[Athletic Training]

The Effects of Exercise on Decreasing Pain and Increasing Function in Patients With Patellofemoral Pain Syndrome: A Systematic Review

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Context: Exercise or rest is commonly prescribed as treatment for patellofemoral pain syndrome.

Study Selection: This study is based on Level I or II research studies examining the effects of exercise and rest on decreasing pain (visual analog scale) and increasing function (Kujala Scoring Questionnaire) using human participants. Articles were limited to those printed in English from PubMed (1966–September 2010), CINAHL (1982–September 2010), and SPORTDiscus (1972–September 2010).

Data Extraction: Weighted aggregate effect sizes and 95% confidence intervals were calculated from means and standard deviations extracted from 10 studies, resulting in an analysis of 433 patients.

Results: A very large effect for exercise was found for patient-reported functional outcomes ($d = 2.19$) and perceived pain ($d = -1.24$) in treated patients, which were larger than functional outcomes ($d = 0.77$) and pain ($d = -0.14$) in controls. Short-term follow-up of 191 patients from 4 data sets in 2 studies revealed a large effect for functional outcomes ($d = 1.04$) and pain ($d = -0.82$) in patients who performed an exercise intervention. One study reported moderate effect sizes for functional outcomes ($d = 0.59$) and pain ($d = -0.35$) at 3 months postintervention.

Conclusions: Exercise is the more effective treatment for immediate decrease in pain and increase in function although these differences appear to be less distinguishable over time.

Keywords: visual analogue scale, Kujala Scoring Questionnaire

Patellofemoral pain syndrome (PFPS) is one of the most frequent diagnoses of knee pain⁹ and has been reported to account for almost 10% of all visits to sports injury clinics.⁴ Nonoperative treatment has classically been chosen as the initial form of intervention, although there is no clear choice for the most effective type of intervention, making treatment difficult.²⁰

Understanding the cause of injury for these patients can be challenging. Anterior or retropatellar knee pain is associated with functional impairments and disability, including diffuse knee pain, decreased quadriceps strength, and pain with activities such as stair climbing, prolonged sitting, squatting, kneeling, and running.¹⁵ Proposed causes of this pain include patellofemoral malalignment; overuse; muscle or strength imbalances; osteochondral defects; and foot, ankle, hip, and pelvis biomechanical abnormalities.^{4,8,9}

Exercise therapy is commonly prescribed as a nonsurgical means to address deficits in muscular function in patients suffering from PFPS. Conservative exercise therapy tends to focus on improving the function of muscles controlling the patellofemoral and tibiofemoral joints, primarily increasing quadriceps and hip abductor strength.^{12,16}

Rest is also used to decrease knee pain symptoms. The goal is to eliminate activities that aggravate the patellofemoral joint.

Exercise and rest prescriptions may not address any of the etiologies that cause patellofemoral joint pain with activity. Since the exact cause of patellofemoral joint pain is often hard to diagnose, different treatment choices are likely to result in varied outcomes.

Pain is commonly measured by a visual analog scale (VAS), and physical function is often assessed by the Kujala Scoring Questionnaire: 13 items designed to assess knee function.¹⁰ The

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VAS and Kujala Scoring Questionnaire are reliable measures of pain and function in patients with PFPS.²

METHODS

Systematic searches were performed in September 2010 in 3 databases: PubMed (1966-present), CINAHL (1982-present), and SPORT Discus (1972-present). Keywords were *patellofemoral pain syndrome, patellofemoral pain syndrome treatment, patellofemoral pain and exercise, chondromalacia, anterior knee pain, efficacy of treatment, exercises, strengthening*. Combinations of these were used to be sure that all relevant articles were identified. Search limits included, if available in the search engine, human participants, studies reported in English, and clinical trials. Level I or II studies were included that reported means and standard deviations of VAS or Kujala scores as the primary outcome following an exercise/strengthening intervention in patients with PFPS. Studies were not included if they examined other interventions, such as bracing, taping, orthotics, or osteoarthritis. The search resulted in the acquisition of 125 initial studies. Ten studies were included after elimination of studies that were not Level I or II studies, did not use the Kujala Scoring Questionnaire or the VAS as an outcome measure, or did not report means and standard deviations (Figure 1).

