Effectiveness of Isolated Hip Exercise, Knee Exercise, or Free Physical Activity for Patellofemoral Pain

A Randomized Controlled Trial

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Background: Exercise for patellofemoral pain (PFP) is traditionally knee focused, targeting quadriceps muscles. In recent years, hip-focused exercise has gained popularity. Patient education is likely an important factor but is underresearched.

Purpose: To compare 3 treatment methods for PFP, each combined with patient education: hip-focused exercise, knee-focused exercise, or free physical activity.

Study Design: Randomized controlled trial; Level of evidence, 1.

Methods: A single-blind randomized controlled trial was performed with 112 patients who were 16 to 40 years old (mean, 27.6 years) and had a symptom duration >3 months (mean, 39 months) with a clinical diagnosis of PFP and no radiograph or magnetic resonance evidence of other pathology. Patients were randomized to a 6-week intervention consisting of patient education combined with isolated hip-focused exercise (n = 39), traditional knee-focused exercise (n = 37), or free physical activity (n = 36). The primary outcome was Anterior Knee Pain Scale (0-100) at 3 months. Secondary outcomes were visual analog scale for pain, Tampa Scale for Kinesiophobia, Knee Self-efficacy Scale, EuroQol, step-down, and isometric strength.

Results: There were no between-group differences in any primary or secondary outcomes at 3 months except for hip abduction strength and knee extension strength. Between-group differences at 3 months for Anterior Knee Pain Scale were as follows: knee versus control, 0.2 (95% CI, –5.5 to 6.0); hip versus control, 1.0 (95% CI, –4.6 to 6.6); and hip versus knee, 0.8 (95% CI, –4.8 to 6.4). The whole cohort of patients improved for all outcomes at 3 months except for knee extension strength.

Conclusion: The authors found no difference in short-term effectiveness in combining patient education with knee-focused exercise, hip-focused exercise, or free training for patients with PFP.

Registration: NCT02114294 (ClinicalTrials.gov identifier).

Keywords: patellofemoral pain; anterior knee pain; exercise therapy; hip strengthening; education

Patellofemoral pain (PFP) is defined as pain around or behind the kneecap that is aggravated by activities that load the patellofemoral joint in the absence of other distinct knee pathology.[10] Annual prevalence is reported as 23% in the general population and 29% among adolescents.[50] It is postulated that an interplay among biomechanical, anatomic, psychosocial, and behavioral factors contributes to PFP.[42] Imbalances in strength and timing of core and lower extremity muscles, especially the quadriceps, are thought to influence tracking of the patella during loading of the patellofemoral joint.[14,42] Psychological factors also appear to be important, but the number of studies is limited.[33]

Treatment of PFP is nonoperative and commonly emphasizes improvement of patellofemoral joint mechanics through exercise, as often supplemented by tape, insoles, biofeedback, and other adjunctive treatments in a multimodal or combined approach.[2,7] Exercise has been advocated as a mainstay in treating PFP.[2,7] A recent Cochrane systematic review concluded that there is consistent but low-quality evidence recommending exercise as a treatment for PFP.[55] There is little evidence to recommend a specific type of exercise therapy for PFP, and it is unclear which patients would benefit most from which treatment.[46,55] Traditionally, exercise interventions for

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PFP have been knee focused, targeting quadriceps strength and timing,[26,55] while the addition of hip-focused exercise is a more recent area of research.[28,37,55]

Hip and knee exercises are both advocated in newer recommendations.[2,7] However, the relative contributions of the components are yet to be elucidated. Knee exercises were found to be effective in treating PFP.[26,55] The results of studies investigating the effect of hip exercises alone are inconsistent.[1,11,17,24,25] Superior effects of hip exercise as compared with knee exercise have been reported,[1,11,24] while others found no benefit from hip versus knee exercise.[17,19] One possible reason for the lack of difference shown between hip and knee exercise might be that many hip exercise protocols also involve the knee and vice versa. Investigation of exercises aiming to isolate the different muscle groups might help elucidate the relative contributions of the components.

Patient education is widely recommended as an important component of PFP treatment.[2,7] However, this field is largely unexplored.[45] Some evidence suggests that patient education may be an effective treatment for PFP.[16] The most recent international consensus underlines the need for more research on the role of patient education in the management of PFP.[7] Given the resources required to deliver therapist-guided exercises over a several-week period, it is important to know whether patient education and free physical activity could be equally effective for some patients.

The goal of the present study was to investigate the short-term effectiveness of combining patient education with isolated hip-focused exercises, traditional knee-focused exercises, or free physical activity for PFP.

METHODS

Trial Design

This trial was registered with the ClinicalTrials.gov database (NCT02114294) and took place between September 2014 and September 2017. Ethical approval was obtained from the Ethics Committee Health Region South-East, Norway (2013/1860/REKsør-øst). The full trial protocol was published previously.[22] Patients provided written informed consent.

CONSORT Statement and Flowchart

This trial was designed and reported in accordance with the CONSORT (Consolidated Standards of Reporting Trials) guidelines for reporting of randomized controlled trials[36] (Figure 1).

