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The 'Best Practice Guide to Conservative Management of Patellofemoral Pain': incorporating level 1 evidence with expert clinical reasoning

Christian John Barton,^{1,2,3,4} Simon Lack,¹ Steph Hemmings,¹ Saad Tufail,¹ Dylan Morrissey^{1,5}

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¹Centre for Sport and Exercise Medicine, Queen Mary University of London, London, UK

²Complete Sports Care, Melbourne, Australia

³Pure Sports Medicine, London, UK

⁴Lower Extremity Gait Studies, La Trobe University, Melbourne, Australia

⁵Physiotherapy Department, Bart's Health NHS Trust, London, UK

Correspondence to

Dr Dylan Morrissey, Centre for Sports and Exercise Medicine, William Harvey Research Institute, Bart's and the London School of Medicine and Dentistry, Queen Mary University of London, Mile End Hospital, Bancroft road, London E1 4DG, UK; d.morrissey@qmul.ac.uk twitter @DrDylanM

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ABSTRACT

Importance Patellofemoral pain (PFP) is both chronic and prevalent; it has complex aetiology and many conservative treatment options.

Objective Develop a comprehensive contemporary guide to conservative management of PFP outlining key considerations for clinicians to follow.

Design Mixed methods.

Methods We synthesised the findings from six *high-quality* systematic reviews to September 2013 with the opinions of 17 experts obtained via semistructured interviews. Experts had at least 5 years clinical experience with PFP as a specialist focus, were actively involved in PFP research and contributed to specialist international meetings. The interviews covered clinical reasoning, perception of current evidence and research priorities.

Results Multimodal intervention including exercise to strengthen the gluteal and quadriceps musculature, manual therapy and taping possessed the strongest evidence. Evidence also supports use of foot orthoses and acupuncture. Interview transcript analysis identified 23 themes and 58 subthemes. Four key over-arching principles to ensure effective management included—(1) PFP is a multifactorial condition requiring an individually tailored multimodal approach. (2) Immediate pain relief should be a priority to gain patient trust. (3) Patient empowerment by emphasising active over passive interventions is important. (4) Good patient education and activity modification is essential. Future research priorities include identifying risk factors, testing effective prevention, developing education strategies, evaluating the influence of psychosocial factors on treatment outcomes and how to address them, evaluating the efficacy of movement pattern retraining and improving clinicians' assessment skills to facilitate optimal individual prescription.

Conclusions and relevance Effective management of PFP requires consideration of a number of proven conservative interventions. An individually tailored multimodal intervention programme including gluteal and quadriceps strengthening, patellar taping and an emphasis on education and activity modification should be prescribed for patients with PFP. We provide a 'Best Practice Guide to Conservative Management of Patellofemoral Pain' outlining key considerations.

occupational and physical capacity often reduced.⁴ The condition affects a wide range of ages, often beginning in early adolescence.⁵ Between 71 and 91% of individuals report chronic ongoing pain up to 20 years following initial diagnosis.^{6–8} PFP may also increase the risk of developing patellofemoral osteoarthritis.⁹

Numerous biomechanical factors have been linked to PFP and these are discussed in more detail elsewhere.^{10–11} As a result, various conservative interventions have been proposed and evaluated, including education, exercise, taping, braces, foot orthoses, soft tissue manipulation and acupuncture.¹² Barton *et al*¹³ published a review of systematic reviews in 2008, which covered literature until 2007. Since 2007 a number of high-quality reviews covering conservative interventions for PFP provide greater guidance for research and clinical practice. Thus, an updated review and summary of findings from high-quality systematic reviews is warranted.

Despite high-quality systematic reviews being a source of concise and accurate information to guide evidence-based practice, limitations in relying solely on their findings must also be considered. First, published reviews often omit emerging knowledge and early research findings due to stringent inclusion and exclusion criteria. Second, such reviews often inadequately address how best to apply findings clinically thus compromising external validity. In a preliminary study exploring experienced clinicians' clinical reasoning, a perceived lack of clinical applicability of research and systematic review findings was a primary barrier inhibiting evidence translation to patient management.¹⁴ This is particularly important for clinicians who are confronted with assessing and treating markedly heterogeneous patient presentations and groups. To achieve optimal results, the clinician must additionally consider their own clinical experience and, ideally, synthesised expert guidance alongside published evidence.¹⁵ Methods are needed to garner and copresent such evidence in order to optimise evidence translation.¹⁶

This study combines findings from high-quality systematic reviews (ie, level 1 evidence) with clinical reasoning from clinicians considered as international experts in the management of PFP, similar to previously published and described methods.¹⁷ Our aim is to optimise patient outcomes, and provide a basis for reflection on practice and high-quality education through the development of a comprehensive 'Best Practice Guide to Conservative Management of Patellofemoral Pain.'



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Patellofemoral pain (PFP) has a high prevalence in general practice,¹ orthopaedic^{2–3} and sports settings. Pain is exacerbated by tasks which increase patellofemoral joint (PFJ) loading including running, squatting and stair negotiation, with

METHODS

Review of systematic reviews

Inclusion and exclusion criteria

Reviews published in any language and using an unbiased, documented and reproducible search were considered. Inclusion criteria of reviews required participants to be described as having retropatellar, peripatellar or PFP; anterior knee pain; patellar or patellofemoral dysfunction; or chondromalacia patellae. Each review was required to focus on PFP and primarily evaluate non-pharmacological interventions. Non-English papers were translated to English prior to evaluation. Non-peer reviewed publications were excluded.

Search strategy

MEDLINE, EMBASE, CINAHL and Current Contents were searched in September 2013 for systematic reviews published since May 2007 as an update from Barton *et al.*¹³ Limits were applied to limit the search to reviews. The following key terms were combined; (*patellofemoral or patella or chondromalacia*) and (*pain or dysfunction or syndrome*). Mesh headings were not used to narrow or broaden the search. In addition to the initial electronic search, reference list screening and citation tracking in Google Scholar was completed for each included review.

Review process

Titles and abstracts found during the initial electronic search were uploaded into Endnote Web (Thomson Reuters), and duplicates removed. Titles and abstracts were then screened for inclusion by two independent reviewers (CB and ST). To resolve disagreement about exclusion, a third reviewer was available. Where necessary, the full text was retrieved.

Quality assessment

A quality assessment scale specifically designed for PFP reviews¹³ was applied to each included review. Items within the scale were developed based on more generalised tools including the Oxman checklist¹⁸ and texts addressing quality expectations from systematic reviews.^{19 20} The scale is scored out of 26, containing 13 items (2 points per item) covering reporting of search methods (item 1); comprehensiveness of search strategy (items 2–5); reporting of inclusion criteria (items 6–7); avoidance of selection bias (item 8); use of quality assessment (item 9); methods used to synthesise findings (items 10–11); and appropriateness of conclusions (items 12–13). Further details of scale development, validity and reliability can be found in Barton *et al.*¹³ A score of equal to or greater than 20 was considered as high quality.¹³ Findings from high-quality systematic reviews were summarised to provide the basis for level 1 conservative management evidence definition.

Semistructured interviews

Participants

Prospective interview participants were identified from a list of attendees to the 2009 and 2011 'international patellofemoral pain retreats' in Baltimore, USA,²¹ and Ghent, Belgium,²² respectively. Suggestion of additional participants was also sought during each interview. Each participant was required to have had at least 5 years clinical experience with PFP as a specialist focus, be actively involved in PFP research and be contributing to specialist international meetings. It was felt that experts with a good blend of clinical experience and research knowledge would be able to provide the best information on the perceptions of current evidence (published and unpublished), and

its external applicability for the management for PFP. Seventeen international experts from the UK (5), USA (4), Canada (1), Belgium (1) and Australia (6) were included. There were 12 physiotherapists, 3 athletic trainers and 2 physical therapists. Further details related to participant characteristics are outlined in online supplementary file 1. Ethical approval was granted by Queen Mary Ethics of Research Committee (QMERC). Each participant provided informed consent.