Study Quality Assessment

The PEDro scale was used to assess the quality of the articles meeting the inclusion criteria. It was developed for the Physiotherapy Evidence Database by the Centre for Evidence-Based Physiotherapy; it includes a set of systematic questions designed to assess the internal validity and interpretability of the study,¹⁴ as well as an 11-item checklist for study evaluation

(maximum score of 10 points; the first criterion is not calculated in the total score).

Data Analysis

The effect sizes were calculated using the following formula:

$$\text{Cohen's } D = (\text{Mean}_{\text{Baseline}} - \text{Mean}_{\text{Post}}) / \text{Standard deviation}_{\text{Baseline}} \quad (1)$$

Weighted aggregate effect sizes and 95% confidence intervals were calculated for all studies reporting postintervention functional outcomes (Kujala scores) and pain ratings (VAS representing “usual” pain or pain at rest). Separate analyses were performed for outcomes measured immediately after the end of an intervention period and for outcomes measured at 3-month follow-up. Participant attrition (loss to follow-up) was accounted for in effect size calculations.

RESULTS

A total of 433 patients (297 women, 68.6%; 136 men, 31.4%) were analyzed with PFPS from 10 research articles (Table 1).[§] Mean demographics were as follows: age, 29.13 ± 8.89 years; mass, 67.19 ± 11.09 kg; and height, 165.79 ± 245.18 cm.

The analysis separated outcomes immediately after an exercise intervention and 3 months after. Five studies were clinical trials comparing an exercise intervention to a control group (1 sham was excluded; others were true controls); 4 compared 2 exercise interventions with no true control group; and 1 had no control group. Weighted effect sizes and 95% confidence intervals were determined (Figures 2 and 3).

Outcome data reported immediately following an exercise intervention were collected for PFPS in 200 patients (11 data

[§]References 1, 3, 5, 6, 11, 13, 17–19, 21.

Table 1. Descriptions and critiques of reviewed studies.^a

Study	Design	PEDRO	Critique
Van Linschoten ¹⁹	Open-label randomized controlled trial	7	Participants not randomized to group; participants, therapists, and assessors not blinded
Crossley ³	Randomized double-blinded placebo-controlled trial	9	Therapist not blinded to group
Loudon ¹¹	Controlled clinical trial	5	Participants not randomized to group; participants, therapists, and assessors not blinded; measures not obtained from $\geq 85\%$ of original participants
Song ¹⁸	Randomized controlled trial	8	Participants not randomized to group; participants and therapists not blinded
Alaca ¹	Prospective cohort study	3	No random assignment; allocation not concealed; participants, therapist, and assessor not blinded; no between-group comparisons
Nakagawa ¹³	Randomized controlled pilot trial	9	No blinded therapist
Sacco ¹⁷	Pre- and posttest intervention cohort study	6	No random assignment; allocation not concealed; participants and therapist not blinded
Witvrouw ²¹	Prospective randomized clinical trial, no control	5	Allocation not concealed; participants, therapist, and assessors not blinded; measures not obtained from 85% or more
Ferber ⁶	Cohort study	4	No random assignment; allocation not concealed; participants, therapist, and assessors not blinded; groups not similar at baseline regarding the most important prognostic indicator
Earl ⁵	Case series	3	No random assignment; allocation not concealed; participants, therapist, and assessors not blinded; groups not similar at baseline regarding the most important prognostic indicator; between-group statistical comparisons not used

^aOutcome at 3 months postintervention.

sets in 8 articles) and for 52 following a control intervention (3 data sets from 3 articles). There was a loss to follow-up in 14 patients (8%) and 6 controls (17%). There was a very large effect for patient-reported functional outcomes ($d = 2.19$) and perceived pain ($d = -1.24$), which were larger than functional outcomes ($d = 0.77$) and pain ($d = -0.14$) in controls.