Study Population

Patients with PFP were referred to the outpatient clinic at the Department of Physical Medicine and Rehabilitation at Sørlandet Hospital by primary care physicians or other medical specialists (eg, orthopaedic surgeons, rheumatologists) in the surrounding area. All participants were screened with radiographs and magnetic resonance imaging (MRI) and underwent a clinical examination by a specialist in physical medicine and rehabilitation at inclusion.

Inclusion Criteria. Patients were considered eligible if they were 16 to 40 years old with a minimum 3-month history of PFP (pain, $\geq$3 of 10) reproduced by at least 2 activities (stair ascent/descent, hopping, running, prolonged sitting, squatting, kneeling) and present on at least 1 clinical test (compression of the patella, palpation of the patellar facets). For patients with bilateral pain, the worst knee was included.

Exclusion Criteria. Exclusion criteria included (1) clinical, radiographic, or MRI findings indicative of other specific pathology, including meniscal, ligament, or cartilage injury, as well as osteoarthritis, epiphysitis, significant knee joint effusion, or recurrent patellar subluxation or dislocation; (2) significant pain from hip or back hindering the ability to perform the prescribed exercises; (3) previous surgery to the knee joint; (4) nonsteroidal anti-inflammatory drug or cortisone use over an extended period; (5) previous trauma to the knee joint with an effect on the presenting clinical condition; and (6) physiotherapy or other similar exercises for PFP syndrome within the previous 3 months.

Randomization

The randomization sequence was computer generated with blocks of a variable size, stratified by sex, and unknown to anyone in the research team. The sequence was concealed in opaque envelopes, stored by a nurse not otherwise involved in the study, and delivered sequentially to the study physiotherapist at randomization.

Blinding

Physiotherapists providing the interventions were blinded to baseline measures. Members of the research team who handled outcome measures were blinded to treatment allocation. Data analysis and writing of the manuscript were performed blinded until consensus about the interpretation was reached, as recommended by Järvinen et al[23]

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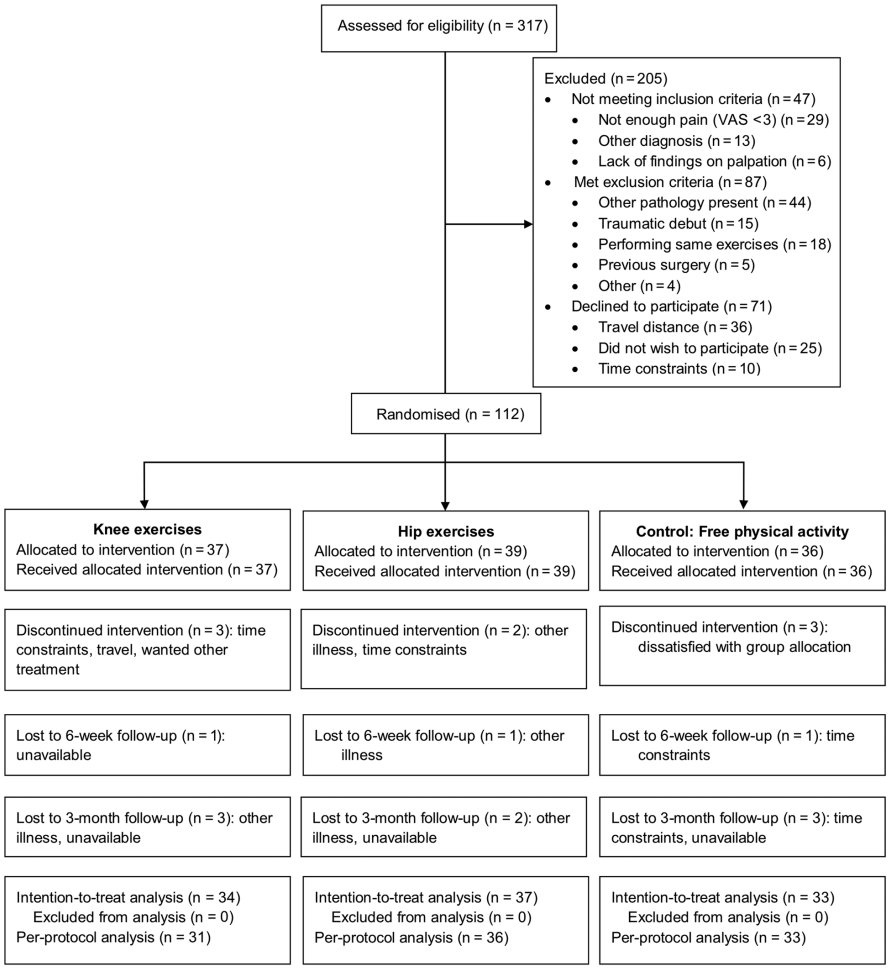

Figure 1. CONSORT (Consolidated Standards of Reporting Trials) flowchart. VAS, visual analog scale.

and used by Schrøder et al.[48] It was not possible to blind the participants or the physiotherapists who provided the interventions. Patients' expectations about the effectiveness of each intervention were assessed at baseline (Table 1).