Interview process

One interviewer (ST) completed and recorded all interviews, which lasted between 30 and 120 min, and were transcribed for further analysis. To limit bias during questioning as a result of clinical experience and beliefs, the interviewer had sound medical knowledge but minimal clinical experience in the musculoskeletal field. To further reduce bias, a second non-clinical medical researcher assisted in the creation of the topic guide (see box 1) and conservative management summary (see online supplementary figure 1) used to stimulate discussion between the researcher and interviewer. Content of the conservative management summary was based on systematic review findings

Box 1 Topic guide used to facilitate semistructured interviews

Background and History

- ▶ Tell me about your current occupation?
- ▶ How long have you been working clinically?
- ▶ What types of patients do you see (or used to see if no longer working clinically)?
- ▶ How many cases of PFP do you see (or used to see if no longer working clinically) per week?
- ▶ Please tell me about your level of experience in teaching and research.

Examine how the evidence is accessed

- ▶ How do you access the evidence?
- ▶ Are you currently involved in research for PFP?

Explore perceptions of the evidence

- ▶ What are your perceptions of the evidence for PFP?
- ▶ What gaps do you feel exist in the evidence?
- ▶ What should the priorities be for research in this field?
- ▶ What barriers exist for the translation of evidence into clinical practice?
- ▶ What facilitators exist for the translation of evidence into clinical practice?

Management of PFP

- ▶ What do you feel is important when treating a patient?
- ▶ Do you perform any treatments that are not evidence based?
- ▶ Could you tell me about your clinical reasoning for those treatments that are not evidence based (if yes to previous question)?

Reflections on clinical pathway and perception of evidence and clinical reasoning for each modality

- ▶ What are your initial thoughts on the clinical pathway?
- ▶ Could you tell me about your perceptions of the evidence for each of the treatment modalities?
- ▶ Could you tell me about gaps in the evidence for each of the treatment modalities?
- ▶ Could you tell me about your clinical reasoning for each of the treatment modalities?

Table 1 Best Practice Guide to Conservative Management of Patellofemoral Pain

Education	Active rehabilitation	Passive interventions
<ol style="list-style-type: none"> <i>Ensure the patients understands potential contributing factors to their condition and treatment options</i> <i>Advise of appropriate activity modification</i> <i>Manage the patients expectations regarding rehabilitation</i> <i>Encourage and emphasise the importance of participation in active rehabilitation</i> 	<p>Principles</p> <ol style="list-style-type: none"> <i>Give preference to CKC exercises to replicate function</i> <i>Consider OKC exercises in early stages of rehabilitation to target specific strength deficits and movements</i> <i>Provide adequate supervision in the early stages to ensure correct exercise techniques, but progress to independence as soon as possible</i> <i>When independent, limit the number of exercises to 3 or 4 to aid compliance</i> <i>Use biofeedback such as mirrors and videos to improve exercise quality</i> <p>Specifics</p> <ol style="list-style-type: none"> <i>Incorporate quadriceps and gluteal strengthening</i> <i>Target distal and core muscles where deficits exist</i> <i>Consider stretching, particularly of the calf and hamstrings, based on assessment findings</i> <i>Incorporate movement pattern retraining, particularly of the hip</i> 	<p>Pain reduction</p> <ol style="list-style-type: none"> <i>Provide tailored patellar taping to reduce pain in the immediate term</i> <i>Provide PFJ braces where taping is inappropriate (e.g. skin irritation)</i> <i>Consider foot orthoses</i> <p>Optimising biomechanics</p> <ol style="list-style-type: none"> <i>Consider foot orthoses based on assessment findings (i.e. presence of excessive dynamic pronation)</i> <i>Consider massage and acupuncture/dry needling to improve the flexibility of tight muscle and fasciae structures, particularly laterally</i> <i>Consider PFJ mobilisation but only in the presence of hypo-mobility</i> <i>Consider mobilisation of the ankle and first ray in the presence of sagittal plane joint restriction</i>

[Italics] = based on expert opinion without supporting Level 1 evidence.

and findings from a preliminary study exploring clinical reasoning for PFP management.¹⁴ Specifically, the summary was created to outline potential interventions, without highlighting their associated evidence base, and thus avoiding biasing interview participants. The topic guide included questions about the participant's background, how to access evidence informing PFP management, their perception about the available evidence and its external applicability, how current evidence influences their clinical reasoning and their thoughts on the conservative management summary shown (see online supplementary figure 1). Typically 50% of the interview was on the last section.

Data analysis

Qualitative data was evaluated using a 'framework' approach²³ by an experienced physiotherapist with previous experience in conducting interviews and evaluating data related to qualitative research (CB). First, each transcript was read to gain familiarity, and then a thematic framework was formed by mapping the ideas and opinions stated by the interviewees and combining these to generate themes and subthemes, subsequently tabulated with each interviewee being coded to enable anonymous quote attribution. Additional interviews were performed until data saturation, whereby no new themes were being identified. A second experienced physiotherapist in the team also read through each interview transcript to reinforce the analysis (SL). Finally, the analysis was repeated by another experienced clinical academic (DM) with extensive clinical and qualitative research experience, in order to ensure the accuracy and validity of interpretation.

Triangulation was by means of respondent validation and performed by presenting each interviewee with the final themes, subthemes and accompanying findings, with a request for free comment. Any new comment was added to the Framework analysis.

Synthesis of level 1 evidence with expert opinion

For the purpose of synthesising level 1 evidence (high-quality systematic review findings) with expert opinion, the findings were tabulated with level 1 evidence findings designated as either 'Findings supporting the intervention' and 'Other findings related to the intervention' in two separate columns. A third column contained qualitative themes and subthemes associated with the review findings. Qualitative findings which did not

have supporting review evidence were tabulated separately. These tools were used to facilitate discussion of each conservative management option and principle, and the development of the 'Best Practice Guide to Management of Patellofemoral Pain.' Identified themes and subthemes not underpinned by level 1 evidence were synthesised into the discussion where appropriate, and italicised in the 'Best Practice Guide to Management of Patellofemoral Pain' while findings with level 1 evidence were written in normal text (see table 1).

RESULTS

Summary of systematic reviews

Figure 1 illustrates a flow chart of the search results. After the application of the inclusion and exclusion criterion, 13 contemporary reviews (ie, since 2007) were identified.²⁴⁻³⁶ Following quality assessment, six reviews³⁰⁻³⁵ were deemed high quality with scores ranging from 20 to 26 (see table 2). The average quality score was 16.3 (out of 26). Consistent limitations of lower quality reviews included absence of additional alternate searching, exclusion of non-English language studies, inadequate ranges of key words and an absence of two independent reviewers.