Short-term follow-up after exercise intervention for PFPS was reported in 191 patients from 4 data sets in 2 studies. A large effect for functional outcomes ($d = 1.04$) and pain ($d = -0.82$) was detected in patients who performed an exercise intervention. One study reported moderate effect sizes for functional outcomes ($d = 0.59$) and pain ($d = -0.35$) at 3 months postintervention.

Figure 2. Pooled and weighted effect sizes with associated 95% confidence intervals for the changes in Kujala scores following exercise intervention (squares) and control interventions (circles). The top graphs represent outcomes reported immediately after the end of exercise intervention (solid circle and square), and the bottom part of the graph (outlined circle and square) shows outcomes measured 3 months following the intervention.

Figure 3. Pooled and weighted effect sizes with associated 95% confidence intervals for the changes in visual analog scale scores following exercise intervention (squares) and control interventions (circles). The top graphs represent outcomes reported immediately after the end of exercise intervention (solid circle and square), and the bottom part of the graph (outlined circle and square) shows outcomes measured 3 months following the intervention.

DISCUSSION

These results indicate that exercise and rest both decrease pain and increase function in patients suffering from PFPS. However, the magnitude of effect for the improvements in pain and function in patients receiving exercise therapy were considerably higher and represent a favorable treatment for patients suffering from PFPS. While exercise is preferred to increase function and decrease pain, this review cannot detail the best exercise to perform (Table 2). Exercise protocols were 3, 5, 6, or 8 weeks in duration. Single exercises, such as a leg press,⁸ had significant improvement in pain and increased function (Lysholm scale scores), as did exercise prescriptions

that included flexibility, strength, and muscle balance (quadriceps, adductor, and gluteals).^{1,3,11,13,17,19,21} In studies comparing the effects of different exercise programs, no differences were found between the 2 exercise groups. Witrouv et al²¹ compared open (n = 30) and closed kinetic chain (n = 30) exercise protocols and found that both statistically improved Kujala function scores and decreased perceived pain, although no statistical differences were found between the 2 groups. Only 1 study (group 1, n = 7; group 2, n = 7) found that exercise did not improve pain.^{1,3,11} In this study, all participants performed general lower leg stretching with quadriceps strengthening, while the intervention group added strengthening of the transverse abdominis, hip abductors,

Table 2. Treatment groups and effect size calculations for changes in pain ratings from baseline to postintervention.^a

Study	Treatment Group 1	Treatment Group 2	Control Group	Intervention, Weeks
Van Linschoten ¹⁹	Quadriceps, hip adductor, and gluteal muscle strengthening (n = 65, d = -1.2)	N/A	Daily isometric quadriceps contractions (n = 66, d = -0.62)	6
Crossley ³	Patellar taping, vastus medialis obliquus biofeedback, gluteal muscle strengthening (n = 36, d = -3.5)	N/A	Placebo tape, sham ultrasound (n = 35, d = -2.0)	6
Loudon ¹¹	Lower extremity muscle stretch/strengthen and patellar mobilizations (n = 9, d = -2.3)	Home exercise program including stretching and strengthening (n = 9, d = -1.1)	True control: no exercise (n = 11, d = -0.27)	4
Song ¹⁸	Leg press with external hip abduction force and quadriceps stretching (n = 27, d = -1.04)	Leg press exercises (n = 27, d = -0.96)	True control: no exercise (n = 25, d = -0.08)	8
Witvrouw ²¹	Closed chain strengthening exercises (n = 30, d = -0.87)	Open kinetic chain strengthening exercises (n = 30, d = -0.80)	No control group	5
Sacco ¹⁷	Lower extremity muscle and iliotibial band stretching and squatting exercises (n = 6)	N/A	True control: no exercise (n = 5) ^b	5
Nakagawa ¹³	Standard care, including muscle stretching and quadriceps strengthening with added hip abductor and lateral rotator muscles and transverse abdominis exercises (n = 7, d = -1.29)	Standard care including muscle stretching and quadriceps strengthening (n = 7, d = -0.27)	No control group	6
Alaca ¹	Lower extremity muscle and iliotibial band stretching and isokinetic knee extension exercises (n = 22, d = -1.77)	N/A	No control group	6
Ferber ⁶	Hip abductor strengthening (n = 10, d = -1.19)	N/A	True control: no exercise (n = 10) ^b	3
Earl ⁵	Three-phase stability program: (1) hip and core muscle volitional control, (2) perturbation training, (3) patterned movement training (n = 19, d = -1.94)	N/A	No control group	8

