Best practice guide for patellofemoral pain based on synthesis of a systematic review, the patient voice and expert clinical reasoning

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ABSTRACT

Objective Define a best practice guide for managing people with patellofemoral pain (PFP).

Methods A mixed-methods convergent segregated synthesis of meta-analysed data with a thematic analysis of semistructured interviews and focus groups. Agreement between subproject results informed the strength of clinical recommendation for interventions eligible for best practice recommendation.

Data sources Medline, Web of Science, Scopus, reference lists and citation tracking; semistructured interviews of people with PFP; and semistructured interviews and focus groups with clinical experts.

Eligibility criteria High-quality (PEDro scale >7) randomised controlled trials (RCTs) were retained for efficacy estimation using meta-analysis. People with PFP were required to have experienced an episode of care in the past 6 months and clinical experts were required to have>5 years of clinical experience alongside direct involvement in research.

Results Data from 65 high-quality RCTs involving 3796 participants informed 11 meta-analyses of interventions. Interviews with 12 people with PFP led to 3 themes and interviews with 19 clinical experts led to 4 themes. These were further explored in three clinical expert focus groups. Best practice for PFP should first involve understanding a patient's background risk factors, their reasons for seeking care, greatest symptoms, and physical impairments, to inform treatment selection. Synthesis led to six distinct interventions being recommended. Knee-targeted±hip-targeted exercise therapy underpinned by education should be delivered, with additional supporting interventions such as prefabricated foot orthoses, manual therapy, movement/running retraining, or taping decided on and tailored to a patient's needs and preferences.

Conclusion A best practice guide based on a synthesis of three data streams recommends that exercise therapy and education be delivered as the primary intervention for people with PFP. Prescription of other supporting interventions should be aligned with the individual patient's particular presentation following a thorough assessment.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Existing consensus supports the effectiveness of exercise therapy in the management of people with patellofemoral pain, alongside specific adjunctive treatments (eg, prefabricated foot orthoses).
⇒ Best practice recommendations for patellofemoral pain based on evidence synthesis in combination with patient and clinician preferences are absent.

WHAT THIS STUDY ADDS

⇒ This study adds insight into the application of a specific best practice guide for people with patellofemoral pain by synthesising multiple data streams including data from randomised controlled trials and interviews with patients and clinical experts.
⇒ Best practice for patellofemoral pain should include delivering knee-targeted exercise therapy, with supportive interventions as required.
⇒ Education should underpin all interventions, adjusted to reflect the needs of the person.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides a clinical framework for the application of evidence into practice when treating people with patellofemoral pain.
⇒ Key evidence gaps to be addressed by future high-quality research are also highlighted.

INTRODUCTION

People with patellofemoral pain (PFP) typically report gradual onset diffuse retropatellar and/or peripatellar pain during activities such as squatting, stair ambulation and running.[1] It is common in both adolescents and adults[2] and has a poor prognosis, with over 50% of people reporting persistent pain more than 5 years post-diagnosis despite receiving treatment.[3] People with PFP are six times more likely to be anxious or depressed,[4] are on average less physically active,[5] and have poorer health-related quality of life[6] than their asymptomatic peers. PFP is thought to be a precursor to patellofemoral osteoarthritis,[7 8] making a greater understanding of optimal management essential. Best practice guides (BPGs) that synthesise high-quality trial findings with patient and expert perspectives are essential to guide clinicians on how to apply the evolving yet incomplete evidence base.[9 10]

We produced the original BPG for PFP in 2015 by synthesising a systematic review of reviews with qualitative analysis of expert clinical reasoning.[11] Combined interventions including hip-targeted and knee-targeted exercise, taping/bracing, and prefabricated foot orthoses were advocated by both

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meta-analysis and expert opinion, with patient education and acupuncture/dry needling advocated by expert opinion only. This mixed-methods study was innovative at the time but is limited by the inclusion of only physiotherapy experts despite people with PFP encountering numerous healthcare professionals who offer a broad range of treatment options. There is also a need to include patients' perspectives in BPGs,[10 12] and many new trials have been published since the evidence synthesis was completed in 2013. Further syntheses of evidence surrounding the diagnosis and management of PFP have been published in the format of consensus[13 14] and clinical practice guidelines.[15] In all instances, clear indications for evidence-informed interventions have been presented but guides to clinically reasoned implementation are absent. Such guidelines score poorly on quality checklists, particularly in relation to the applicability domain of the Appraisal of Guidelines for Research and Evaluation (AGREE) II instrument.[12 16]

Qualitative exploration involving people with PFP to date has predominately centred on the lived experience of having PFP,[17 18] with limited consideration to treatment expectations and experiences, which could inform subsequent healthcare provision.[19 20] We aimed to produce a contemporary BPG for PFP by conducting a convergent segregated synthesis of a systematic review with meta-analysis of empirical data, qualitative analysis of the patient voice, and experts' clinical reasoning.

METHODS

Preregistration

We conducted a convergent segregated synthesis,[21] which involved analysing and synthesising a previously published systematic review with meta-analysis[22] and semistructured interviews of patients[23] and clinicians.[24] The topic guides for our semi-structured interviews were not influenced by our meta-analysis outcomes. We also collected de novo qualitative data through a series of clinician focus groups, conducted using a topic guide developed using our initial synthesis. We registered our systematic review and meta-analysis component with PROSPERO a priori (CRD42019152252) and conducted it in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement.[25] We collected and reported qualitative data in accordance with the Standards for Reporting Qualitative Research.[26] We used the AGREE II criteria[12] to direct the formulation and presentation of the final BPG.