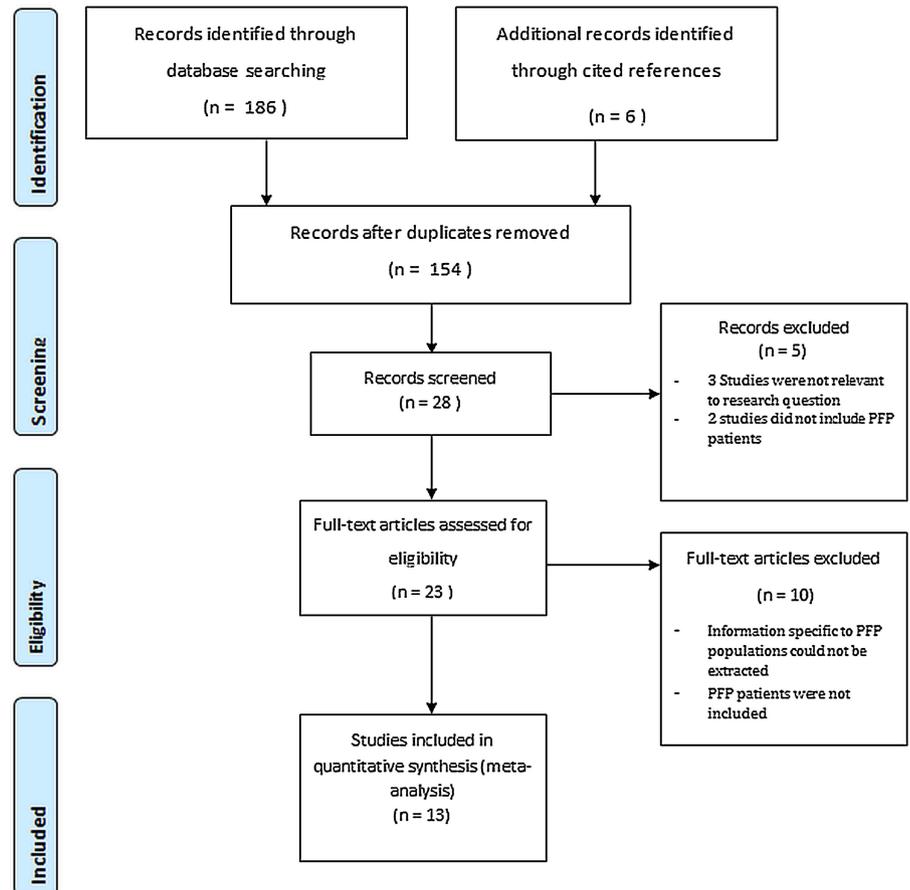
Clinical reasoning qualitative data from international expert clinicians

Interview transcript analysis identified 7 sections with 23 themes and 58 subthemes. The seven sections were 'Over-arching principles' (see online supplementary file 2.1); 'Exercise principles' (see online supplementary file 2.2); 'Exercise specifics' (see online supplementary file 2.3); 'Movement pattern and gait retraining' (see online supplementary file 2.4); 'Local interventions' (see online supplementary file 2.5); 'Acupuncture, dry needling and massage' (see online supplementary file 2.6); and 'Gaps in the evidence and future directions' (see online supplementary file 2.7).

Synthesis of level 1 evidence with expert opinion

A summary of level 1 evidence (high-quality systematic review findings) and associated themes and subthemes from expert opinion is provided in table 3. Interventions covered in current high-quality systematic reviews include multimodal interventions, exercise, biofeedback, patellar taping, patellar bracing, foot orthoses and other adjunctive interventions including foot and ankle mobilisation, ultrasound and massage.

Figure 1 Clinical summary of treatment modality options for patellofemoral pain management.



Identified themes and subthemes not also evaluated in included high-quality systematic reviews are summarised in table 4. These included a number of over-arching principles (see online supplementary file 2.1); exercise dose and principles to optimise outcomes (see online supplementary file 2.2); exercise to address the foot and ankle, core and lower limb flexibility (see online supplementary file 2.3); movement pattern and gait retraining (see online supplementary file 2.4); adjunctive interventions including foot and ankle mobilisation, ultrasound and

massage (see online supplementary file 2.6); and gaps in the evidence and priorities for future research (see online supplementary file 2.7).

The 'Best Practice Guide to Conservative Management of Patellofemoral Pain'

Multimodal interventions result in the strongest and most consistent evidence, particularly in the long term (1 year; see table 3).³⁰ However, varying the multimodal

Table 2 Quality assessment of included studies

Review	A	B	C	D	E	F	G	H	I	J	K	L	M	Total score
Hossain <i>et al</i> ^{34*}	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Barton <i>et al</i> ^{32*}	2	2	2	2	1	2	2	2	2	2	2	2	2	25
Callaghan ^{35*}	2	2	2	2	2	2	2	2	2	1	2	1	1	23
Collins <i>et al</i> ^{12*}	2	2	2	2	0	2	1	2	2	2	2	2	2	23
Warden <i>et al</i> ^{31*}	2	2	2	1	0	2	1	2	2	2	2	2	1	21
Swart <i>et al</i> ^{33*}	1	2	1	0	1	2	1	2	2	2	2	2	2	20
Bolgia ²⁴	2	1	0	1	0	1	0	2	2	0	1	2	2	14
Fagan ²⁵	1	0	1	0	0	1	1	2	2	2	0	1	2	13
Frye <i>et al</i> ²⁶	1	1	0	1	0	2	1	0	2	2	2	1	0	13
Page ²⁷	2	1	0	0	0	2	2	0	2	2	2	0	0	13
Lake and Wofford ²⁸	2	2	0	0	0	2	1	2	2	0	0	0	0	11
Ferenci ³⁶	2	2	1	0	0	2	2	0	1	0	0	0	0	10
Al-Hakim <i>et al</i> ²⁹	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Denotes high-quality review.

A—search methods were explicitly described to allow replication; B—adequate number and range of databases searched; C—adequate alternate searches applied; D—adequate range of key words applied; E—no language restrictions applied; F—inclusion criteria explicitly described to allow replication; G—excludes studies which do not adequately address exclusion of non-PFP diagnosis; H—use of two independent reviewers during search; I—valid quality assessment explicitly described; J—valid meta-analysis completed or limitations to homogeneity discussed; K—CIs/effect sizes reported where possible; L—conclusions supported by meta-analysis or other data analysis; M—conclusions address levels of evidence for each intervention/comparison.

Table 3 Summary of high-quality systematic review findings and associated expert opinion themes and subthemes