^aN/A = not applicable (because the study did not have a second treatment group); n = number of participants; d = effect size for visual analog scale pain ratings from baseline to immediately following treatment. For ratings, negative effect sizes indicate reduced pain following treatment.

^bControls did not have patellofemoral pain syndrome, so effect sizes are not calculated.

and lateral rotator muscles. The effect size for the intervention group was small for usual pain ($d = -0.27$) but very large for worst pain ($d = -1.40$). The effect sizes for the control group were very large for usual ($d = -1.29$) and worst pain ($d = -1.40$). These results suggest that adding transverse abdominis, hip abductor, and lateral rotator muscles may improve pain outcomes in PFPS patients.

There were differences among the control groups used in the various studies included in this review. Many of the participants from these studies were not “true controls.” Some control groups received placebo treatments, nonsteroidal anti-inflammatory drugs, or less rigorous forms of exercise for comparison with those in experimental intervention groups (Table 2). The studies using “true controls”^{6,11,17,18} had average effect sizes in Kujala and VAS outcomes of 0.23 and -0.29 , whereas the average Kujala and VAS scores for patients in other control groups^{1,3,5,13,19,21} were 0.8 and -1.18 . This suggests that patients with PFPS will benefit from doing some exercise rather than nothing.

Two studies demonstrated large effect sizes for the no exercise group,^{3,10} while 2 studies had small effect sizes indicating a positive treatment effect in control groups.^{5,8} In review of these studies, larger treatment effects were reported in “controls” who were provided with some instructions or guidelines during the study period,¹⁰ while smaller treatment effects for control groups were observed in studies^{5,8} giving little information or suggestions for at-home treatment. Patient education—including activity recommendations, sham treatments,³ low-intensity exercises,¹⁰ and nonsteroidal anti-inflammatory drugs¹⁰—have a role in improving patient outcomes. Participants in 1 study¹⁰ were 2 to 3 times more likely than the exercise group to take nonsteroidal anti-inflammatory drugs. Improvements seen in PFPS patients treated with various interventions make it difficult to isolate the source of improvements.

Time also appears to influence recovery in PFPS patients when rest is compared to exercise. A 12-month follow-up of patients who had initially improved with exercise found no differences between the control and exercise groups.¹⁰ In this review, there were much higher magnitude effect sizes immediately following the exercise/control interventions compared to the outcomes at 3 months (Figure 1-2). In patients that benefited from exercise interventions, once the rigorous guidance of supervised and/or home exercise programs stopped, patient outcomes clearly diminished.

There are several factors to consider when critically appraising research and when designing future research on PFPS. Few Level I clinical trials exist with ample effect sizes. There is a considerable lack of consistency regarding the content of control, experimental interventions, and patient-reported outcome instruments. Duration of treatments, follow-up time points, and use of the VAS vary among studies. Last, females tend to dominate the patient pool of most studies, and results are not separated by sex, thus compromising

generalizability. However, since females tend to have higher incidences of PFPS,^{2,7} this may be a fair representation of this sex bias.

In conclusion, exercise interventions for PFPS are effective for immediate decrease in pain and increase in function. However, these data suggest that improvements may not be maintained after short-term follow-up.

