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The efficacy of traditional approaches with and without hip strengthening in the treatment of patellofemoral pain syndrome

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Disciplines

Physical Therapy

Title: The efficacy of traditional approaches with and without hip strengthening in the treatment of patellofemoral pain syndrome

Clinical Scenario: A young man came to me with bilateral anterior knee pain, or patellofemoral pain syndrome (PFPS), which developed during a rigorous summer backpacking trip. He restricted his weight-bearing exercise for several months and found some relief, but now continues to have pain with activities such as running and stair-climbing. He is concerned that he will not be ready for the upcoming hiking season. I know of various treatment approaches for PFPS such as quadriceps strengthening, patellar taping, and stretching, and have heard that there is evidence that strengthening hip musculature may be beneficial as well. This has led me to inquire whether my patient will have better results if hip strength is addressed in addition to using the traditional treatment approaches.

Brief Introduction:

A lot is unknown about the etiology of PFPS and it has been under discussion for as long as the diagnosis has existed. The general consensus is that the pain is caused by excessive pressure on the patellofemoral joint due to poor tracking of the patella and other aspects of malalignment, but specifics remain controversial (Fukuda et al, Mascal et al, Nakagawa et al). Traditional treatments tend to always include strengthening and motor training of the quadriceps muscle (especially the oblique fibers of vastus medialis), and some include stretching of the hamstrings, iliotibial band, and quadriceps; patellar mobilization and taping; biofeedback; soft tissue mobilization; normalization of subtalar joint mechanics; and use of foot orthoses to decrease pronation (Fukuda et al, Nakagawa et al, Mascal et al, Witvrouw et al, Clelund et al).

Hip weakness has been under suspicion in recent years as a factor in the development of PFPS because it has been found consistently in individuals with PFPS. As lower extremity alignment and patellar tracking have historically been thought to be the cause, an increase in hip internal rotation and adduction due to weak external rotators and abductors could logically lead to an excessive valgus force and increase pressure on the joint (Fukuda et al). This lack of hip control may wear down the articular cartilage during weight-bearing activities and lead to PFPS (Nakagawa et al). While the theory behind treating PFPS with hip strengthening is logical, I want to know whether it is supported by evidence through high-quality randomized controlled trials that show improved outcomes in pain when compared to traditional treatments alone.

My Clinical Question: Is the addition of hip strengthening exercises to traditional treatments of patellofemoral pain syndrome more effective in decreasing patellofemoral pain than traditional treatments alone?

Clinical Question PICO:

P—Young and active individuals with patellofemoral pain

I—Strengthening of hip and knee musculature

C—Strengthening of knee musculature

O—Pain scale, measured during aggravating activities at baseline and following the intervention

Overall Clinical Bottom Line: Based on the results from Nakagawa et al and Fukuda et al, the addition of hip strengthening exercises to knee strengthening exercise in the treatment of PFPS is likely to be beneficial. With one article showing statistical significance and the other showing improvement that was not statistically significant, hip strength should be addressed in patients with PFPS. No adverse events were reported so there is no risk in applying these exercises with hopes of achieving better outcomes for my patients.

Search Terms: Patellofemoral Pain Syndrome, Hip Weakness, Hip Strength

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Article 1—Nakagawa et al

Nakagawa, T. H., Muniz, T. B., Baldon, R. M., Maciel, C. D., Reiff, R. B., Serrao, F. V. The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain syndrome: a randomized controlled pilot study. *Clinical Rehabilitation* (2008); 1051 – 1060

Clinical Bottom Line: Strengthening hip muscles as well as doing traditional treatment for PFPS is more beneficial for decreasing pain with ascending and descending stairs and squatting than traditional treatment alone. The article had good internal validity but a study with a larger sample size is required before the results can be given much merit. Based on this information I will include hip strengthening exercises in my treatment of PFPS, but will continue to search the literature for stronger evidence.

Article PICO:

P—Fourteen subjects with PFPS

I—Quadriceps, hip abductor and external rotator strengthening

C—Quadriceps strengthening

O—Pain scale, isokinetic eccentric quadriceps, hip abductor and external rotator torques, gluteus medius electromyographic activity

Blinding: The subjects of the study and the two assessors were blinded throughout the six weeks. Once the subjects were allocated to their groups, the principle investigator was no longer blinded.