Interventions

Patient Education. There are indications that kinesiophobia and catastrophizing might be important in PFP.[12,13,40,41,51] The patient education component was formulated with the intention to reduce kinesiophobia and encourage self-mastery of symptoms. All patients received standardized oral and written information at the time of inclusion to the study and at randomization. At inclusion, all participants attended an individual 1-hour consultation with a specialist in physical medicine and rehabilitation, which contained important elements from the "good back consultation."[29] This includes a thorough patient-centered history and physical examination and information focused on the benign nature of PFP, including the fact that the knee had been thoroughly examined and no injury was found to the structures of the knee. PFP was referred to as "loading pain" and not as an "injury." The presumed importance of muscle strength and coordination in controlling the kneecap was explained. The rationale behind the current study was explained, stressing that it is thought that exercise helps PFP but it is unknown what type of exercise is best, including that it is unknown whether structured exercises are better than free training. Patients were advised to gradually increase physical activity without excessively provoking knee pain. Traditional advice to avoid certain activities or to focus on "correct" biomechanical positions of the lower extremity were not given, as we theorized that this may contribute to increased kinesiophobia.[29,39] A shorter version of the same information was presented again at the first meeting with the physiotherapist for randomization (approximately 30 minutes). All research personnel were instructed to communicate in the same vein, and meetings were held in the planning stage and at several points during the study to ensure standardization of communication with participants.

Exercise Dosage. The hip-based and knee-based exercise regimens were matched in dosage and progression. Exercise schedules (number of sessions, exercises, and series) were chosen to reflect those commonly used in previous studies with similar exercises, to allow comparison with these.[11,15,18,25,58] We chose a slightly increased number of repetitions based on a previous study suggesting dose

dependence,[38] and other studies showing positive effect with this strategy.[15,25] A written and illustrated manual was provided to the patient to ensure quality and standardization of exercises. Patient compliance with the exercise program was recorded at the weekly session with the physiotherapist. To ensure standardization of procedures, meetings between physiotherapists and investigators were held at several points during the study.

Three sessions per week were performed for 6 weeks: 1 under supervision of the physiotherapist and 2 home sessions, with at least 1 day between sessions. Initial dosage was 3 sets of 10 repetitions for each exercise, with progression to a maximum 3 × 20 repetitions. Each repetition was performed dynamically over 2 to 3 seconds, with a 2-second pause between repetitions and a 30-second pause between sets. Additional resistance thereafter was achieved through weights or elastic tubing depending on the exercise.

A dosage was chosen in which the last repetitions were difficult while still allowing the patient to maintain high quality of movement (control) throughout the entire program. To avoid focus on pain, dosage was based on principles for operant conditioning,[31] which entails setting quotas of exercise below the patient's limit of tolerance as opposed to training up to the pain threshold. Details of the exercise program are provided in the appendix (available in the online version of the article).

Hip-Focused Exercises. The hip-focused exercises were based on previous studies[11,25] and consisted of side-lying hip abduction, hip external rotation (clam shell), and prone hip extension. These exercises were intended to maximally isolate the hip abductors, extensors, and external rotators without stimulating the quadriceps muscles.

Knee-Focused Exercises. The knee-focused exercise regimens was based on previous studies[11,57] and was intended to maximally isolate the quadriceps muscles. The exercises consisted of straight-leg raises in the supine position, supine terminal knee extensions (from 10° of flexion to full extension), and a mini-squat (45° of flexion) with the back supported against the wall (to reduce stabilizing requirements from the hip muscles).

Control Group (Free Physical Activity). At randomization, the control group was encouraged by the study physiotherapist to be physically active in accordance with standardized information.

Assessment Procedures

Observers blinded to treatment allocation assessed all participants at baseline, 6 weeks, and 3 months after inclusion. Full assessment was performed at baseline and 3 months. A limited assessment consisting of pain and disability (Anterior Knee Pain Scale [AKPS]) and pain intensity (visual analog scale [VAS]), strength tests, and a step-down test was performed at 6 weeks.

Outcome Measures

All outcome measures are explained in detail in the published protocol.[22] A short explanation of their use is given here.

Primary Outcome Measure. The main outcome is the AKPS at 3 months. This self-report questionnaire consists of 13 questions assessing pain and disability.[27] The score ranges from 0 (worst possible function) to 100 (perfect function). The minimal clinically important difference (MCID) is reported[9] to be 10.

