistics), Allied Health Sciences, University of Chenab, Gujrat , Punjab, Pakistan http://orcid.org/0000-0002-7667-1869

Fourth Author: Farooq Islam, PhD (Scholar), Assistant Professor, Department of Rehabilitation Sciences, University of Chenab, Gujrat, Punjab, Pakistan.

Fifth Author: Afifa Tariq, Student, University Institute of Physical Therapy, University of Lahore, Lahore, Punjab, Pakistan,

Corresponding Authors: Asim Raza