Quantitative findings (high-quality systematic reviews)	Other findings related to the intervention	Related qualitative findings (expert opinion)
<p>Findings supporting the intervention</p> <p>3.1 Multimodal interventions</p> <ul style="list-style-type: none"> ▶ Based on pooled data from two studies, a 6-week program of multimodal physiotherapy has a significant moderate effect compared to placebo intervention (flat inserts or physiotherapy) over a 6-week period (SMD 1.08; 95% CI 0.73 to 1.43).³⁰ ▶ A 6-week programme of multimodal physiotherapy combined with prefabricated foot orthoses has a significant large effect at 6 weeks (SMD 1.45; 95% CI 0.96 to 1.94), moderate effect at 12 weeks (SMD 0.86; 95% CI 0.40 to 1.33) and moderate effect at 1 year (SMD 0.77; 95% CI 0.33 to 1.21) compared to placebo (flat inserts).³⁰ ▶ A 6-week programme of multimodal physiotherapy has a significant moderate effect compared to placebo intervention at 12 weeks (SMD 0.69; 95% CI 0.23 to 1.14).³⁰ ▶ A 6-week programme of multimodal physiotherapy has a significant small effect compared to placebo intervention at 1 year (SMD 0.44; 95% CI 0.01 to 0.88).³⁰ ▶ An 8-week multimodal programme consisting of manual therapy, stretches, vasti retraining and patellar taping has a significant moderate effect compared to no treatment (SMD 0.63; 95% CI 0.00 to 1.26).³⁰ ▶ The addition of a 6-week program of multimodal physiotherapy to prefabricated foot orthoses has a significant moderate effect compared to foot orthoses alone at 6 weeks (SMD 0.87; 95% CI 0.42 to 1.32), 12 weeks (SMD 0.63; 95% CI 0.16 to 1.07) and 1 year (SMD 0.70; 95% CI 0.27 to 1.14).^{30 32} ▶ Multimodal physiotherapy involving patellar taping and vasti retraining has small significant effect compared to supervised strengthening and stretching exercise at 4 weeks (SMD 0.56; 95% CI 0.00 to 1.12).³⁰ 	<p>Other findings related to the intervention</p> <ul style="list-style-type: none"> ▶ An 8-week multimodal programme consisting of manual therapy, stretches and general lower limb exercises is not more effective than no treatment.³⁰ ▶ Exercise, patellar taping and education is not more effective than education alone at 12 weeks or 1 year.³⁰ ▶ One review reported a 6-week program of multimodal physiotherapy has a significant small effect compared to foot orthoses at 6 weeks (SMD 0.51; 95% CI 0.07 to 0.95) and 12 weeks (SMD 0.45; 95% CI 0.01 to 0.88),³⁰ while another reported no significant difference at these time points (MD 7.60 mm; 95% CI -1.77, 16.97).³⁴ ▶ A 6-week program of multimodal physiotherapy does not improve outcomes compared to foot orthoses at 1 year.^{30 34} ▶ Multimodal physiotherapy involving patellar taping and vasti retraining is not more effective than supervised or unsupervised strengthening and stretching exercise at 12, 26 and 52 weeks.³⁰ 	<p>Related themes/subthemes (see online supplementary file link) identified from interview transcripts</p> <p>Considering PFP as a multifactorial condition (see online supplementary file 2.1)</p> <ul style="list-style-type: none"> ▶ PFP as a multifactorial condition ▶ On the importance of tailoring intervention programs
<p>3.2 Exercise (active interventions)</p> <ul style="list-style-type: none"> ▶ A 6-week programme of CKC exercise has a very large effect compared to no treatment (SMD 3.02; 95% CI 1.93 to 4.11).³⁰ ▶ A 6-week programme of OKC exercise has a large effect compared to no treatment (SMD 1.82; 95% CI 0.95 to 2.69).³⁰ ▶ An 8-week programme of standard leg press has a moderate effect compared to control (SMD 1.01; 95% CI 0.43 to 1.59).³⁰ ▶ An 8-week programme of leg press with hip adduction has a moderate effect compared to control (SMD 0.83; 95% CI 0.26 to 1.40).³⁰ ▶ Supervised exercise has a small effect compared to control at 12 weeks (SMD 0.44; 95% CI 0.09 to 0.78) and 1 year (SMD 0.49; 95% CI 0.14 to 0.83).³⁰ 	<ul style="list-style-type: none"> ▶ Contrasting findings exist comparing open to closed kinetic chain exercise in the short term, with one study showing a significant moderate effect favouring CKC at 6 weeks (SMD 1.01; 95% CI 0.25 to 1.78), but another showing no difference at 5 weeks. Additionally, one study showed a small effect favouring OKC at 5 years (SMD -0.57; 95% CI -1.14 to 0.00).³⁰ ▶ Based on two studies, the addition of hip exercises to standard quadriceps exercise does not improve outcomes.³⁰ ▶ Findings from one study indicate there is no difference between supervised and unsupervised exercise.³⁰ ▶ The addition of exercise to education does not improve outcomes compared to education alone at 12 and 52 weeks.³⁰ ▶ The addition of exercise to patellar mobilisation/manipulation does not improve outcomes over 5 weeks.³⁰ ▶ The addition of exercise to foot orthoses does not improve outcomes over 8 weeks.³⁰ 	<p>Closed and open chain exercises (see online supplementary file 2.2)</p> <ul style="list-style-type: none"> ▶ The link between CKC exercises and restoration of normal function ▶ The perceived value, or otherwise, of using OKC exercises ▶ Supervised or unsupervised exercise (see online supplementary file 2.2) ▶ Preferences for open or closed chain ▶ Importance of supervision ▶ Practicality of supervised exercise ▶ Quadriceps exercise (see online supplementary file 2.3) ▶ The importance of quadriceps strengthening ▶ The combination of VMO exercise with quadriceps exercises ▶ Gluteal/hip exercise (see online supplementary file 2.3) ▶ Importance of gluteal/hip strengthening ▶ Using functional exercise to facilitate gluteal strengthening ▶ Balancing strength and control at the hip
<p>3.3 Biofeedback (active interventions)</p>	<ul style="list-style-type: none"> ▶ Pooled data from 2 studies indicates combining EMG biofeedback with exercise does not improve outcomes at 4 weeks (SMD -0.21; 95% CI -0.64 to 0.21) or 8–12 weeks (SMD -0.22; 95% CI -0.65 to 0.20).³⁰ 	<p>Biofeedback (see online supplementary file 2.3)</p> <ul style="list-style-type: none"> ▶ Using electromyographic biofeedback, or not, to retrain VMO

Continued

Table 3 Continued

Quantitative findings (high-quality systematic reviews)		Related qualitative findings (expert opinion)
<p>3.4 Patellar taping (passive interventions)</p> <ul style="list-style-type: none"> ▶ Pooled data from 5 studies indicates a trend that medially directed patellar taping reduces pain greater than sham tape in the immediate term (9.1 mm; 95% CI -1.8 to 19.9; $p=0.10$).³¹ ▶ Pooled data from 6 studies indicate medially directed patellar taping reduced pain greater than no tape in the immediate term (14.7 mm; 95% CI 6.9 to 22.8).³¹ 	<ul style="list-style-type: none"> ▶ There are conflicting conclusions from three high-quality reviews regarding the effectiveness of patellar taping. Specifically, one review³⁵ reported pooled data from 4 studies indicate patellar taping does not provide any benefits at the end of treatment (1 week to 3 months) (SMD -0.15; 95% CI -1.15 to 0.85); one review³³ reported conflicting evidence for combining patellar taping with exercise compared with exercise alone in the short term (4–12 weeks); and one review³⁰ reported the addition of patellar taping to exercise has a very large positive effect compared to exercise alone (SMD 2.47; 95% CI 1.25 to 3.70), and large positive effect compared to exercise and placebo tape (SMD 1.35; 95% CI 0.36 to 2.35) at 4 weeks. ▶ Findings from one study indicate the addition of patellar taping to education, or exercise and education does not improve outcomes at 12 and 52 weeks.³⁰ ▶ There is moderate evidence that combining patellar taping with exercise is no more effective than exercise alone in the long term (1 year).³³ 	<p>Patellar taping (see online supplementary file 2.5)</p> <ul style="list-style-type: none"> ▶ Taping use and effects
<p>3.5 Patellar bracing (passive interventions)</p> <ul style="list-style-type: none"> ▶ Pooled data from 3 studies indicates a medially directed patellar brace reduces pain greater than no brace in the immediate to short term (14.6 mm; 95% CI 3.8 to 25.5).³¹ 	<ul style="list-style-type: none"> ▶ Moderate evidence indicates that the addition of knee braces (various) to exercise compared to exercise alone in not effective in reducing pain in the short term.³³ ▶ There is conflicting evidence regarding the effects of combining knee braces (various) with exercise compared with exercise alone on function in the short term 	<p>Patellar bracing (see online supplementary file 2.5)</p> <ul style="list-style-type: none"> ▶ Bracing use and effects
<p>3.6 Foot orthoses (passive interventions)</p> <ul style="list-style-type: none"> ▶ Prefabricated foot orthoses provide greater global improvement compared to placebo (flat inserts) at 6 weeks (RR 1.48; 95% CI 1.11 to 1.99).^{32 34} 	<ul style="list-style-type: none"> ▶ Prefabricated foot orthoses do not provide greater global improvement compared to placebo (flat inserts) at 1 year.^{32 34} ▶ At 6 weeks, one review reported prefabricated foot orthoses have small positive effect on pain (SMD 0.59; 95% CI 0.15 to 1.04),³⁰ while two others reported they do not provide a statistical or clinically meaningful pain reduction compared to placebo (flat inserts; MD 8.20 mm; 95% CI -1.27 to 17.67).^{32 34} ▶ Prefabricated foot orthoses do not improve outcomes at 12 or 52 weeks compared to placebo (flat inserts).^{30 32 34} ▶ There is conflicting evidence regarding the effects of combining foot orthoses with exercise compared to exercise alone in the short term (4–8 weeks),^{30 33 34} but related research appears to be underpowered.^{30 34} ▶ Prefabricated foot orthoses combined with multimodal physiotherapy does not produce better outcomes compared to multimodal physiotherapy alone at 6, 12 or 52 weeks.^{30 32 34} ▶ Moderate evidence indicates the addition of foot orthoses does not improve outcomes compared to exercise alone in the long term (1 year).³³ 	<p>Foot orthoses (see online supplementary file 2.5)</p> <ul style="list-style-type: none"> ▶ When foot orthoses prescription is considered ▶ Prescription specifics for foot orthoses
<p>3.7 Adjunctive interventions (passive interventions)</p> <ul style="list-style-type: none"> ▶ Findings from one study indicate acupuncture produces a moderate positive effect compared to control at 5 months (SMD 0.65; 95% CI 0.13 to 1.16) 	<ul style="list-style-type: none"> ▶ 2 weeks of medial glide and tilt mobilisations and lateral retinacular massage did not improve outcomes compared to no intervention.³⁰ ▶ 2 weeks of PFJ manipulation did not improve outcomes compared to no intervention.³⁰ ▶ Knee manipulation or full lower limb kinetic chain manipulation does not improve outcomes when added to exercise and soft tissue treatment at 6 or 14 weeks.³⁰ ▶ The addition of spinal manipulation to patellar mobilisation does not improve outcomes over 4 weeks.³⁰ ▶ The addition of high-voltage pulsed galvanic stimulation to exercise did not improve outcomes at 6 weeks 	<p>Acupuncture or dry needling (see online supplementary file 2.6)</p> <ul style="list-style-type: none"> ▶ Using acupuncture/dry needling, or not ▶ Acupuncture and dry needling use and effects on soft tissue structures PFJ mobilisation (see online supplementary file 2.6) ▶ The use, or otherwise, of PFJ mobilisation ▶ Indications for PFJ mobilisation