Secondary Outcome Measures. Usual pain and worst pain were measured with a VAS (0-10 [worst pain]). For these measurements, an MCID of 2 was reported.[9] The Tampa Scale for Kinesiophobia was used to assess fear of movement/reinjury (range, 0-52 [most kinesiophobia]).[20] Self-efficacy was measured with the Knee Self-efficacy Scale (range, 0-10 [highest self-efficacy]).[52] The EQ-5D-5L (EuroQol-5 Dimensions -5 Level) was used to measure health-related problems and quality of life.[3] The Danish validated index value calculator was used (range, –0.62 to 1.00 [best possible]).[43] The EQ-VAS (EuroQol–Visual Analog Scale; 0-100 [best possible]) was used to record patients' self-rated overall health.[43] A step-down test was used as an objective measure of function.[32] The subject steps forward from a 20-cm step and down toward the floor. For 1 repetition, the heel of the down limb touches the floor before the up limb returns to full extension. The measure is number of step-down repetitions in 30 seconds.

Isometric strength was measured for hip abduction, hip external rotation, and knee extension. Positioning and external stabilization with straps were used according to techniques validated by Thorborg et al.[53,54] Strength was measured with a force sensor (300 kg, MuscleLab 6000 ML; Ergotest Innovation) instead of a handheld dynamometer, as it was considered a superior measurement device. Standardized procedures are based on existing techniques.[4,53] Measures are reported in newtons. We used 75% completion of exercise sessions (home and supervised) to define compliance. Patients in the control group who received supervised exercise therapy were defined as noncompliant.

Sample Size

The power and sample size calculations were based on previous studies. Standard deviations of the AKPS and pain (VAS) were assumed to be 13.5 and 2.25, respectively.[56] The MCID for the AKPS and pain were assumed to be 10 and 2.[9] With these assumptions, 27 patients were required in each of the 3 treatment groups to obtain 80% statistical power with a 5% significance level for the AKPS and 19 in each group for pain. To take into account possible missing data or dropouts, we planned to include a minimum of 35 patients in each group.

Statistical Analysis

The principle of intention to treat was used in the main analysis. A blinded statistical analysis and review of the outcome data were performed, and the original manuscript and interpretation were prepared blinded. Only after the writing committee members had agreed that there would be no further changes in the interpretation was the randomization code broken and the final manuscript prepared for publication.

TABLE 1
Baseline Characteristics[a]

Group Allocation	Knee (n = 37)	Hip (n = 39)	Control (n = 37)
Age, y, mean ± (SD)	28.5 ± 6.2	27.8 ± 8.6	26.3 ± 7.0
Female:male	24:13	25:14	24:12
Body mass index, kg/m^2			
<25	12 (32)	21 (54)	18 (50)
25-30	19 (51)	10 (26)	10 (28)
>30	6 (16)	8 (21)	8 (22)
Unilateral:bilateral	10:27	13:26	8:28
Symptom duration, mo			
3-6	2 (5)	1 (3)	5 (14)
6-12	7 (19)	5 (13)	11 (31)
12-24	8 (22)	10 (25)	6 (17)
>24	20 (54)	23 (59)	14 (39)
Education >13 y	11 (30)	10 (25)	12 (33)
Sick listed	6 (16)	3 (8)	6 (16)
Regular use of analgesics	5 (14)	6 (15)	8 (22)
Use of insoles	4 (11)	3 (8)	9 (25)
Use of knee support or brace	5 (14)	9 (23)	5 (14)
Emotionally distressed (HSCL ≥1.8)	9 (24)	11 (28)	10 (28)
Expectation of effect (VAS, 0-10), mean ± (SD)			
For knee training	6.6 ± 2.3	7.0 ± 2.3	6.8 ± 2.4
For hip training	6.6 ± 2.6	6.9 ± 2.5	6.6 ± 2.3
For free activity	5.9 ± 2.3	6.9 ± 2.3	6.4 ± 2.6

[a]Data are presented as n (%), unless otherwise indicated. HSCL, Hopkins Symptom Checklist; VAS, visual analog scale.

The differences among the 3 treatment groups at follow-up were analyzed with an analysis of covariance model with the baseline value as a covariate. Results were analyzed after 6 weeks and 3 months. Assumptions of the model were checked. Improvement from baseline was assessed with paired-samples *t* tests. Effect size was calculated with Cohen *d* for the paired-samples *t* test ($d = t/\sqrt{N}$), where *t* is the *t* statistic and N is the sample size.

Missing values in the AKPS, Tampa Scale for Kinesiophobia, Knee Self-efficacy Scale, and Hopkins Symptom Checklist were treated as follows: If <25% of items were missing, the values were substituted with the arithmetic mean of values from the available items.[5] If ≥25% of items were missing, the outcome was regarded as missing for the patient.

RESULTS

Participants

Between September 2014 and September 2017, 316 patients were referred to our department with a presumed diagnosis of PFP: 205 were excluded, and 112 were included in the study and randomized to 1 of the 3 groups. For details, see the flowchart (Figure 1). Baseline characteristics are described in Table 1.

Main Findings

At 3 months, there were no between-group differences in the AKPS ($P = .90$) (Tables 2 and 3). Per-protocol analysis did not reveal any significant between-group difference. Paired-samples *t* test demonstrated an improvement in the AKPS at 3 months for the group as a whole, from 65.9 to 73.5 (mean difference, 7.6; 95% CI, 5.6-9.6; $P < .001$).