Equality, diversity, and inclusion statement

We acknowledge that our author team is biased towards the male gender and is from a single country (UK) but is diverse in terms of varied academic career stages (research assistant through to professor). Three authors are physiotherapists, and one is a medical doctor. Our patient participants were balanced across the male/female genders but again are predominantly from the UK. Our clinician participants were diverse with respect to their clinical backgrounds, country of practice, and level of experience.

Patient and public involvement

People with PFP attended a face-to-face patient and public involvement event at Queen Mary University of London where our methods were presented and discussed. Attendees were in support of our methods and had the anticipation a BPG would lead to improved clinical care.

Systematic review and meta-analysis component

These methods and results are published and described in detail elsewhere,[22] with no updates being undertaken ahead of this best practice synthesis. We used the following search terms composed of keywords only with no MeSH terms, duplicated from Barton *et al*[11]: (patell* OR femoropat* OR anterior knee pain) AND (pain OR syndrome OR dysfunction) AND (clinical trial OR controlled trial OR random*). We searched MEDLINE, Web of Science, and Scopus from inception to May 2022, with the English language and human participants as limitations and conducted a citing reference search in Google Scholar. We used the following eligibility criteria, again from Barton *et al*[11]: (1) randomised controlled trials (RCTs) involving participants with PFP and (2) RCTs investigating non-surgical interventions. Two independent authors (BSN and CB) applied the PEDro scale[27] to all identified RCTs to determine methodological quality, with consensus scores of >7 reflecting high quality.[28] These trials were retained for data synthesis.

We applied the Cochrane risk of bias tool (RoB2)[29] to retained trials and classified the bias risk as being high, of some concern, or low. Follow-up length was defined from the commencement of treatment as short (<3 months), medium (>3 but <12 months) and long term (>12 months).[30] We pooled data and conducted meta-analyses where studies were methodologically homogeneous, and treatment modalities comparable, using a random effects model.[31] Continuous data for both pain and function (eg, numerical pain rating scale or Kujala scale) were used to calculate standardised mean differences (SMDs) with 95% CIs, interpreted as small (≤0.59), medium (0.60–1.19), and large (≥1.20).[32] Where studies did not report appropriate continuous data, nominal data (eg, global rating of change scale) were instead used to calculate odds ratios (ORs) with 95% CIs, interpreted as small (1.0–1.99), medium (2.0–4.99), and large (≥5.0).[33] Data from single inadequately powered RCTs or pooled data failing to achieve adequate power (n<22 per arm, calculated using the minimum detectable change score of 2 points for a Numerical Pain Rating Scale and 10 points for the Kujala scale[13] with $\alpha=5\%$, $\beta=0.90$) were considered inadequately tested. Interventions or combinations of interventions were determined to have primary or secondary efficacy, superiority, equivalence, no-additional benefit, or non-efficacy based on predetermined criteria.[22] We determined the certainty of evidence for each outcome to be high, moderate, low or very low using the Grading of Recommendations Assessment, Development, an Evaluation (GRADE) approach.[34]

Semistructured interviews

These methods are published and described in the respective substudy publications.[23 24] We recruited people with PFP who had had insidious onset symptoms and at least one episode of care in the past 6 months to explore their experiences of their diagnosis and treatment; and clinical academic experts with a minimum of 5 years' experience in treating people with PFP and a direct involvement in research to explore their clinical reasoning when diagnosing and managing PFP. These participants took part in online semistructured interviews that were conducted using separate topic guides (see online supplemental files 1 and 2). Data were analysed by moving backwards and forwards through the Braun and Clarke six-phase model of thematic analysis.[35]