CKC, closed kinetic chain exercise; EMG, electromyography; OKC, open kinetic chain exercise; PFP, Patellofemoral pain; PFJ, patellofemoral joint; VMO, vastus medialis oblique.

programme components according to assessment findings for the individual patient emerged strongly from the interview data. Thus, treatment programmes should be individualised. A 'Best Practice Guide to Conservative Management of Patellofemoral Pain' outlining key

considerations for what may be included based on the synthesis of level 1 evidence with expert opinion can be found in [table 1](#). The guide is divided into three sections including 'Education,' 'Active Rehabilitation' and 'Passive Rehabilitation.'

Table 4 Themes and subthemes identified from interview transcripts unrelated to current level 1 evidence

Theme (see online supplementary file)	Subtheme	Illustrative quotes
<i>Over-arching principles to consider when treating PFP (see online supplementary file 2.1)</i>		
Keys to success	Addressing pain and at what treatment stage	"The most important aspect, probably reducing their pain, that's obviously what they've come for." ¹ "First of all, you need to reduce their pain" ⁵
	The importance of patient education	"Education is the key ingredient to any good therapy." ⁶ "Patient-specific advice and education is critical" ¹⁶
	Empowering the patient through education	"Educating the patient to make sure they understand what's causing their pain and how it's developed and what they can do to try and fix it." ¹ "The most important thing I was able to do was educate the patient on what was wrong with them and what they needed to do to help themselves to get better" ⁷
	On the issue of patients actively engaging or being passive recipients of therapy	"Some people are looking for the passive laying on of hands, the cure, and all that kind of stuff, and for Patellofemoral pain, that just isn't where it's at." ⁸ "Explain to the patient that there's a balance between intrinsic (active) and extrinsic (passive) therapy" ¹
	Managing expectations	"This condition is not cured, it is managed, and that's completely different." ¹⁰ "I think therapists spend too much time thinking they can cure this, probably instead of actually trying to educate the patient on how to manage it" ¹³
Activity modification	Controlling the amount of loading activities	"I tell people to stop doing the activities that cause them pain until we can correct their movement patterns." ⁹ "Number one (is) reduction of primary aggravating factors. You're going to see a reduction in pain and symptoms just from doing that alone" ¹⁵
	The importance of individualising activity modification	"I think it's a very negative thing to say, 'oh, you've got to stop doing all of those things.' ¹⁰ "You can't ask a runner to stop running, you can only ask them to be reasonable about the mileage that they incur on a weekly basis" ¹⁵
Addressing psychosocial factors	Identifying psychosocial factors	"There's always, probably, some underlying psychological or some psycho-social issues." ⁹ "The one thing that is here that needs to be thought about is, which patients aren't going to benefit from treatment..... there's a psychological element, and there are certain patients who will not benefit from physiotherapy" ¹¹
	Addressing fear-avoidance behaviours	"Sometimes patients are very fearful of even moving and unless this is addressed they just decondition and that makes the problem worse." ¹ "Particularly in the younger girls I see, they have this fear of movement, this fear of loading up their knee, and so they actually offload so much that they get weaker and therefore more pain" ⁵
<i>Exercise prescription principles (see online supplementary file 2.2)</i>		
Dose	Dose considerations in relation to compliance and quality	"The simpler you make it, the better it is, the more likelihood you have of someone being compliant." ¹ "I give them no more than four exercises to do, that they can do any time, any place, anywhere..... you want it to become part of their daily routine" ¹⁰
Other principles	On balancing muscle strength and movement control	"Power is nothing without control. And, to me, that's pretty much it. What we're doing, as physiotherapists, is very much about trying to improve control at some level with the patients, and if you can improve that control, that will have an impact on their pain" ⁸
	Exercise principles to optimise outcomes	"Exercise needs to be done regularly, there's not much point in doing exercise once every now and again when you go and see the physio. Exercise, for the most, needs to be repeated for it to be of any benefit." ⁶ "(Exercises should) facilitate them getting back into functional activity. So, if their problem was going up and downstairs, exercises that help them to achieve that, or if they want to get back to running, exercises that help them to achieve their goals" ⁷
<i>Exercise specifics (see online supplementary file 2.3)</i>		
Foot and ankle	Exercises to control foot pronation	"Those people (with excessive foot pronation) could benefit from being given foot muscle exercises to allow them to elevate their midfoot." ⁹ "I would much rather teach that foot to be stronger—and we don't have a lot of evidence for that yet, but ... by strengthening the foot so it does it on its own and doesn't need a brace to hold it up, I think would be a much better way to approach a musculoskeletal injury like that " ¹⁶
Core	Incorporating core strengthening	"There's no evidence for trunk strengthening and I would use trunk strengthening quite frequently." ⁷ "Trunk strengthening, I think it's important for postural control and dynamic control of movement" ¹⁴
Biofeedback	Incorporating other forms of biofeedback to improve hip and knee control	"Exercises in front of mirrors, is about trying to give the patient the feedback about their control mechanisms, which is about improving the pattern of activity." ⁸ "Video feedback is going to give you an ability for the patient to understand better what they're doing wrong" ¹³
Stretching and addressing flexibility	On the importance of stretching	"Flexibility, range of motion, often look at that, maybe not as immediate priority but certainly longer-term, that can certainly help in terms of stretching." ¹ "I think flexibility/range of motion is an adjunct" ⁹
	The importance of ITB stretching	"I don't think you can stretch your ITB, and that's where the foam roller is much more effective in terms of releasing tension in ITB." ⁵ "I'm not a great fan of the Iliotibial band stretching the Iliotibial band probably is a non-modifiable factor" ⁸
	Addressing hamstring flexibility	"Hamstrings, I think people need 80° of hamstring range for normal everyday function." ⁴ "There's a high degree of association between short hamstrings and Patellofemoral pain" ¹³
	Addressing calf flexibility	"Calf, I think you need 15° of dorsi-flexion minimum or else you'll get compensation at the knee and/or the foot." ⁴ "Calf stretching, if it's appropriate sometimes just stretching the calf is sufficient to minimise the excessive pronations through the midfoot" ¹⁰