Secondary Findings

There were no significant between-group differences at 3 months for usual pain, worst pain, step-down, EQ-5D-5L index score, EQ-VAS, knee self-efficacy, or kinesiophobia (Tables 2 and 3). There were between-group differences in hip abduction strength (knee vs control) at 6 weeks and 3 months and in knee extension strength (hip vs control) at 6 weeks and 3 months and between knee and control groups at 6 weeks.

The group as a whole improved at 6 weeks and 3 months on all primary and secondary outcomes except for knee extension strength (Table 2, Figure 2). The effect size for the AKPS was 0.74. There was significant improvement for the hip and knee groups from baseline to 6 weeks and 3 months for all muscle strength tests, while the control group did not have significant improvements in muscle strength (Figure 3).

Compliance was high, with 88% of patients adhering to the protocol (hip group, 92%; knee group, 84%; control group, 92%). There was no significant difference in expectation for hip exercises, knee exercises, and free training measured for the group as a whole at baseline.

DISCUSSION

To our knowledge, this is the first study to compare the effectiveness of combining patient education with isolated hip

TABLE 2
Primary and Secondary Outcomes at Baseline, 6 Weeks, and 3 Months[a]

Outcome	Knee (n = 37)	Hip (n = 39)	Control (n = 36)	All (N = 112)
Primary outcome				
AKPS (0-100)[b]				
Baseline	67.2 (62.7-71.7)	64.5 (61.1-67.9)	65.3 (61.2-69.5)	65.9 (63.6-68.3)
6 wk	74.5 (69.7-79.4)[c]	73.3 (69.9-76.7)[c]	73.6 (69.1-78.1)[c]	73.8 (71.4-76.2)[c]
3 mo	74.4 (69.8-79.0)[c]	73.1 (69.5-76.7)[c]	73.1 (68.2-78.0)[c]	73.5 (71.1-75.9)[c]
Secondary outcomes				
Usual pain (VAS, 0-10)				
Baseline	4.3 (3.6-5.0)	4.4 (3.8-4.9)	3.7 (3.0-4.4)	4.1 (3.8-4.5)
6 wk	2.6 (1.9-3.2)[c]	3.1 (2.5-3.7)[c]	2.8 (2.0-3.5)[c]	2.9 (2.5-3.2)[c]
3 mo	2.6 (1.8-3.4)[c]	2.9 (2.4-3.5)[c]	3.2 (2.5-3.9)	2.9 (2.5-3.3)[c]
Worst pain (VAS, 0-10)				
Baseline	6.0 (5.2-6.8)	6.5 (5.8-7.1)	5.8 (5.1-6.5)	6.1 (5.7-6.5)
6 wk	4.1 (3.2-5.0)[c]	5.3 (4.7-6.0)[c]	4.7 (3.9-5.5)[c]	4.7 (4.3-5.2)[c]
3 mo	4.0 (3.0-5.1)[c]	4.9 (4.1-5.7)[c]	5.0 (4.1-5.9)	4.7 (4.1-5.1)[c]
Kinesiophobia (TSK, 13-52)				
Baseline	27.2 (24.9-29.5)	26.8 (24.9-28.6)	27.2 (25.0-29.4)	27.1 (25.9-28.2)
6 wk	—	—	—	—
3 mo	24.5 (21.8-27.1)[c]	24.5 (22.5-26.4)[c]	25.9 (23.6-28.3)	24.9 (23.6-26.2)[c]
Knee self-efficacy (KSES, 0-10)[b]				
Baseline	6.2 (5.6-6.8)	6.2 (5.6-6.8)	5.8 (5.1-6.3)	6.0 (5.7-6.3)
6 wk	—	—	—	—
3 mo	7.1 (6.3-7.8)[c]	7.0 (6.5-7.6)[c]	6.4 (5.7-7.1)[c]	6.8 (6.5-7.2)[c]
EQ-5D-5L (–0.62 to 1.00)[b]				
Baseline	0.75 (0.70-0.80)	0.76 (0.73-0.80)	0.73 (0.69-0.78)	0.75 (0.72-0.77)
6 wk	—	—	—	—
3 mo	0.82 (0.78-0.85)[c]	0.80 (0.76-0.83)	0.77 (0.73-0.82)	0.80 (0.77-0.82)[c]
EQ-VAS (0-100)[b]				
Baseline	64.3 (58.5-70.2)	66.6 (59.4-73.7)	62.9 (57.4-68.4)	64.6 (61.1-68.1)
6 wk	—	—	—	—
3 mo	67.0 (60.4-73.5)	71.1 (64.3-77.9)[c]	68.7 (62.8-74.6)[c]	69.0 (65.4-72.6)[c]
Step-down[d]				
Baseline	15.6 (13.6-17.6)	16.7 (15.2-18.2)	16.4 (14.4-18.4)	16.2 (15.2-17.3)
6 wk	18.1 (15.8-20.4)[c]	18.7 (17.1-20.2)[c]	18.6 (16.2-20.9)[c]	18.4 (17.3-19.6)[c]
3 mo	19.2 (16.8-21.6)[c]	19.5 (18.1-20.9)[c]	19.2 (16.7-21.6)[c]	19.3 (18.1-20.5)[c]
Hip abduction strength[e]				
Baseline	126 (110-141)	138 (124-152)	138 (122-154)	134 (126-142)
6 wk	143 (128-158)[c]	150 (135-166)[c]	141 (124-158)	145 (136-154)[c]
3 mo	145 (131-159)[c]	149 (134-163)[c]	135 (119-151)	143 (135-151)[c]
Hip external rotation strength[e]				
Baseline	103 (88-118)	111 (96-125)	114 (97-131)	109 (101-118)
6 wk	117 (102-132)[c]	124 (109-139)[c]	119 (103-136)	120 (112-129)[c]
3 mo	119 (104-133)[c]	123 (110-136)[c]	117 (101-133)	120 (112-128)[c]
Knee extension strength[e]				
Baseline	317 (272-362)	321 (283-358)	337 (289-386)	325 (300-349)
6 wk	326 (283-368)[c]	345 (311-379)[c]	322 (273-371)	331 (308-355)
3 mo	313 (279-357)	342 (307-376)[c]	319 (270-368)	327 (304-350)