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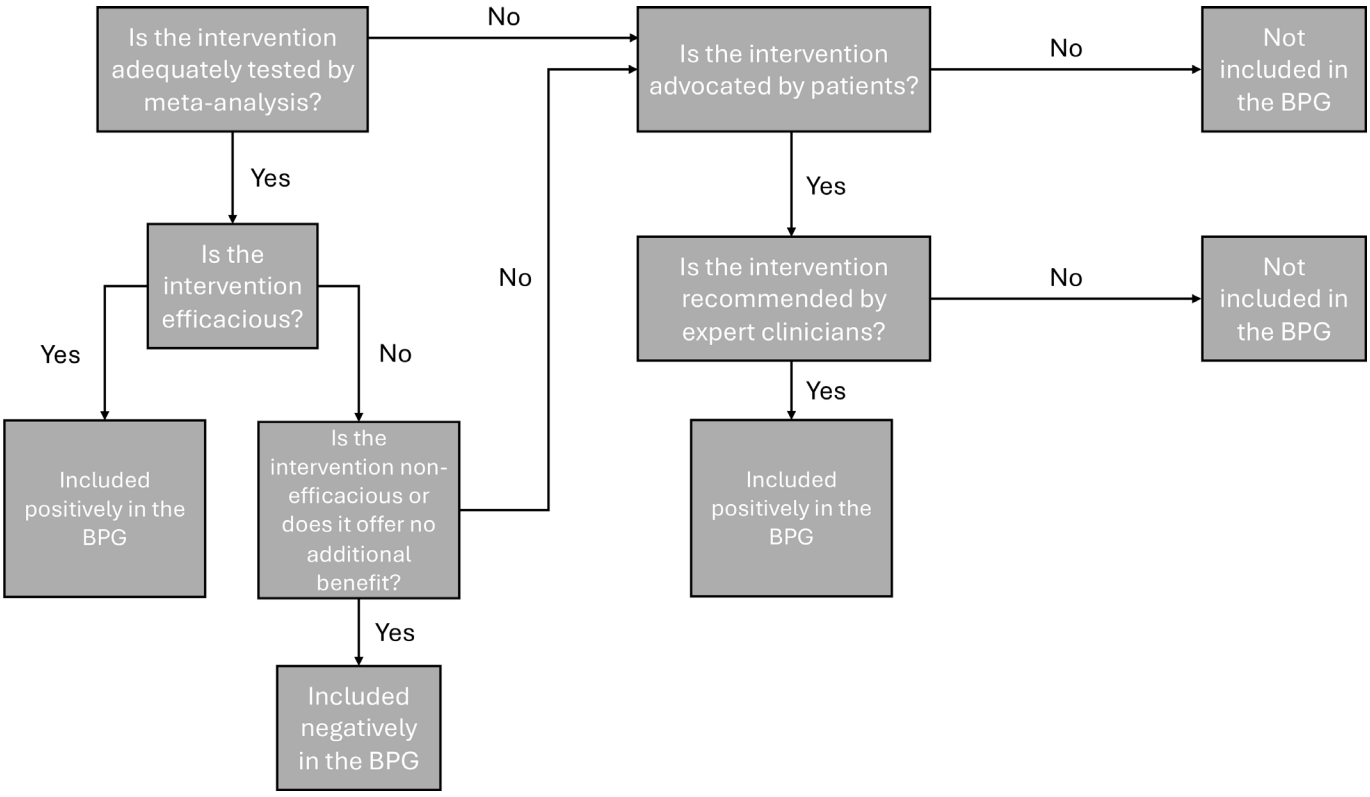

Figure 1 Decision flow chart for intervention synthesis. BPG, best practice guide.

Focus groups

Three de novo online, 90 min focus groups containing a minimum of two clinical experts were conducted by a single investigator (DM) in February 2023. Results from these focus groups have not been published separately. These focus groups aimed to provide further clinical insight into the decision-making of how, when, why, and in whom, interventions included in our best practice synthesis should/could be delivered. Participants were presented with a preliminary synthesis of our quantitative systematic review and qualitative findings, and an interactive graph plotting a series of differing patient journeys, to facilitate discussion (see online supplemental file 3). Focus groups were recorded and transcribed using Microsoft Teams (Microsoft Office 365, Redmond, Washington, USA) and analysed by moving backwards and forwards through the Braun and Clarke six-phase model of thematic analysis.[35]

Data were coded by a single author (SL), which involved theme development, naming, and refinement after reading transcriptions multiple times. A second investigator (DM), who facilitated the focus groups, independently verified the codes and themes against the transcripts and notes taken during the focus groups.

Intervention synthesis

We conducted a convergent segregated synthesis,[21] analysing and synthesising a previously published systematic review with meta-analysis[22] and semistructured interviews of patients[23] and clinicians[24] (see figure 1). Interventions were considered for inclusion if they were adequately tested by meta-analysis and shown to be efficacious (ie, had a significant SMD). Interventions were also considered for inclusion if they were not adequately tested by meta-analysis (ie, no SMD could be calculated) but were both advocated by patients and recommended by expert clinicians (ie, not if they were only advocated by patients or recommended by clinicians). Interventions adequately tested by meta-analysis and identified to be non-efficacious or offer no additional benefit were categorised as inappropriate for people with PFP outside a clinical trial setting.

We used the following questions adapted from mixed-methods guidance produced by Stern *et al*,[21] to guide our synthesis:

1. Are the results from the systematic review with meta-analysis and semistructured interviews supportive or contradictory?
2. Does the semistructured interview data provide insight into how and when interventions should be delivered?
3. Which aspects of the systematic review with meta-analysis are or are not explored in the semistructured interview data?
4. Which aspects of the semistructured interview data are or are not explored in the systematic review with meta-analysis?

We subsequently applied a ranking system to arrive at a strength of clinical recommendation (very high; high; moderate; low; very low). The highest certainty of evidence derived from a systematic review with meta-analysis was the starting point for interventions adequately tested by meta-analysis. Interventions that were inadequately tested by meta-analysis, therefore, having no certainty of evidence, started with no strength of clinical recommendation. The strength of clinical recommendation was elevated by one category where there was both patient advocacy and expert clinician recommendation and elevated by a further category where there was a clear approach to application from our expert clinician focus groups. All strengths of clinical recommendations were made through a process of consensus involving three authors (BSN, SL, and DM).