Continued

Table 4 Continued

Theme (see online supplementary file)	Subtheme	Illustrative quotes
<i>Movement pattern and gait retraining (see online supplementary file 2.4)</i>		
Movement pattern and gait retraining	Potential effects of movement and pattern gait retraining	"I try and do movement pattern retraining, with most patients." ⁷ "We do gait retraining with the majority of the patients that we see. Just strengthening alone is not going to change mechanics" ¹⁶
	The challenges of implementing gait retraining	"Clinically, I don't have the time necessarily to spend with someone, implementing the types of programmes that they use in the studies, particularly the real time feedback." ⁵ "It's very easy to see. We've videotaped them, it doesn't take a lot of high-tech equipment" ¹⁶
<i>Adjunctive interventions (see online supplementary file 2.5)</i>		
Foot and ankle mobilisation	Addressing foot and ankle mobility limitations	"If motion is limited in the sagittal plane, this should be addressed through soft tissue or mobilisation. Otherwise more pronation is likely and this will cause medial collapse at the knee." ¹ "I will mobilise the subtalar joint, to improve calcaneal inversion, to improve shock absorption" ¹⁰
Massage	Massage use and effects	"Massage, probably along with some of the stretches, such as hamstring and hips, I'd probably go less towards, because I really struggle to see how they're adding value to the situation" ¹³ "I think massage plays a big role and people underestimate the effectiveness of massage, just in terms of getting—I would say massage is far more effective than have somebody stretch their IT band or even do fascial lengthening, that's rolling. So, more times than not, we actually recommend one or two massage therapy visits, in combination with our home programme" ¹⁵
Ultrasound	Ultrasound use and effects	"I don't overly see where it adds to value within the patient management of these sort of patients." ¹³ "If somebody's doing ultrasound on a Patellofemoral joint, that's bad medicine" ¹⁵
<i>Gaps in evidence and priorities for future research (see online supplementary file 2.6)</i>		
Pain and pathology	Understanding risk factors and developing prevention programs	"Prevention's probably the holy grail." ⁴ "We need to discriminate a lot more as to cause and effect, rather than just an association" ¹³
	The source of pain	"Priority, try and understand what causes the pain and where does it come from ... because if we understand that, then we can design better intervention and prevention strategies" ¹²
Treatment principles	Identifying those likely to become chronic	"We need to better understand what it is that makes the condition become chronic" ⁵
	The potential relationship between PFP and PFJ OA	"(We need to) work out the relationship between Patellofemoral pain and Patella Osteoarthritis" ⁷
Specific interventions	Approaches to patient specific advice and activity modification	"It would be great to have a sort of smorgasbord of patient-specific advice, so you can pick out the right bits" ⁴
	Subgroups and tailoring interventions	"I think we need to try and develop research around identifying subgroups that are likely to benefit (from various interventions) That's probably where the biggest gap lies." (1) "Our ability to target individual patients with an evidence-based approach, I think is an area which is most lacking ... The priority has definitely got to be looking for predictors of outcomes for different treatments." (6)
Specific interventions	The effectiveness of longer term interventions (ie, >6 weeks)	"Most of the interventions have been quite short, and I think that, in clinical practise, we tend to treat people for longer. And so I think that we need to evaluate whether a longer intervention will provide better results.... I think the six week intervention is too short." (7)
	Improving our understanding of the impact of psychosocial factors on PFP	"Nobody's really looked at the psychosocial aspect of whether that predicts whether someone will get Patellofemoral pain" ⁵
Specific interventions	The relationship of the foot, footwear and orthoses to pathology	"Footwear would be interesting, both from an efficacy and from a biomechanics point of view." ⁷ "I think we need to understand a little bit more about what's going on with the foot, up" ¹⁶
	The value of proximal strengthening	"The gaps are clearly in hip strengthening. And I also said earlier, I think there are gaps in trunk strengthening." ⁷ "People are going to start moving in to the core and the trunk also" ⁹
	The value of gait retraining	"There's good stuff that's looking at retraining movement patterns and retraining the way in which people move, to try and modify their pain. I think that's something that needs more support and needs more work" ²

ITB, iliotibial band; PFP, Patellofemoral pain; PFJ, patellofemoral joint; OA, osteoarthritis.

DISCUSSION

This mixed-methods study synthesises level 1 evidence from contemporary high-quality systematic reviews to guide management of PFP, formulation of clinical guidelines, reflection, educational initiatives and audit of treatment quality. Additionally, structured analysis of international experts' reasoning was combined with the synthesised trial data to facilitate optimal evidence translation to clinical practice. The combination of methods yielded confirmation and illustration of findings, and important but under-researched topics that should facilitate clinical uptake as well as future innovation and evaluation. A comprehensive 'Best Practice Guide to Conservative Management of Patellofemoral Pain' outlining key considerations for clinicians to follow is provided in [table 1](#).

Multimodal interventions result in the strongest and most consistent evidence, particularly in the long term (1 year) (see 3.1 in [table 3](#)).³⁰ Specifically, multimodal physiotherapy consisting of vasti and gluteal strengthening, stretching and PFJ mobilisation and taping has a moderate to large therapeutic effect in the short term (6–12 weeks), and small therapeutic effect in the long term (1 year).³⁰ Framework analysis identified four key over-arching principles to ensure effective management, including—(1) PFP is a multifactorial condition requiring an individually tailored multimodal approach. (2) Immediate pain relief should be a priority to gain patient trust. (3) Patient empowerment by emphasising active over passive interventions is important. (4) Good patient education and activity modification is essential.

Active interventions

Exercise prescription principles

Compared to a control or placebo, current level 1 evidence indicates exercise prescription is clearly effective³⁰ (see 3.2 in table 3), with both open (OKC) and closed kinetic chain (CKC) exercise providing large and clinically meaningful reductions in pain (see 3.1 in table 3 and supplementary file 2.2).³⁷ However, it is unclear from high-quality systematic reviews whether OKC or CKC is more effective, or how important supervision is to ensuring successful outcomes.³⁰ Findings from the qualitative component of this study provide greater guidance on these matters. Specifically, preference should be given to closed rather than open kinetic chain exercise in order to replicate function, although OKC exercise may be useful during early stage rehabilitation to strengthen specific musculature or target movements. Qualitative data suggested supervision be provided where possible to ensure correct technique and optimal movement patterns, particularly in the early stages. However, it must also be considered that high levels of supervision may not always be practical or financially viable, and as such, patients should be progressed to independence as soon as possible.

Exercise specifics

Quadriceps (particularly vastus medialis oblique—VMO) strengthening dominates current evidence-based exercise programmes (see 3.2 in table 3), and inclusion in rehabilitation was a strong feature of experts' interviews (see 3.2–3.3 in table 3 and supplementary file 2.3). Despite evidence supporting a link between delayed activity of VMO and PFP,^{38–39} current level 1 evidence shows specific VMO electromyography (EMG) biofeedback may not improve rehabilitation outcomes (see 3.3 in table 3).³⁰ Additionally, some experts highlighted the need to consider associated time and practical restraints of using EMG biofeedback in a clinical setting.

Passive interventions

Taping, bracing and orthoses

Level 1 evidence indicates medially directed patellar taping provides immediate pain reduction (see 3.4 in table 3),³¹ a feature that emerged strongly as desirable in early patient management to gain trust, facilitate active engagement and optimise outcomes (see table 4 and supplementary file 2.1). Inconsistent beliefs regarding the value of patellar taping in the longer term were consistent with varying conclusions drawn from high-quality systematic reviews evaluating taping in the longer term (see 3.4 in table 3). Specifically, one review³⁵ reported no benefit, one review³³ reported conflicting evidence and one review³⁰ reported large positive effects for patellar taping outcomes. Important methodological considerations related to meta-analysis used in each review may explain these inconsistent conclusions.