[a]Data are reported as mean (95% CI). Unadjusted values are given. AKPS, Anterior Knee Pain Scale; EQ-5D-5L, 5-level EuroQol–5 Dimensions 5 Level; EQ-VAS, EuroQol–Visual Analog Scale; KSES, Knee Self-efficacy Scale; TSK, Tampa Scale for Kinesiophobia; VAS, visual analog scale.
[b]Higher value indicates better function.
[c]Significant difference from baseline at the $P \leq .05$ level.
[d]Step-down: number in 30 seconds.
[e]Muscle strength (newtons).

exercise, traditional knee-focused exercise, or free physical activity. We found no between-group differences for any of the primary or secondary outcome measures at 3 months, except for nonspecific changes in hip abduction strength and knee extension strength.

Comparison With Previous Studies

Hip- Versus Knee-Focused Exercise. The latest Cochrane review concludes that there is sparse evidence to recommend any specific type of exercise therapy or to indicate

TABLE 3
Adjusted Between-Group Mean Differences at 6 Weeks and 3 Months[a]

Outcome	Hip vs Control	Knee vs Control	Hip vs Knee
Primary outcome			
AKPS (0-100)[b]			
6 wk	0.5 (–5.2 to 6.1)	–0.2 (–5.9 to 5.6)	0.6 (–5.1 to 6.3)
3 mo	1.0 (–4.6 to 6.6)	0.2 (–5.5 to 6.0)	0.8 (–4.8 to 6.4)
Secondary outcome			
Usual pain (VAS, 0-10)			
6 wk	0.0 (–1.0 to 1.0)	–0.5 (–1.5 to 0.5)	0.5 (–0.5 to 1.5)
3 mo	–0.6 (–1.6 to 0.4)	–0.85 (–1.9 to 0.2)	0.2 (–0.8 to 1.3)
Worst pain (VAS, 0-10)			
6 wk	0.4 (–0.9 to 1.6)	–0.7 (–1.9 to 0.6)	1.0 (–0.2 to 2.3)
3 mo	–0.4 (–1.8 to 1.1)	–1.0 (–2.4 to 0.5)	0.6 (–0.9 to 2.0)
Kinesiophobia (TSK, 13-52)[c]			
6 wk	—	—	—
3 mo	–1.0 (–3.8 to 1.7)	–1.5 (–4.3 to 1.3)	0.5 (–2.3 to 3.2)
Knee self-efficacy (KSES, 0-10)[b]			
6 wk	—	—	—
3 mo	0.3 (–0.5 to 1.2)	0.3 (–0.5 to 1.2)	–0.0 (–0.8 to 0.8)
EQ-5D-5L (–0.62 to 1.00)[b]			
6 wk	—	—	—
3 mo	0.02 (–0.04 to 0.07)	0.03 (–0.02 to 0.09)	–0.02 (–0.07 to 0.03)
EQ-VAS (0-100)[b]			
6 wk	—	—	—
3 mo	–0.8 (–8.4 to 6.8)	–2.2 (–10.0 to 5.6)	1.5 (–6.1 to 9.0)
Step-down[d]			
6 wk	–0.3 (–2.1 to 1.4)	0.2 (–1.6 to 2.0)	–0.5 (–2.2 to 1.2)
3 mo	–0.2 (–2.3 to 2.0)	0.35 (–1.8 to 2.5)	–0.5 (–1.6 to 2.6)
Hip abduction[e]			
6 wk	9.7 (–1.4 to 20.8)	13.6 (2.2 to 24.9)[f]	–3.9 (–15.0 to 7.2)
3 mo	10.9 (–3.7 to 25.5)	17.9 (2.7 to 33.2)[g]	–7.2 (–21.7 to 7.6)
Hip external rotation[e]			
6 wk	9.2 (–2.8 to 21.2)	10.9 (–1.4 to 23.2)	–1.6 (–13.6 to 10.3)
3 mo	8.1 (–6.6 to 22.9)	10.3 (–4.9 to 25.6)	–2.2 (–16.8 to 12.4)
Knee extension[e]			
6 wk	40.0 (14.7 to 65.3)[h]	28.7 (2.8 to 54.5)[g]	11.3 (–13.9 to 36.6)
3 mo	34.9 (3.9 to 65.9)[g]	19.4 (–12.8 to 51.5)	15.6 (–15.1 to 46.2)