Construction of the BPG

All four data sources (ie, systematic review with meta-analysis, patient and expert clinician semistructured interviews and expert clinician focus groups) informed the construction of the BPG for people with PFP. Guided by the outputs of our expert clinician focus groups and supplemented by the outputs from our patient

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semistructured interviews, we iteratively aligned the content and themes to the existing paradigms of an initial clinical assessment. This included information to be extracted using both subjective questions and objective testing to inform the delivery of the interventions identified by our intervention synthesis. Illustrative quotes were used to ensure and demonstrate rigour.[36]

RESULTS

Summary of systematic review results

The original meta-analysis results are published elsewhere.[22] In brief, our systematic search identified 5740 titles and abstracts for screening, with 170 RCTs eligible for quality appraisal after removing duplicates and adding 30 eligible studies via cited reference searching. We retained 65 high-quality RCTs that led to 11 adequately tested interventions or a combination of interventions at short-term follow-up, with no high-quality RCTs adequately testing any intervention beyond this time point. Four interventions demonstrated primary efficacy compared with wait-and-see, placebo, or sham controls: (1) knee-targeted exercise therapy; (2) the combination of hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching, and McConnell-style patellar taping; (3) prefabricated foot orthoses and (4) lower quadrant manual therapy. Two interventions demonstrated secondary efficacy compared with knee-targeted exercise therapy: (1) hip-and-knee-targeted exercise therapy and (2) knee-targeted exercise therapy combined with perineural dextrose injection. Three interventions demonstrated no additional benefit when combined with efficacious interventions: (1) prefabricated foot orthoses when combined with hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching and patellar taping; and both (2) dry needling and (3) vibration therapy when combined with to hip-and-knee-targeted exercise therapy. Two interventions demonstrated non-efficacy: (1) hip-and-knee-targeted exercise therapy combined with hyaluronic acid injection (compared with hip-and-knee-targeted exercise therapy combined with sham saline injection) and (2) dry needling (compared with sham needling).

Summary of patient semistructured interviews

The original qualitative patient results are published in detail elsewhere.[23] In brief, we interviewed 12 international people with PFP (7 women, 5 men, mean age in years 26.5±4.7, mean symptom duration in months 43.3±42.3) from England (n=8), Europe (n=1) and North America (n=3). These semistructured interviews led to three themes: the value of diagnosis; the need for tailored care; and the role of education.

Summary of expert clinician semistructured interviews

The original qualitative clinician results are published in detail elsewhere.[24] In brief, we interviewed 19 international (UK=13; USA=2; Australia=1; India=1; Canada=1; the Netherlands=1), multidisciplinary clinical experts (one athletic trainer, one general practitioner, one sports physician, three orthopaedic surgeons, four podiatrists, and nine physiotherapists; mean years of experience 18.6±8.6). These semistructured interviews led to four themes: assessment and diagnosis of PFP; information provision; active rehabilitation; and treatment adjuncts.

Summary of expert clinician focus groups

We conducted three semistructured focus groups involving nine international (UK=4; USA=2; Australia=1; the Netherlands=1; Brazil=1), multidisciplinary clinical experts (two athletic trainers, one general practitioner, one sports physician, two podiatrists, and three physiotherapists; mean years of experience 22.1±9.3). Five of these clinical experts also participated in the prior semistructured interviews. These focus groups led to four themes: goal-orientated intervention choice; education as an intervention; deficit-driven intervention choice; and population-specific considerations. An initial BPG draft and the accompanying figure were sent to all focus group participants for triangulation. Two participants were satisfied this was an appropriate representation of their focus group and provided no further comments. Three participants provided minor suggestions for amendment that were integrated into our finalised BPG.

Intervention synthesis

13 interventions were included in total. Six interventions or combinations of interventions were included after being adequately tested by meta-analysis and determined to be efficacious. Two interventions were included after being inadequately tested by meta-analysis but advocated by patients and recommended by expert clinicians. Five interventions were adequately tested by meta-analysis and determined to be non-efficacious or offer no additional benefit and were considered inappropriate outside a clinical trial setting. A summary of our intervention synthesis is provided in table 1.

Meta-analysis identified high certainty evidence for knee-targeted exercise therapy in relation to short-term pain reduction (SMD 1.16, 95% CI 0.66, 1.66) and moderate certainty evidence in relation to short-term function improvement (SMD 1.19, 95% CI 0.51, 1.88). This intervention was advocated by patients and recommended by experts:

> Strengthening my quads, how that can help overnight, quite literally (Patient D)
> We will progressively reload the quadriceps in an open and closed chain way
> (Expert 13)

Meta-analysis identified very low certainty evidence for hip-and-knee-targeted exercise therapy in relation to short-term pain reduction (SMD 1.02, 95% CI 0.58, 1.46) and low certainty of evidence for short-term function improvement (SMD 1.03, 95% CI 0.61, 1.45). This intervention was advocated by patients and recommended by experts:

> …best thing to do to fix it is just to strengthen up the whole leg so that when you when you are running or moving, you're going to put less pressure on that joint… (Patient B)
> Would say that quadriceps and hip strengthening … best practice for the treatment of patellofemoral pain (Expert 16)

Meta-analysis identified low certainty evidence for prefabricated foot orthoses in relation to positive short-term outcome using the global rating of change scale (OR 4.31, 95% CI 1.48, 12.56). This intervention was advocated by patients and recommended by experts:

> I got insoles, like special insoles for them to, to help with the foot thing. And yeah, that's help(ed) as well (Patient J)
> Then I might go straight to the (prefabricated) foot orthoses a passive intervention that we can stick in. And the only compliance that relies on is them (is) that they're actually wearing something getting comfortable enough. That's an instant treatment (Expert 15)