Callaghan and Selfe³⁵ defined short term as 3 months or less, and chose to pool data from five studies with different time points (1 week to 3 months) and taping methods (ie, tailored and untailored), concluding patellar taping was not beneficial in the short term. In this instance it is possible that results from studies using untailored taping methods and longer term (eg, 3 months) follow-up may have washed out positive findings from studies evaluating tailored patellar taping and shorter, but clinically relevant, durations (eg, 1 week). Swart *et al*³³ used a similar definition for short term (4–12 weeks), but chose not to pool data due to heterogeneity associated with time points and taping methods. Importantly, this led to a conclusion that findings were

inconsistent. Finally, the review by Collins *et al*,¹² separated time points so that 4 week and 12 week (ie, 3 month) data were considered separately, concluding large positive effects when taping is combined with exercise at 4 weeks. These contrasting findings highlight the need to consider the methods of meta-analysis and appropriateness of data pooling when interpreting results, and the need to evaluate the effect of varied taping methods (ie, tailored versus untailored) and time points in future research.

Level 1 evidence indicates patellar bracing, often designed to reduce lateral patellar tracking, is effective at providing immediate pain reduction (see 3.5 in table 3).³¹ This justifies experts' recommendations for bracing in patients where taping is inappropriate, for example due to skin irritation. However, beyond the immediate term, the effectiveness of patellar bracing is reported to be inconsistent,³³ possibly owing to the multifactorial nature of PFP and indicating the need for further research to identify those most likely to benefit.

Level 1 evidence indicates prefabricated foot orthoses do not improve outcomes at 12 or 52 weeks compared to placebo (flat inserts; see 3.6 in table 3).^{30–32–34} However, foot orthoses may improve outcomes over 6 weeks,^{32–34} although the clinical significance of reported pain reduction magnitude is debatable. Specifically, one review reported foot orthoses to yield a small positive effect on pain (SMD 0.59; 95% CI 0.15 to 1.04),³⁰ while two others^{32–34} reported they do not provide greater pain reduction compared to placebo (flat inserts; see table 3, section 3.6). The discrepancy may be brought about by differences in CIs used when calculating standard mean differences, with the positive review³⁰ using 95% CIs, and the other reviews^{32–34} using 99% CIs. Regardless, the lack of clinical meaningfulness of the pain reduction from foot orthoses prescription (MD 8.20 mm)^{32–34} pointed out by two of the reviews^{32–34} indicates foot orthoses as a stand-alone treatment are unlikely to constitute an adequate management plan. When used in conjunction with other interventions, there is conflicting evidence regarding the effects of combining foot orthoses with exercise compared to exercise alone in the short term (4–8 weeks),^{30–33–34} although this research must be treated cautiously as it is typically underpowered.^{30–34} Additionally, the addition of prefabricated foot orthoses to multimodal physiotherapy at 6, 12 or 52 weeks^{30–32–34} and the addition of foot orthoses to exercise at 52 weeks does not produce better outcomes.³³

One important clinical consideration is that foot orthoses are not prescribed to all individuals presenting with PFP. Synthesis of expert clinical reasoning findings indicates that foot orthoses efficacy may be improved by targeting specific individuals based on measures of pronation. This belief is supported by case series studies which report that greater peak rear-foot eversion during walking⁴⁰ and greater mid-foot mobility^{41–42} may be predictive of foot orthoses prescription success in individuals with PFP. Additionally, qualitative findings indicate that using the treatment direction test concept proposed by Vicenzino⁴³ to identify those most likely to benefit may assist in more efficient tailoring of intervention in regard to foot orthoses prescription.

Adjunct interventions

Limited evidence from one systematic review³⁰ indicates acupuncture may be effective in the management of PFP, but there are conflicting opinions among experts regarding its value in rehabilitation (see 3.7 in table 3 and supplementary file 2.6). Further research is needed in this area, particularly in individuals with PFP who possess muscle tightness, trigger points or more chronic pain. Limited evidence indicates ultrasound is not

effective, with support from experts voicing that ultrasound should not be considered for individuals with PFP.

Expert opinion findings lacking supporting level 1 evidence

Overarching principles

Aiming for immediate pain relief was deemed important to gain patient trust and empower a patient to actively engage in treatment rather than rely on passive treatment of proven poor efficacy. Effective education including activity modification, managing patient expectations, and encouraging active management emerged clearly as the most important component of effective PFP management. However, patient education had no specific evaluation in level 1 research and is therefore a primary target for future research in order to develop and evaluate optimal educational resources. Additionally, qualitative evidence shows that clinicians need to be aware of, and address, potential psychosocial factors interacting with other aspects of patients' presentation when managing PFP, again despite a lack of clear systematic review data.

Exercise prescription principles

Interviewed experts recommended the number of exercises prescribed be limited to approximately 3–4 in order to ensure compliance (see online supplementary file 2.2). Interestingly, this common recommendation is contrary to findings by a recent study investigating the dose–response effects of exercise for PFP.⁴⁴ Specifically, high-dose rehabilitation involving seven exercises and taking approximately 60 min to complete was found to produce superior outcomes compared to low dose involving five exercises and taking approximately 20 min to complete.⁴⁴ Establishing the optimal time needed per exercise session to enhance patient outcomes, while maintaining compliance should be a research priority. Other exercise principle recommendations included ensuring exercise specificity, avoiding irritability and encouraging frequent completion of exercises. Further research comparing different exercise approaches and principles is clearly needed in order to optimise outcomes for patients with PFP.

As previously stated the use of VMO EMG biofeedback is not supported by level 1 evidence³⁰ and practicality in a clinical setting may be limited. However, the implementation of other more freely available biofeedback such as mirrors and video during exercise, to facilitate reversal of poor hip and knee mechanics was strongly advocated by experts and as such should be considered in clinical practice. Further research is needed to confirm its usefulness.

Exercise specifics

At the time of searching there was an absence of level 1 evidence (high-quality systematic reviews) to support the implementation of hip and gluteal exercises in PFP (table 3, section 3.2). However, there is growing evidence linking altered hip mechanics,^{45–46} and impaired gluteal strength and function to PFP.^{47–48} Interviewed experts also emphasised a perceived clinical efficacy for exercise prescription designed to reverse proximal movement and strength faults. Additionally, a number of studies have evaluated the efficacy of gluteal strengthening for PFP and reported favourable outcomes,^{49–51} although an updated systematic review to synthesise this research is needed. Regardless, current empirical study findings and strong advocacy from international clinical experts highlights the need to consider the inclusion of gluteal strengthening in the rehabilitation of individuals with PFP.

Moving more proximally, some experts also recommend the incorporation of core stability or trunk strengthening exercises into rehabilitation. Although lacking any validation through level 1 evidence or from clinical trials, recent studies have reported reduced lateral trunk strength⁵² and increased ipsilateral trunk lean during squatting⁵³ and running,⁵⁴ providing some justification for these recommendations. Qualitative data suggests the inclusion of distal strengthening may be important for some individuals with PFP, which may in some instances be more effective than foot orthoses. The paucity of research evaluating the efficacy of distal strengthening in PFP highlights an area requiring attention in future research.