Controls: The comparison group consisted of seven subjects with PFPS who were randomly assigned to a group which performed only quadriceps strengthening. There was not a true control group without an intervention included in the study so there is no guarantee that the results are solely produced by the intervention. However, the comparison group is appropriate for my clinical question.

Randomization: The 14 subjects drew sealed envelopes from a box, with each labeled "intervention group" or "control group." Depending on whether the subjects saw what their envelope was labeled and depending on their familiarity with research terms, these labels may have interfered with the blinding of the subjects. The random allocation led to there being 5 women and 2 men in each group.

Study: This study was a randomized controlled trial with 14 subjects divided equally into two intervention groups. Both groups performed traditional treatments for PFPS but the "intervention" group performed hip strengthening exercises while the "control" group did not. The protocol of the control group included patellar mobilization, stretching of the quadriceps, gastrocnemius, iliotibial band, and hamstrings, and open and closed-kinetic chain strengthening of the quadriceps muscles. The intervention group protocol included the same but had additional functional and strengthening exercises to target the transverse abdominis muscle and the hip abductors and lateral rotators. All subjects performed the exercises once per week with supervision and four times per week at home. To encourage compliance, the subjects were given detailed descriptions of the exercises and were instructed to keep a log and contact the principal investigator if they had any problems when exercising at home.

Subjects were included in the study if they had anterior or retropatellar knee pain with at least 3 of the following activities: going up/down stairs, squatting, running, kneeling, jumping, or prolonged sitting; an insidious onset of at least 4-week duration; and pain with palpation of patellar facets while stepping down or during a two-legged squat. Subjects were excluded if they showed signs of any intra-articular pathologic condition, ligament involvement, tenderness of the patellar tendon, iliotibial band, or pes anserine, patellar apprehension, other known syndromes, referred pain from the hip or lumbar spine, history of patellar dislocation, knee joint effusion, or previous knee surgery.

Outcome Measures: All outcome measurements were taken before and after the 6-week intervention period. The outcome measure relevant to my clinical question is the 10-cm visual analogue scale (VAS) which was used to measure pain during stair-climbing and descending, squatting, and prolonged sitting. A study by Crossley et al showed the VAS to be a reliable and valid measure of pain outcomes for subjects with PFPS, however no MCID seems to be established at this time.

Study Losses: No study losses occurred during the intervention period and therefore an intention-to-treat analysis with not necessary. All subjects were analyzed in the groups to which they were randomized.

Summary of Internal Validity: The internal validity of this study is very good. The randomization process, blinding of subjects and assessors, and the outcome measures were appropriate and effective for this study. To blind the principle investigator was not feasible as someone needed to oversee both groups and I view this as a minor threat to the validity. The subjects were fairly similar at baseline in age, gender and pain levels at baseline, but the authors did not share other information that may impact the results, such as activity level or height and weight. This threat to validity is not so significant that I would call into question the results of the study. There will always be some variability among patients and therefore I believe the results are still valuable. All of the subjects completed the study and therefore an intention-to-treat analysis was not necessary.

Evidence: Of the three outcome measures used in this study, the one that applied to my clinical question was the 10-cm VAS which was used to measure pain before and after the 6-week intervention period. The data included measurements of pain during stair-climbing and descending, squatting, and prolonged sitting.

Table 1—Mean results and standard deviations of the Visual Analogue Scale (in cm) for both groups at baseline, following intervention, and the mean change based on data presented by the authors for pain levels with activity.