Meta-analysis identified moderate certainty evidence for lower quadrant manual therapy in relation to short-term function improvement (SMD 2.30, 95% CI 1.60, 3.00). Meta-analysis identified moderate certainty evidence that lower quadrant

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Table 1 Intervention synthesis

Intervention	Certainty of evidence from SR/MA	Size of effect	Patient voice	Clinical experts	Application clear in focus groups	Strength of clinical recommendation
Knee-targeted exercise therapy*	Pain: High Function: Moderate	Pain: Medium Function: Medium	A	R	Y	Very high
Hip-and-knee-targeted exercise therapy†	Pain: Very low Function: Low	Pain: Medium Function: Medium	A	R	Y	High
Foot orthoses*	Outcome: Low	Outcome: Medium	A	R	Y	High
Lower quadrant manual therapy*	Pain: Absent Function: Moderate	Pain: Absent Function: Large	ND	ND	N	Moderate
Knee-targeted exercise therapy combined with perineural dextrose injection†	Pain: Moderate Function: Moderate	Large	ND	ND	N	Moderate
Movement/running retraining	IT	Absent	A	R	Y	Low
Taping	IT	Absent	A	R	Y	Low
Combined interventions*‡	Pain: Very low Function: Very low	Pain: Medium Function: Medium	ND	ND	N	Very low
Dry needling+hip-and-knee-targeted exercise therapy	Moderate	Absent	ND	ND	N/A	N/A
Combined interventions and foot orthoses	Very low	Absent	ND	ND	N/A	N/A
Dry needling	Very low	Absent	ND	ND	N/A	N/A
Vibration therapy+hip-and-knee-targeted exercise therapy	Very low	Absent	ND	ND	N/A	N/A
HA injection & hip-and-knee-targeted exercise therapy	Very low	Absent	NA	ND	N/A	N/A

Green and red colouring reflects (in order) interventions with a positive clinical recommendation and interventions inappropriate outside of a clinical trial setting.
*Primary efficacy.
†Secondary efficacy.
‡The combination of hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching and patellar taping.
A, advocated; HA, hyaluronic acid; IT, inadequately tested by meta-analysis; N, no; NA, not advocated; N/A, not applicable; ND, not described; R, recommended; SR/MA, systematic review with meta-analysis; Y, yes.

manual therapy had no significant effect on short-term pain reduction (SMD 2.19, 95% CI −1.02, 5.41). This intervention was not discussed by patients or experts.

Meta-analysis identified moderate certainty evidence for hip-and-knee-targeted exercise therapy combined with perineural dextrose injection in relation to short-term pain reduction (SMD 1.34, 95% CI 0.72, 1.95) and function improvement (SMD 1.12, 95% CI 0.60, 1.82). This intervention was not discussed by patients or experts.

Movement/running retraining was inadequately tested by meta-analysis but was advocated by patients and recommended by experts:

> The step is much lighter on the ground and then not that much impact. So, I'm noticing changes kind of in the way that I'm running and that's helping to decrease the pain (Patient L)
> The interventions, in particular are engaging that I use would be usually just either increasing cadence or increasing step width and I think there is some evidence behind both of those (Expert 6)

Taping was inadequately tested by meta-analysis, but it was advocated by patients and recommended by experts:

> And I found that using tape is actually quite helpful (Patient L)
> So, evidence kind of tends to support taping and bracing help to short term with pain. So, I would use them as an adjunct to allow the person to do some physical activity (Expert 5)

Meta-analysis indicated very low certainty evidence the specific combination of hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching and patellar taping in relation to short-term pain reduction (SMD 0.79, 95% CI 0.26, 1.29) and function improvement (SMD 0.98, 95% CI 0.47, 1.49). This intervention was not discussed by patients or experts.

Inappropriate interventions for managing people with PFP outside of a clinical trial

Meta-analysis indicated very low certainty evidence of no additional benefit for prefabricated foot orthoses combined with hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching and patellar taping in relation to a positive short-term outcome (OR 0.75, 95% CI 0.16, 3.58). This intervention was not discussed by either patients or experts.

Meta-analysis indicated low certainty evidence of non-efficacy for dry needling in relation to short-term pain reduction (SMD −0.19, 95% CI −0.73, 0.35) and function improvement (SMD 0.02, 95% CI −0.51, 0.55). This intervention was not discussed by either patients or experts.

Meta-analysis indicated very low certainty evidence of no additional benefit for vibration therapy combined with hip-and-knee-targeted exercise therapy in relation to a short-term pain reduction (SMD −0.07, 95% CI −0.42, 0.28) and function improvement (SMD 0.76, 95% CI −0.85, 2.37). This intervention was not discussed by either patients or experts.

Meta-analysis indicated low certainty evidence of no additional benefit for dry needling when combined with hip-and-knee-targeted exercise therapy in relation to a short-term pain reduction (SMD −0.95, 95% CI −2.68, 0.78), and moderate certainty evidence for function improvement (SMD −1.26, 95% CI −3.38, 0.85). This intervention was not discussed by either patients or experts.

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Figure 2 How to apply the BPG for PFP. BPG, best practice guide; PFP, patellofemoral pain.