[a]Data are reported as mean (95% CI). AKPS, Anterior Knee Pain Scale; EQ-5D-5L, EuroQol-5 Dimensions -5 Level; EQ-VAS, EuroQol–Visual Analog Scale; KSES, Knee Self-efficacy Scale; TSK, Tampa Scale for Kinesiophobia; VAS, visual analog scale.
[b]Higher value indicates better function.
[c]Lower value indicates less kinesiophobia.
[d]Step-down: number in 30 seconds.
[e]Muscle strength (newtons).
[f]$P = .01$.
[g]$P = .02$.
[h]$P = .001$.

who would benefit from exercises.[55] Four previous studies directly compared hip exercises with knee-focused exercises.[1,11,17,24] Dolak et al,[11] Khayambashi et al,[24] and Baldon et al[1] found hip exercises to be more effective than knee-focused exercises; however, their sample sizes were small (15-18 per group), and Khayambashi et al lacked randomization. Our results are in agreement with Ferber et al,[17] who performed a multicenter randomized controlled trial of 199 patients to compare hip exercises and knee-focused exercises. They found no difference in pain and function at 6 weeks between the groups.

Patient Education Plus Guided Exercises or Free Physical Activity. Little research exists regarding patient education in PFP, although it is generally thought to be important.[2,45] We found 4 previous studies comparing education alone with exercise-based interventions, all with combined exercise strategies and at least some exercises performed daily.[6,16,44,56] Rathleff et al[44] and van Linschoten et al[56] found exercise-based intervention superior to education alone. Clark et al[6] and Esculier et al[16] found no significant difference in pain or function outcomes between exercise-based intervention and education alone, although Clark et al reported that patients who exercised were more likely to be discharged from physiotherapy after 3 months as compared with those who did not exercise.

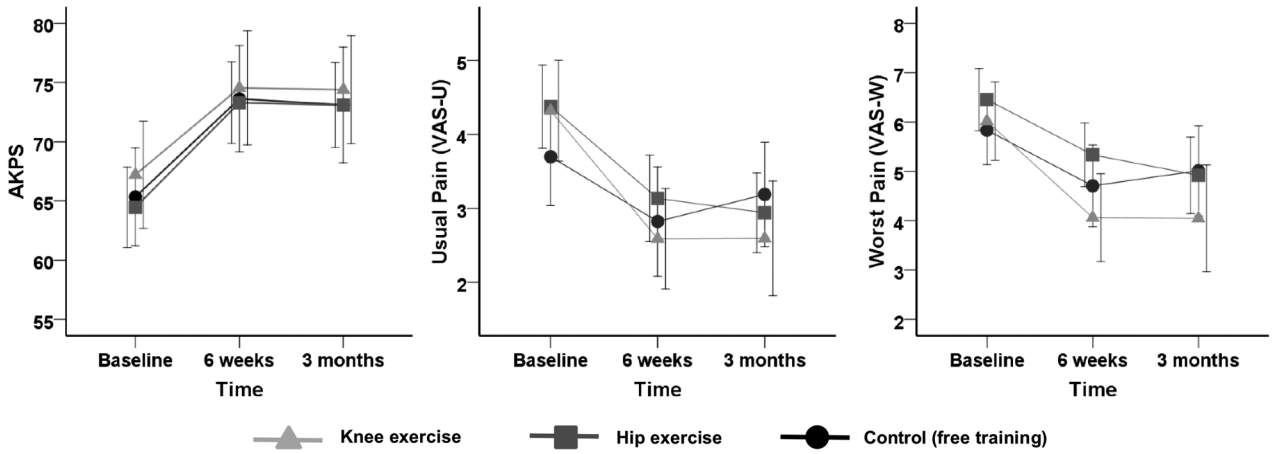

Figure 2. Mean group scores for the AKPS (0 to 100), usual pain (0 to 10), and worst pain (0 to 10). Error bars represent 95% CI. AKPS, Anterior Knee Pain Scale; VAS, visual analog scale.