	Baseline	**6 Weeks**	**Mean Change**
Intervention Group			
Stair-Climb	3.5 (+/- 3.7)	0.4 (+/- 0.6)	-3.0 (+/- 3.2)*
Stair-Descent	4.5 (+/- 3.1)	0.3 (+/- 0.4)	-4.1 (+/- 2.9)*
Squat	5.7 (+/- 3.2)	0.4 (+/- 0.6)	-5.4 (+/- 3.0)*
Prolonged Sit	2.9 (+/- 3.2)	1.1 (+/- 1.6)	-1.9 (+/- 2.9)
Control Group			
Stair-Climb	5.0 (+/- 3.4)	2.6 (+/- 2.8)	-2.4 (+/- 3.6)
Stair-Descent	4.7 (+/- 3.3)	2.0 (+/- 2.4)	-2.8 (+/- 2.7)
Squat	4.8 (+/- 3.0)	3.0 (+/- 3.1)	-1.8 (+/- 2.6)
Prolonged Sit	5.2 (+/- 2.8)	2.9 (+/- 3.1)	-2.3 (+/- 3.1)

*The authors used asterisks as shown above to indicate statistical significance with $P < 0.05$. A negative Mean Change value indicates a desirable outcome (a decrease in pain).

Table 2—Visual Analogue Scale pain results before and after intervention for each activity tested.

		Baseline	6 Weeks
Stair Climb			
	Mean Difference (cm)	1.5	2.2*
	95% C.I.	(-2.53 – 5.53)	(-0.10 – 4.50)
	Effect Size (Between)	0.42 (Small)	1.09 (Large)
	95% C.I.	(-0.64 – 1.48)	(-0.04 – 2.21)
Stair Descent			
	Mean Difference (cm)	0.2	1.7*
	95% C.I.	(-3.43 – 3.83)	(-0.25 – 3.65)
	Effect Size (Between)	0.06 (Small)	0.99 (Large)
	95% C.I.	(-0.99 – 1.11)	(-0.12 – 2.10)
Squat			
	Mean Difference (cm)	0.9	2.6*
	95% C.I.	(-2.62 – 4.42)	(0.07 – 5.13)
	Effect Size (Between)	0.29 (Small)	1.16 (Large)
	95% C.I.	(-0.76 – 1.34)	(0.03 – 2.30)
Prolonged Sit			
	Mean Difference (cm)	2.3	1.8
	95% C.I.	(-1.11 – 5.71)	(-1.00 – 4.60)
	Effect Size (Between)	0.76 (Medium)	0.73 (Medium)
	95% C.I.	(-0.32 – 1.85)	(-0.35 – 1.81)

*Indicates greater pain decrease in the hip and knee strengthening group

Table 2 provides a comparison between the two groups and describes the change in pain scores based on the mean VAS results for each activity. The mean changes in Table 1 show that the scores of both groups improved with all four activities, but the control group had no statistically significant improvements. Although the confidence intervals (C.I.) include narrow ranges for each mean difference and effect size, the negative C.I.s of all but the squatting measurement suggest that if tested again, the results could be reversed. The scores of the intervention group improved significantly with the exception of the prolonged sitting measurement, in which there was a larger change for the control group. The effect size between the two groups changed from small to large with stair-climbing, so before the intervention period there was only a small difference in pain levels between them, but after the intervention there was a large difference between them. The same is true of the stair-descent and the squatting measurements. The measurements for prolonged sitting showed that there was a medium effect size before and after the intervention period, so there was not a significant difference between the groups in how much improvement occurred with that activity.

In short, both groups improved in all areas that were tested, but not all of these changes were significant. With such a small sample size, the power would only allow a 25% chance of producing a moderate effect size if any at all, so these results could be drastically different with a larger sample. The change in the pain scores of the intervention group was shown to be statistically significant for three of the four activities, including ascending and descending stairs and squatting. No statistically significant change occurred with prolonged sitting.

Applicability of Results:

Benefits verses Costs: According to the results of this study, the addition of hip strengthening exercises to traditional methods is beneficial in treating PFPS and is therefore worth the extra time to complete the intervention group protocol. Because more time is needed, patients would need to demonstrate good adherence in doing exercises at home. The financial costs are equal between groups and neither group reported adverse events due to the exercises they performed.

Feasibility of Treatment: The authors refer to an appendix in which the exercises performed by each group are described, making the procedures reproducible in clinic. The equipment and expertise required are available in most orthopedic physical therapy settings. With a program of 1 session per week for 6 weeks, and 4 days per week of a home exercise program, it is definitely feasible for most insurance plans. The subjects were required to log the times they did exercises at home and any problems or questions they had. No comment was made by the authors specifically regarding adherence but there is no reason based on their protocol that adherence would be more of a challenge than any other home program.