Meta-analysis indicated very low certainty evidence of non-efficacy for hyaluronic acid injection combined with hip-and-knee-targeted exercise therapy in relation to short-term pain reduction (SMD −0.21, 95% CI −0.64, 0.21)), and low certainty evidence in relation to function improvement (SMD −0.57, 95% CI −1.00 to −0.13). This intervention was not described by either patients or experts and is, therefore, a priority for knowledge translation.

How to apply the BPG for people with PFP

Best practice for people with PFP should be guided by the framework (see figure 2) as part of the usual clinical assessment that emphasises **understanding** the person and their history, **subjectively establishing** key tenets of their lived experience, **objectively evaluating** characteristics that guide treatment selection, **delivering** knee-targeted exercise therapy and education and **deciding** if supporting interventions are required.

Understanding the background of the person includes determining if they are from a relevant population and any subsequent influence on their PJF demand (eg, in-season athlete), the impact of their symptoms on their life (eg, unable to work, unable to partake in hobbies/sports) and their symptom history/pattern, details relating to their previous episodes of care, and where they are on the continuum of structural joint health (ie, PFP vs early onset patellofemoral joint (PFJ) osteoarthritis).

> I (try) to classify them between athletic population and sedentary population because in this group, we have those two types of profiles, I think, the very athletic and sporty and the other ones that (do) no movement at all (Expert focus group 2)

Seek to understand what the patient believes to be the cause(s) of their PFP (ie, aetiology) and their symptom severity/duration and pattern (eg, 24-hour pain behaviour) to gain insight into their predominant pain mechanism.

> How long has the patient had this? How bad is it? What stage is (it) at? That would guide my decision making significantly based on tolerance and getting buy in (Expert focus group 3)

Subjectively establish why the person has sought care and what factors are having the greatest influence over their symptom presence and persistence. For different people, the goals of treatment will vary and are an essential component of shared decision-making.

> So, it's kind of individualising patient care … everyone copes and reacts differently (Patient L)

Clinicians should establish the priorities and goals of the person (eg, climbing stairs or running 5 km) and treatment should target the components required to achieve these goals, such as reducing pain and/or fear of movement, managing expectations of their outcome relative to their presentation, increasing self-efficacy, or building PFJ resilience (increasing tissue or neurological tolerance to load).

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> We identify their needs and (their) current status and we build a map with signposts on it to get them from one end to the other (Expert focus group 1)
> Goal setting completely influences everything here … all these individual factors, are you able to address (or) account for these? (Expert focus group 1)

Objectively evaluate physical impairments may influence treatment selection and include factors such as muscle strength (hip and knee), movement pattern(s) of the lower extremity (eg, observation of a single leg squat), tissue tolerance to load (eg, pain provocation tests or presence of effusion) and PFJ structure/function specific to the person (eg, patella alta, hypermobility), and the contextual factors related to their symptoms (eg, fear avoidance during functional tasks reflected by an antalgic gait or hesitance/refusal to perform certain tasks).

> A lot of it comes down to (what) are the impairments or what are they showing as problematic during the initial evaluation … if they are presenting with weakness, either quadriceps or hip muscles, that is my first step to try to intervene (Expert focus group 3)

Deliver knee-targeted exercise therapy and **decide** whether hip-and-knee targeted exercise therapy is required. Exercise therapy should be prescribed relative to specific severity and irritability, with a greater focus on hip exercises in people with poor tolerance to loaded knee flexion, with task/load/intensity/frequency modified as required.

> I think there's good evidence now that we know hip and knee strengthening improves patellofemoral pain outcomes (Expert 6)

Education should underpin any/all interventions, adjusted to reflect the needs of the person. Education may seek to challenge inaccurate beliefs, build confidence and understanding of the diagnosis, explore the concept of pain not correlating with damage (particularly when symptoms have persisted for longer durations), develop insight into the recovery journey and expected timeframes, aid in managing load(s), or promote autonomy and reduce fear.

> Education, I feel like is done inherently, in every one of the interventions that we use. (Expert focus group 2)

Decide on supporting approaches to deliver exercise successfully based on subjective and objective findings.

> I might offer something with less therapeutic value (weaker evidence base) just to get buy in (Expert focus group 3)

Prefabricated foot orthoses should be prescribed to those who respond favourably to treatment direction tests and be customised for comfort by modifying density and geometry.

> The evidence for (prefabricated) foot orthoses is that they are most beneficial in the short term … you don't necessarily need them in the long term, but they can help change function and you can do a test to get someone to squat with them/ without them and see if it makes a difference (Expert 14)

Movement/running retraining can be considered in those with symptoms reasoned to be associated with assessment findings aligning with the intervention (eg, a runner with a low cadence receiving an intervention to increase cadence).

> But the interventions in particular that I use would be just either increasing cadence or increasing step width and I think there is some evidence behind both (Expert 6)

Taping should be considered for people where rehabilitation is hindered by elevated symptom severity and irritability. If favourable outcomes are not observed after a realistic period, clinicians should revisit the assessment findings that their intervention(s) are aiming to address, review engagement and/or ensure that intervention(s) align well with symptom severity and irritability.