REFERENCES

- Alaca R, Yilmaz B, Goktepe AS, Mohur H, Kalyon TA. Efficacy of isokinetic exercise on functional capacity and pain in patellofemoral pain syndrome. *Am J Phys Med Rehabil*. 2002;81(11):807-813.
- Boling MC, Padua DA, Marshall SW, Guskiewicz K, Pyne S, Beutler A. A prospective investigation of biomechanical risk factors for patellofemoral pain syndrome: the Joint Undertaking to Monitor and Prevent ACL Injury (JUMP-ACL) cohort. *Am J Sports Med*. 2009;37(11):2108-2116.
- Crossley KM, Cowan SM, McConnell J, Bennell KL. Physical therapy for patellofemoral pain syndrome: test retest reliability and inter-relationships. *Am J Sports Med*. 2002;30:857-865.
- Davis IS, Powers CM. Patellofemoral pain syndrome: proximal, distal, and local factors, an international retreat, April 30-May 2, 2009, Fells Point, Baltimore, MD. *J Orthop Sports Phys Ther*. 2010;40(3):A1-A16.
- Earl JE, Hoch AZ. A proximal strengthening program improves pain, function, and biomechanics in women with patellofemoral pain syndrome. *Am J Sports Med*. 2011;39(1):154-163.
- Ferber R, Kendall KD, Farr L. Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome. *J Athl Train*. 2011;46(2):142-149.
- Fulkerson JP. The etiology of patellofemoral pain in young, active patients: a prospective study. *Clin Orthop Relat Res*. 1983;179:129-133.
- Grelsamer RP, Klein JR. The biomechanics of the patellofemoral joint. *J Orthop Sports Phys Ther*. 1998;28(5):286-298.
- Insall J. Current concepts review: patellar pain. *J Bone Joint Surg Am*. 1982;64(1):147-152.
- Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. *Arthroscopy*. 1993;9(2):159-163.
- Loudon JK, Gajewski B, Goist-Foley HL, Loudon KL. The effectiveness of exercise in treating patellofemoral-pain syndrome. *J Sport Rehabil*. 2004;13:323-342.
- Malone T, Davies G, Walsh WM. Muscular control of the patella. *Clin Sports Med*. 2002;21(3):349-362.
- Nakagawa TH, Muniz TB, Baldon Rde M, Dias Maciel C, de Menezes Reiff RB, Serrao FV. The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain syndrome: a randomized controlled pilot study. *Clin Rehabil*. 2008;22(12):1051-1060.
- Physiotherapy Evidence Database. PEDro scale. <http://www.pedro.org.au/english/downloads/pedro-scale/>. Updated June 21, 1999. Accessed June 3, 2011.
- Post WR, Fulkerson J. Knee pain diagrams: correlation with physical examination findings in patients with anterior knee pain. *Arthroscopy*. 1994;10(6):618-623.
- Powers CM. Rehabilitation of patellofemoral joint disorders: a critical review. *J Orthop Sports Phys Ther*. 1998;28(5):345-354.
- Sacco I, Konno GK, Rojas GB, et al. Functional and EMG responses to a physical therapy treatment in patellofemoral syndrome patients. *J Electromyogr Kinesiol*. 2006;16:167-174.
- Song CY, Lin YF, Wei TC, Lin DH, Yen TY, Jan MH. Surplus value of hip adduction in leg-press exercise in patients with patellofemoral pain syndrome: a randomized controlled trial. *Phys Ther*. 2009;89(5):409-418.
- van Linschoten R, van Middelkoop M, Berger MY, et al. Supervised exercise therapy versus usual care for patellofemoral pain syndrome: an open label randomised controlled trial. *BMJ*. 2009;339:b4074.
- Wilk KE, Davies GJ, Mangine RE, Malone TR. Patellofemoral disorders: a classification system and clinical guidelines for nonoperative rehabilitation. *J Orthop Sports Phys Ther*. 1998;28(5):307-322.
- Witvrouw E, Dannaels L, Van Tiggelen D, Willemss TM, Cambier D. Open versus closed kinetic chain exercises in patellofemoral pain: a 5-year prospective randomized study. *Am J Sports Med*. 2004;32(5):1122-1130.