Summary of External Validity: The study included men and women 17 to 40 years old who were referred to physical therapy and have no other knee problems. The results may be applied to patients of this description, however details regarding activity level, lifestyle choices, or general health conditions were not provided, and these factors may have influenced the results. Due to the small sample size I cannot confidently apply these results to the greater population based on this study alone, however the cost and the risk of adverse events are so low that I would not hesitate to incorporate hip exercises into my treatment of PFPS.

Article 2—Fukuda et al

Fukuda, T. Y., Rossetto, R. M., Magalhaes, E., Bryk, F. F., Lucareli, P. R. G., Carvalho, N. A. D. A. Short-term effects of hip abductors and lateral rotators strengthening in females with patellofemoral pain syndrome: a randomized controlled clinical trial. *Journal of Orthopaedic & Sports Physical Therapy* (2010); 736 - 742

Clinical Bottom Line: No statistically significant difference was found between the two intervention groups, in spite of a greater improvement by the hip and knee strengthening group. With the exception of using unblinded therapists and subjects, the internal validity of this study was very good and the sample size was sufficient according to a power analysis done by the authors. Because the study results showed slightly greater improvement in the intervention group with no adverse events, I would consider the addition of hip exercises to knee strengthening to be beneficial for sedentary female patients. Unfortunately this study did not include patients similar to the young man who inspired my clinical question.

Article PICO:

P—Sedentary females with PFPS

I—Knee and hip strengthening exercises

C—Knee strengthening exercises

O—Anterior Knee Pain Scale (AKPS), 11-point Numerical Pain Rating Scale (NPRS), Lower Extremity Functional Scale (LEFS)

Blinding: One blinded examiner administered all tests before and after the intervention. The subjects were not blinded and they received treatment from two unblinded therapists.

Controls: While a true control group was used in the study, it is not relevant to my clinical question which inquires as to which treatment is more effective rather than whether they are effective at all. The control group is therefore the group which performed only knee strengthening exercises, and the intervention group is the one which performed a combination of knee and hip strengthening exercises.

Randomization: After the initial evaluations, each subject was randomly assigned into one of the groups using sealed envelopes.

Study: This study was a randomized clinical trial with a total of 45 participants in the two groups. Both groups performed knee strengthening and stretching exercises but the intervention group performed additional exercises to strengthen the hip abductor and external rotator muscles. The study was 4 weeks in duration, with 3 sessions per week. The subjects did not perform the exercises at home. The specific exercises, sets, and repetitions performed by each group were presented by the authors in tables.

Subjects were included in the study if they were sedentary females between 20 and 40 years of age, had a 3-month history of anterior knee pain, and had pain with at least two of the following: ascending/ descending stairs, squatting, kneeling, jumping, long-sitting, isometrically contracting quadriceps, and with palpation of the medial or lateral patellar facets. Subjects were not included if they were pregnant, had a neurological disorder, hip or ankle injury, low back or sacroiliac pain, rheumatoid arthritis, used corticosteroids or anti-inflammatory drugs, had a heart condition, previous lower extremity surgery, or other knee pathologies.

Outcome Measures: All outcome measurements were taken before and after the 4-week intervention period. The outcome measures relevant to my clinical question are the 11-point Numerical Pain Rating Scale (NPRS) which was used to measure pain with ascending and descending stairs, and the Anterior Knee Pain Scale (AKPS) which is a 13-item assessment tool that measures pain with functional activities. The authors report that the NPRS is shown to be reliable and valid and has a published MCID of 2 points. They also report that the AKPS has "high test-retest reliability, moderate responsiveness, and adequate validity," with a published MCID of 13 points.

Study Losses: Each group lost 2 subjects before the completion of the study. An intention-to-treat analysis was completed to account for these losses.

Summary of Internal Validity: The internal validity of this study is very good. The study is randomized, the outcome measures have been validated and even have MCIDs. There was an intention-to-treat analysis to account for study losses, and there were no statistically significant differences in baseline demographics or outcomes among the subjects. The only area in which the validity could be stronger is with blinding. The subjects and treating therapists were not blinded which may have influenced their behavior, possibly leading to a Hawthorne Effect. The examiner was blinded and overall I consider the lack of subject and therapist blinding to be only a minor threat.