> Taping would be something that you might make a decision (on) based on other factors, such as where they are in their season (Expert focus group 1)

No clear guidance on the application of (1) lower quadrant manual therapy, (2) the specific combination of hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching and patellar taping or (3) perineural dextrose injection combined with hip-and-knee-targeted exercise therapy, could be derived from either our semistructured interviews or focus groups.

DISCUSSION

We have synthesised a systematic review with meta-analysis of high-quality RCTs and thematic analysis of the patient voice and expert clinical reasoning to produce an updated BPG for people with PFP that can be implemented in clinical practice. Knee-targeted exercise therapy and underpinning education should be delivered to people with PFP alongside reasoned supporting approaches. Hip-and-knee-targeted exercise therapy, prefabricated foot orthoses, manual therapy, movement/running retraining, taping and combinations of interventions, should be used to support the delivery of knee-targeted exercise therapy. Intervention reasoning should be guided by specific variables identified through a thorough subjective and objective assessment.

Support for knee- and hip-and-knee-targeted exercise therapy aligns well with existing consensus statements[14] and clinical practice guidelines.[15] We identified stronger support for knee-targeted exercise therapy in isolation, compared with the preference for hip-and-knee-targeted exercise therapy reported in the current literature,[14 15] likely to be explained by our inclusion of qualitative findings. The strength of this narrative in our qualitative findings from both patient and expert clinician perspectives indicates the successful translation of this knowledge into practice, and our results indicate that this should continue.

In agreement with existing consensus statements[14] and clinical practice guidelines,[15] we identified primary efficacy for individually modified prefabricated foot orthoses, with both patients and expert clinicians advocating their use. Despite the primary efficacy of prefabricated foot orthoses, physiotherapists in Australia and Canada were recently reported to lack confidence in prescribing them,[37] and they were not one of the top five treatments for people with PFP in a survey of practising physiotherapists in the UK,[38] highlighting a possible knowledge translation gap. Clinicians are encouraged to seek appropriate training to develop competency or establish referral pathways to colleagues competent in prefabricated foot orthoses prescription.

Lower quadrant manual therapy demonstrated efficacy via meta-analysis but was not discussed by people with PFP or clinical experts. This could reflect the speed at which published evidence is changing, with isolated manual therapy not supported by the most recent PFP consensus,[13] conflicting with our findings. Future research seeking to identify a mechanism of action for manual therapy in people with PFP would further aid clinical implementation. Movement/running retraining, taping and education were all advocated by people with PFP and clinical experts despite being inadequately tested and therefore ineligible for meta-analysis. The specific combinations of injected perineural dextrose with knee-targeted exercise therapy and hip-and-knee-targeted exercise therapy, vastus medialis

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oblique biofeedback, soft tissue stretching and patellar taping are supported solely by meta-analysis and were not discussed by people with PFP or clinical experts. This absence of agreement between streams may be explained by our decision to conduct a convergent segregated synthesis; meaning that our meta-analysis outcomes did not contribute to our semistructured interview topic guide.

A recent mediation analysis of a stratified RCT in which one arm received solely hip-targeted exercise therapy identified that increasing hip strength did not mediate short-term pain reduction.[39] This indicates that the short-term efficacy established for hip-and-knee-targeted exercise therapy may not be underpinned by a mechanism involving changes in hip strength. Quadriceps weakness has an established prospective association with PFP development,[40] and a breadth of cross-sectional literature reports quadriceps weakness in people with PFP.[41] Future RCTs should investigate if baseline quadriceps strength, or an increase in quadriceps strength, is a predictor or mediator of response following hip-and-knee-targeted exercise therapy. The clinical methods for individualised prescriptions recommended as part of this BPG are a key target for future prospective research. This could include consideration of multiple precision medicine covariates—such as genetic, psychosocial, biomechanical, and other factors as explanatory variables—in understanding how best to predict and optimise the outcome of interventions for people with PFP.

Interventions inappropriate outside of a clinical trial setting

The specific combination of (1) hip-and-knee-targeted exercise therapy, vastus medialis oblique biofeedback, soft tissue stretching, McConnell-style patellar taping and prefabricated foot orthoses; (2) dry needling in isolation; (3) vibration therapy; (4) dry needling and (5) hyaluronic acid injection (3–5 when combined with hip-and-knee-targeted exercise therapy) were all categorised as being inappropriate interventions or combinations of interventions for people with PFP outside of a clinical trial setting. An effort should be made to translate this message to avoid time and resources being wasted on these non-efficacious and unsupported interventions in routine clinical care, though it may be that the patients and clinical experts in our studies did not describe these interventions as they know they are ineffective. In the case of hip-and-knee-targeted exercise therapy combined with either dry needling or hyaluronic acid injections, researchers should think carefully before conducting future trials involving these interventions given the moderate certainty of non-efficacy and absence of patient advocacy, respectively.

