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 pain and has been reported to account for almost 10% of all visits to sports injury clinics. 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.

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. Proposed causes of this pain include patellofemoral malalignment; overuse; muscle or strength imbalances; osteochondral defects; and foot, ankle, hip, and pelvis biomechanical abnormalities. 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.

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. The

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

**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, if not focused on PFPS, if exercise therapy was not tested, and if Kujala or VAS patient-rated outcomes not utilized (n = 110).

### Data Analysis

The effect sizes were calculated using the following formula:

\[
\text{Cohen's } D = \frac{\text{Mean}_{\text{treatment}} - \text{Mean}_{\text{control}}}{\text{Standard deviation}_{\text{treatment}}}
\]

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

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1References 1, 3, 5, 6, 11, 13, 17 -19, 21.
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.

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Table 1. Descriptions and critiques of reviewed studies.

| Study          | Design                                           | PEDRO | Critique                                                                 |
|----------------|--------------------------------------------------|-------|--------------------------------------------------------------------------|
| Van Linschoten19 | Open-label randomized controlled trial           | 7     | Participants not randomized to group; participants, therapists, and assessors not blinded |
| Crossley3      | Randomized double-blinded placebo-controlled trial | 9     | Therapist not blinded to group                                           |
| Loudon11       | Controlled clinical trial                         | 5     | Participants not randomized to group; participants, therapists, and assessors not blinded; measures not obtained from ≥ 85% of original participants |
| Song18         | Randomized controlled trial                      | 8     | Participants not randomized to group; participants and therapists not blinded |
| Alaca1         | Prospective cohort study                         | 3     | No random assignment; allocation not concealed; participants, therapist, and assessor not blinded; no between-group comparisons |
| Loudon11       | Controlled clinical trial                         | 5     | Participants not randomized to group; participants, therapists, and assessors not blinded; measures not obtained from ≥ 85% of original participants |
| Sacco17        | Pre- and posttest intervention cohort study      | 6     | No random assignment; allocation not concealed; participants and therapist not blinded |
| Alaca1         | Prospective cohort study                         | 3     | No random assignment; allocation not concealed; participants, therapist, and assessor not blinded; no between-group comparisons |
| Nakagawa13     | Randomized controlled pilot trial                | 9     | No blinded therapist                                                     |
| Sacco17        | Pre- and posttest intervention cohort study      | 6     | No random assignment; allocation not concealed; participants and therapist not blinded |
| Witvrouw21     | Prospective randomized clinical trial, no control | 5     | Allocation not concealed; participants, therapist, and assessors not blinded; measures not obtained from 85% or more |
| Ferber6        | 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 |
| Earl5          | 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 |

*Outcome at 3 months postintervention.
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, 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). In studies comparing the effects of different exercise programs, no differences were found between the 2 exercise groups. Witrouv et al 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. 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                   |

\(^a\)N/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.

\(^b\)Controls 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” 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 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, while 2 studies had small effect sizes
indicating a positive treatment effect in control groups. In
review of these studies, larger treatment effects were reported
in “controls” who were provided with some instructions or
guidelines during the study period, while smaller treatment
effects for control groups were observed in studies giving
little information or suggestions for at-home treatment.

Patient education—including activity recommendations,
sham treatments, low-intensity exercises, and nonsteroidal anti-
inflammatory drugs—have a role in improving patient
outcomes. Participants in 1 study were 2 to 3 times more likely
than the exercise group to take nonsteroidal anti-
inflammatory drugs. Improvements seen in PFPS patients
responded to 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. 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 benefitted 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, 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.

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