Evidence: The outcome measures relevant to my clinical question include the NPRS and the AKPS. These were both used to measure pain with activity before and after the 4-week intervention period. The NPRS measures pain on a 10-cm scale with ascending and descending stairs. The AKPS measures 13 items and has a total score of up to 100, with a higher score indicating higher function.

Table 3—The mean results and SD of the Anterior Knee Pain Scale (AKPS) and the 11-point Numerical Pain Rating Scale (NPRS) for each group at baseline and following intervention with the within and between-group changes, as provided by the authors.

	Baseline	**4-Weeks**	**Δ Within**	**Δ Between**
AKPS				
Control	70.4 (+/- 12.5)	80.6 (+/- 13.9)	10.2 (+/- 11.6)	4.8*
Intervention	63.9 (+/- 11.7)	78.9 (+/- 16.0)	15.0 (+/- 12.8)	
NPRS $_{\text{Ascending Stair}}$				
Control	4.9 (+/- 2.9)	3.4 (+/- 2.3)	-1.5 (+/- 1.6)	-0.7**
Intervention	5.2 (+/- 1.6)	3.0 (+/- 1.8)	-2.2 (+/- 2.3)	
NPRS $_{\text{Descending Stair}}$				
Control	4.5 (+/- 2.8)	3.5 (+/-2.5)	-1.0 (+/- 2.2)	-1.6**
Intervention	4.9 (+/- 1.6)	2.3 (+/- 1.5)	-2.6 (+/- 2.3)	

*AKPS—higher scores represent better function

**NPRS—lower scores represent less pain (10 cm scale)

The results in Table 3 show that improvements were made by both groups and that the intervention group achieved greater improvements than the control group based on the raw data. The information presented in Table 4 below shows whether the differences were statistically significant or not.

Table 4—The mean differences and effect sizes between groups for the Anterior Knee Pain Scale (AKPS) and the 11-point Numerical Pain Rating Scale (NPRS) for ascending and descending stairs.

AKPS		**Baseline**	**4 Weeks**
	Mean Difference	6.5	1.7
	95% C.I.	(-1.15 – 14.15)	(-7.79 – 11.19)
	Effect Size (Between)	0.54 (Medium)	0.11 (Small)
	95% C.I.	(-0.06 – 1.13)	(-0.47 – 0.70)
NPRS $_{Asc}$			
	Mean Difference	0.3	0.4
	95% C.I.	(-1.17 – 1.77)	(-0.90 – 1.70)
	Effect Size (Between)	0.13 (Small)	0.19 (Small)
	95% C.I.	(-0.46 – 0.71)	(-0.39 – 0.78)
NPRS $_{Desc}$			
	Mean Difference	0.4	1.2
	95% C.I.	(-1.03 – 1.83)	(-0.10 – 2.50)
	Effect Size (Between)	0.18 (Small)	0.59 (Medium)
	95% C.I.	(-0.41 – 0.76)	(-0.01 – 1.18)

Table 4 shows that between the two intervention groups, no statistically significant improvements were made, so one was not statistically more effective in reducing pain than the other. The effect sizes are small except for the NPRS with descending stairs which achieved a medium effect size. While the CIs are quite narrow overall, they are all negative which indicates that the results could be reversed if the study were repeated. The MCIDs reported by the authors show that clinical importance was achieved by the intervention group, but this is not meaningful because the results were not statistically significant between groups. Therefore the results are not strong enough to confidently say that hip strengthening with traditional treatment is statistically more effective than traditional treatment alone.

Applicability of Results:

Benefits verses Costs: There is no additional financial cost to add hip strengthening exercises to the quadriceps exercises and no special equipment or expertise is needed. Some increased time is required per session for the therapist and patient, but not so that it is an unreasonable amount. No adverse events were reported by the authors.