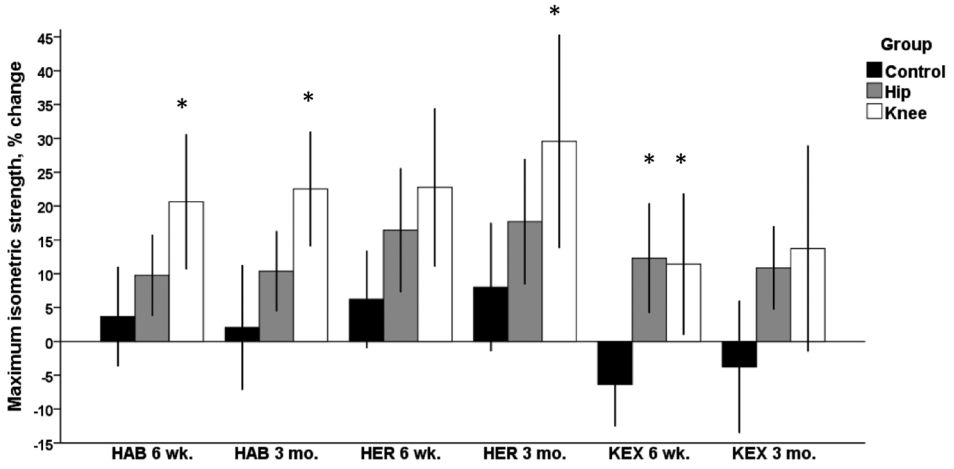

Figure 3. Percentage change in isometric strength for hip abduction (HAB), hip external rotation (HER), and knee extension (KEX) at 6 weeks and 3 months. Error bars represent 95% CI. *$P \leq .05$ vs control.

There is little current evidence to guide the ideal content of educational materials.[45] The education component of Esculier et al[16] focused on load management and training schedules for runners and showed this to be effective. Previous studies indicated that targeting kinesiophobia and catastrophizing might be important.[12,33,34] To our knowledge, this is the first study to utilize an education component intending to influence these factors. The effect sizes for kinesiophobia and self-efficacy in our cohort are small to medium, and it is likely that our education component could be improved. A more comprehensive cognitive-behavioral intervention might be more effective in improving kinesiophobia and self-efficacy.[31] Optimizing the content of educational interventions is important, whether they are used alone or in combination with guided exercise.

Exercise Dosage. Little is known about the ideal dosage of exercises for PFP.[21,59] There is some evidence to suggest a dose dependency, although it is not known what elements in PFP the increased dose is targeting.[38] The exercise schedule used in this study is comparable to that in many previous studies showing positive effect.[1,11,15,16,18,25,58] We chose to increase number of repetitions based on previous evidence suggesting possible dose dependency.[38] Other studies were successful with this strategy.[15,24,25] It is possible that further increasing the exercise dose—for example, to daily exercises, as in some studies[8,17,56]—might have increased the effectiveness of the guided exercises in this study as compared with the control group. However, strength gains in our guided exercise groups were larger than those of the control group and are comparable to those in other

studies,[1,11,15,17,58] suggesting an effect of the guided exercise regimens. The fact that the pain and function improvements are not directly tied to gains in muscle strength was previously observed in systematic reviews[37,47] and might indicate that factors other than muscle strength are important in PFP.

Interpretation of the Results

Our results raise the question whether patient education and free training may be as effective as therapist-guided training programs because of the lack of difference between the groups in the primary and secondary outcomes in this study.

Several points should be considered in interpreting these results. First, the guided exercises in this study were targeted toward isolated muscle groups and not as part of a complex exercise strategy or multimodal intervention, as is often used in PFP.[8,44,56] Second, an isolated exercise regimen might be more effective if it were targeted to specific deficits, as in the subgroup theory by Selfe et al.[49] Third, the content of the educational component, with stress on kinesiophobia, is different from that previously investigated, which might influence its effectiveness. Finally, we note that our cohort has a relatively long pain duration and/or low AKPS score as compared with other studies.[16,17,56,57] These factors predict poor prognosis in PFP[30,35] and might affect the overall treatment response for the cohort.

Strengths of the Current Study

The trial was adequately powered, with good compliance and a low rate of dropout (7%) and missing data. Dosages in the exercise groups were matched, and exercises were chosen to isolate the muscle groups of interest as much as possible. This ensured that the exercise type was the only known difference in the interventions. All investigators were blinded. Although blinding of the participants to group allocation was not possible, expectations of the effects of the different interventions were investigated at inclusion and were not significantly different among groups. This suggests that the interventions were successfully presented as equivalent, reducing expectation bias on the part of the participants. The standardization of written and oral communication with all patients regardless of group allocation, including presentation of the control group as an active treatment group, also likely reduced bias. Data analysis and the first draft of the manuscript were performed blinded to group allocation to avoid bias at this stage of the study. The use of MRI at inclusion ensured that knee injuries other than PFP were excluded.

Limitations and Considerations

A considerable number of patients met exclusion criteria or declined inclusion, potentially decreasing the external validity. The activity level of the control group during the intervention period is not possible to quantify, which limits the interpretability of the findings. The limited effect size for the whole study population raises the question whether the observed improvement represents a natural course of improvement or a regression to the mean. We cannot draw conclusions about long-term effectiveness.

CONCLUSION

Our study shows no difference in the short-term effectiveness of combining patient education with knee exercise, hip exercise, or free training. Guided exercises improved muscle strength but did not translate to additional gains in other outcomes over the control group.

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