Application of best practice for people with PFP

Best practice for PFP should commence by understanding the person; establishing the population they derive from (eg, recreational runner, sedentary worker), their aetiology (eg, symptoms commencing after an increase in exercise frequency), and how these influence the demands on their PFJ. Clinicians should then structure their subjective questions to determine symptom severity and duration to gain insight into the predominant pain pathway. This may be primary nociceptive but could be centrally mediated or nociplastic when severity is high, and/or duration is prolonged. Clinicians should understand how symptoms impact a person's life, their symptom history/pattern, their previous episodes of care, and where they are on the continuum of structural joint health. Discuss why a person has sought care and the factors influencing their symptom presence (eg, aggravating factors) and persistence (eg, absence of behaviour change following symptom aggravation) to establish priorities and goals; an essential component of shared decision-making. Clinicians should use their clinical reasoning to explore the degree to which key features are influencing a person's presentation. This should include levels of pain (eg, 'I can't tolerate my current level of knee pain') and fear of movement (eg, 'I avoid squatting because I am afraid it will hurt'), expectations of their knee relative to their presentation (eg, 'I can only run 5km without pain right now, but I've entered a marathon in six weeks'), levels of self-efficacy relating to symptoms (eg, 'I don't have the confidence to climb stairs anymore, so I take the lift'), and perceived PFJ resilience ('Every time I squat, my knee hurts').

An objective evaluation should be used to explore how these subjective features manifest themselves functionally (eg, fear avoidance during functional tasks). Objective evaluation should then continue to identify key impairments that can influence treatment selection. This should include hip and knee strength (eg, using hand-held dynamometry), movement patterns and foot biomechanics (eg, through observation of a single leg squat or treadmill running), tissue tolerance to load (eg, pain provocation tests or presence of effusion), and PFJ structure/function (eg, patella alta or hypermobility). After this assessment process, clinicians should have an individualised and nuanced list of characteristics to embed into their existing clinical reasoning framework(s) and inform their treatment decisions.

Individualised knee-targeted exercise therapy (±hip) should be delivered following a robust assessment of symptom severity and irritability, with exercise parameters modified accordingly. For example, knee-targeted exercise therapy can be prescribed in the presence of quadriceps atrophy with a person who also demonstrates tolerance to loaded knee flexion, whereas a greater focus on hip exercises may initially be required in a person with poor tolerance to loaded knee flexion. Education should underpin all interventions, providing a rationale for the delivery of a specific intervention plan. Education can also be used to build confidence and understanding of the diagnosis, explore the concept of pain not correlating with tissue damage, develop insight into the recovery journey and expected time frames, and promote autonomy/reduce fear. Supporting approaches should be decided on as adjuncts to successful exercise delivery. Prefabricated foot orthoses should be prescribed when people respond favourably to treatment direction tests (eg, symptom improvement during a functional task with orthoses in situ) and be customised for comfort by modifying density and geometry. Taping and manual therapy should be considered when rehabilitation and/or quality of life is hindered by elevated symptom severity and irritability, or high fear of movement. Movement/running retraining should be considered when symptoms are reasoned to be associated with task-specific biomechanics (eg, increasing step rate in a runner with excessive stride length). If favourable outcomes are not observed after a realistic period (minimum 6 weeks), clinicians should revisit assessment findings to ensure that intervention(s) align well with their initial line of reasoning, and/or review patient engagement.

Limitations and strengths

Our systematic search terms were composed of keywords only with no MeSH terms, but we are confident that we did not fail to identify any appropriate high-quality RCTs. We conducted a convergent segregated synthesis, as we thought it imperative for our systematic review with meta-analysis to not influence the outcomes of our semistructured interviews. Conducting a convergent integrated synthesis (where quantitative and

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qualitative data are combined from the outset) may have led to different outcomes. Consistent with our decision to conduct a convergent segregated synthesis, the search for our systematic review with meta-analysis component included RCTs up to May 2022, after which point this component was published, and data from RCTs completed after this date may also have led to different outcomes.

It is important to consider that RCTs labelled as 'knee-targeted' included exercises engaging the hip musculature (eg, a squat), just as exercises labelled as 'hip-targeted' will engage the knee musculature (eg, banded side steps). We considered methodological homogeneity when pooling data as either knee-targeted or hip-and-knee-targeted by considering the description of the trial aim and the joint with the greatest excursion (eg, leg press=knee). Pooling data in a different manner may have led to a different strength of clinical recommendation for exercise therapy. We conducted additional focus groups with clinical experts to gain further direction on how to implement our intervention synthesis. Additional focus groups involving people with PFP were not conducted as we felt our initial semistructured interviews had already met this implementation aim.

To the best of our knowledge, this is the first clinical practice guide for people with PFP that has synthesised quantitative systematic review/meta-analysis data with qualitative findings from both the patient voice and expert clinical reasoning. We are confident that the assessment and treatment approach developed by our synthesis contains the best available evidence on what should be done in clinical practice and how it should be implemented. We recognise that clinicians adopting this framework in practice need to use their clinical judgement to determine how much a specific factor is influencing a patient's overall presentation. Clinicians need to be aware that not all recommendations include level 1 evidence from multiple RCTs, nor do all recommendations have support from all three aspects of data collection, so note should be taken of the varying strength of recommendations. Testing the implementation and clinical effectiveness of this BPG framework should be a priority for future research. Our methods should also provide an approach for the development of further BPGs in the musculoskeletal field.

CONCLUSION

A BPG has been formulated that is suitable to guide clinicians to apply evidence-based practice informed by patient experience and expert clinical reasoning. This was based on a synthesis of robust findings from three data streams and resulted in a clear recommendation that exercise therapy and education should be included as the primary intervention for people with PFP. They may be offered further supporting interventions, with the prescription aligned with the individual patient's particular presentation following a thorough assessment.

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