Feasibility of Treatment: The study procedures were clearly described and are reproducible. The study lasted 12 sessions, which would be feasible for many patients but not for all depending on the insurance plan. The treatment protocol includes therapeutic exercises that are used regularly in therapy settings and are generally not difficult or painful to do. No home exercise program was utilized in this study so patient adherence was not a factor in attaining good results, although treatment sessions did occur frequently, at 3 times per week.

Summary of External Validity: Prior to generating a sample, the authors estimated the sample size that would be required to avoid a type II error. They determined that 20 subjects per group were necessary and they recruited a few extra in case of study losses. Thus, the sample size was adequate but not so

large that the results could not have gained more significance if it had been larger. The subject sample well-represents young, sedentary female patients seen in a clinic, but the results do not provide sufficient insight into the treatment of males or active females with PFPS. It can be speculated that because similar anatomical and biomechanical factors are involved regardless of gender or activity level, weakness of the hip musculature may also contribute to PFP in active male or female patients. While there is no harm in incorporating these exercises into any treatment plan for PFPS, this study does not provide evidence that hip strengthening is effective in treating PFPS in populations besides young, sedentary females.

Synthesis & Discussion:

The article by Nakagawa et al showed statistical significance in favor of hip strengthening. The study was a randomized controlled trial comparing the use of hip and knee strengthening verses knee strengthening alone in the treatment of PFPS. The authors chose a visual analogue scale to measure pain with various activities, which is validated for this use but currently has no MCID. The study had very good validity but it could have been stronger with double-blinding and a larger sample size. The data show that while the effect sizes were large for most activities done by the hip and knee group, the negative confidence intervals indicate that these results could change if the study were repeated. A larger sample size may have allowed for a more certain outcome.

The article by Fukuda et al showed improvements in favor of hip strengthening, but the difference was not statistically significant. This study was also a randomized controlled trial which compared the use of hip and knee strengthening to knee strengthening alone for the treatment of PFPS. The outcome measures included the Numerical Pain Rating Scale with ascending and descending stairs and the Anterior Knee Pain Scale to measure pain with various activities. The internal validity of the study was very good; the lack of double-blinding was its only weakness.

The quality of the articles by Nakagawa et al and Fukuda et al were evaluated using the PEDro scale, for which the results are displayed in Table 5 below. Both studies are of strong quality with blinding as the only area of weakness. The lack of blinding may have led to a Hawthorne effect, causing the subjects to behave differently than they would if they had not known their group allocation, such as working harder or less hard at their exercises. Use of unblinded therapists may have risked a change in treatment delivery if they had biases as to which group would have better outcomes. It is difficult to judge the severity of these threats, but in light of the otherwise excellent quality of the studies I view these risks as minor.

The study by Nakagawa et al presented with two other concerning factors. The more minor concern is the lack of information regarding the baseline demographics of the subjects. While the authors do report the age, gender, and initial pain levels with activity, they do not provide insight into the activity level or height and weight of the subjects. If these factors are varied among the sample subjects, the outcomes could be very different than if they were all of a similar height, weight, and activity level. I again view this as a minor threat, and it is more realistic that the patients I see will vary greatly in these areas. Of greater concern is the inadequate sample size used in the study. With only 14 subjects in total,

the results cannot well-represent the greater population of individuals with PFPS, and with a larger sample the results may have changed significantly. As a result, I would not choose to apply hip strengthening exercises to PFPS treatment based on this study alone, but in combination with stronger studies such as the study by Fukuda et al, it offers a helpful contribution to the literature.

With these considerations in mind, as well as the strengths offered by these studies, I will certainly incorporate hip strengthening exercises into my treatment protocol for PFPS. There is no risk and these studies show that there may be some benefit.

Table 5—Comparison of PEDro Scores (Self-Rated)

	Article 1—Nakagawa	**Article 2—Fukuda**
Randomized	Yes	Yes
Concealed Allocation	Yes	Yes
Baseline Comparability	Yes	Yes
Blinded Subjects	Yes	No
Blinded Therapists	No	No
Blinded Assessors	Yes	Yes
Adequate Follow-up	Yes	Yes
Intention-to-Treat	Yes	Yes
Between Group	Yes	Yes
Point Estimates/Variability	Yes	Yes
Total Score	**9 / 10**	**8 / 10**

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