Lower limb stretching in isolation currently lacks level 1 evidence, but some experts recommended consideration, particularly of the hamstrings and calf, in order to optimise knee and ankle biomechanics. Supporting justification for hamstring stretching, White *et al*⁵⁵ reported an 8° reduction in hamstring flexibility in a group of individuals with PFP when compared to asymptomatic controls, with PFJ stress during squatting thought to increase in the presence of reduced hamstring flexibility.⁵⁶ Additionally, Witvrouw *et al*⁵⁷ reported reduced gastrocnemius flexibility may be a risk factor for PFP development. Inflexibility of the iliotibial band (ITB) has also been reported in individuals with PFP.⁵⁸ Interestingly, stretching the ITB was not strongly advocated by experts interviewed, some stating it is not a modifiable factor or that stretching it is ineffective. Further research to evaluate the clinical effectiveness of stretching and how to determine those likely to benefit is needed.

Gait and movement pattern retraining

Although lacking level 1 evidence, movement pattern and gait retraining was advocated by experts interviewed in this study, with consideration of activities including walking, running, stair negotiation and sit to stand recommended (see online supplementary file 2.4). However, a lack of consensus among experts on the level of difficulty in implementing these strategies exists, primarily owing to the fact that the majority of research reporting favourable findings utilised gait laboratories to facilitate running retraining.^{59–61} Regardless, considering recent promising case series findings for gait retraining in runners with PFP,^{59–61} movement pattern retraining may be a valuable addition to the clinical management of PFP. Clearly further research to establish clinical approaches to facilitate movement pattern retraining, and evaluate their effectiveness is needed.

Adjunctive interventions

Massage and PFJ mobilisation in isolation lacks level 1 evidence, although they are frequently included in multimodal programmes evaluated in research and commonly applied in clinical practice (see online supplementary file 2.6). Inconsistent beliefs regarding the value of PFJ mobilisation in rehabilitation exists, but consensus was that mobilisation should only be considered in the presence of joint restriction, and never in a PFJ that was already hypermobile. Massage was advocated to reduce muscle and facial tightness, particularly of lateral structures, indicating research is needed to evaluate its value in the management of PFP. Distally, consideration to foot and ankle sagittal plane mobility is thought to be important. Specifically, mobilisation to address ankle and first ray dorsiflexion restriction in order to limit compensatory pronation and internal tibial rotation; and subtalar joint mobilisation to optimise shock absorption is recommended. Considering a lack of guidance on how best to determine the need for mobilisation and massage was provided, this should be addressed in future research.

Quality of available systematic reviews

Overall the quality of reviews has improved since the original review of systematic reviews related to the conservative management of PFP,¹³ with 46% (6/13) of reviews rated high quality and an average quality score of 16.3. This compares to 30% (3/10) of reviews rated high quality and an average quality score of 13.7 in the previous review.¹³ Importantly, four of the six high-quality reviews were not Cochrane reviews, compared to no high-quality non-Cochrane reviews being previously identified.¹³ Additionally, all reviews, except one²⁹ used valid quality assessment scales to critique studies included. This equated to 86% (6/7) of lower quality reviews, much higher than the 43% (3/7) of lower quality reviews including valid quality assessment previously.¹³ Put together, these findings highlight improved methodological processes being undertaken by research groups completing systematic reviews evaluating conservative interventions for PFP.

Of the seven lower quality reviews, only two^{25 36} attempted any additional alternate searching, only one³⁶ included non-English language studies, none were deemed to have used an adequate range of key words, and only three^{24 25 28} used two independent reviewers during application of their search strategy. Each of these methodological factors increases the risk of missing relevant studies,¹⁸ reduce the trustworthiness of findings,¹⁸ and hence should be addressed in future reviews.¹⁸ Of the lower quality reviews, only 43% (3/7) attempted or discussed limitations to meta-analysis,^{25–27} and 29% (2/7) used predetermined criteria for levels of evidence to base conclusions on.^{24 25} These methodological weaknesses mean the findings of these lower quality reviews are open to narrative bias,¹⁸ and should be addressed in future research.

Limitations

Although focusing on level 1 evidence (high-quality reviews) to summarise the current evidence base ensures only the highest possible quality of evidence is summarised, one inherent limitation is that published reviews often omit emerging knowledge and early research findings due to stringent inclusion and exclusion criteria. Additionally, there is often a lag between when the final search completed in the review and its publication. Therefore, some review findings included in this study may be considered outdated. To address this, contemporary research findings not synthesised in the results section were also included in the discussion of findings (eg, gluteal strengthening) and development of the 'Best Practice Guide to Conservative Management of Patellofemoral Pain.' Additionally, the interview component of this study included discussion of emerging evidence and clinical reasoning for the use of interventions lacking an evidence base.

Experts included in this study consisted of physiotherapists, physical therapists and athletic trainers, but did not include sports physicians, rheumatologists or surgeons. Therefore, those professions are not specifically represented as authors of the 'Best Practice Guide to Conservative Management of Patellofemoral Pain.' However, the guide is focused on conservative management which is commonly considered the first-line treatment approach for PFP.

It is likely that experts' clinical reasoning is informed, and therefore could be described as biased, by systematic review findings given their professional interest. Moreover, given that many of the interviewed experts have been involved in the included systematic reviews, their clinical reasoning may have in turn biased focus, findings and conclusions reported. This is an

inherent limitation of the evidence generation and synthesis process, and was not felt to be a barrier to high-quality clinical guidance of practice. The clinical summary (see online supplementary figure 1) used to guide discussion between the researcher and interviewee was based primarily on findings from included systematic reviews and may have therefore led to biased discussions regarding topics with current established evidence. To address this to some extent, the clinical summary used to stimulate discussion included interventions with emerging evidence—such as gait retraining—and did not outline the strength of evidence for any included intervention. Additionally, the topic guide (see box 1) included scope for discussion of clinical reasoning regarding interventions lacking evidence.

Initial evaluation and framework analysis was completed by an experienced physiotherapist, which could lead to biasing of findings. However, this individual did possess previous interview and analysis experience related to qualitative research. Additionally, data accuracy and interpretation was checked by an additional researcher with extensive qualitative research experience, and an additional experienced clinician. Validity of qualitative findings was further strengthened through triangulation of findings via respondent validation.

Gaps in evidence and future research directions

Based on a paucity of research or a discord between the evidence base and expert clinical reasoning, there is a clear lack of guidance regarding various exercise prescription principles, including the value of OKC and CKC; duration and frequency of exercise sessions; and level of supervision required at various stages of rehabilitation. Addressing these questions in future research should be a priority. The synthesis of current level 1 evidence with expert opinion for the management of PFP highlights a number of additional research priorities. These include empirical research to establish the value of core and distal strengthening, and the value of patellar taping in the longer term. Experts also highlighted a number of research priorities (see online supplementary file 2.7) including identifying modifiable risk factors so that better prevention programmes can be developed, and the source of pain to guide treatment. Further priorities were: development of tests to identify chronicity or osteoarthritis risks; optimised education; improved criteria to individually tailor interventions; long-term effectiveness of interventions; and the impact of psychosocial factors on PFP, including how to identify and address them. Specific interventions recommended as priorities for research included the effectiveness of proximal strengthening and gait retraining; and understanding how the foot, footwear and foot orthoses relate to pathology.

The 'Best Practice Guide to Conservative Management of Patellofemoral Pain' has been based on a combination of contemporary level 1 evidence and the analysis of international experts' clinical reasoning. However, despite its strengths, the guide should be considered preliminary. Further evaluation of its usefulness to guide clinical practice, and best methods of translation (eg, online tutorials, workshops, teaching at undergraduate level, etc.) is needed. Proof of efficacy should be definitively established by clinical trials. Finally, the methods used in this study have significant potential for replication in order to provide similar guides for the management of other conditions across the specialities.

CONCLUSION

Our mixed methods approach yielded qualitative data that complements robust systematic review data to help guide clinicians managing patients with PFP. A tailored multimodal intervention

programme, complemented with patient education and activity modification is the key to effective PFP management. Active components should include quadriceps and gluteal exercise, with consideration to core and distal strengthening and movement pattern/gait retraining. Patellar taping can be applied to facilitate pain reduction in the early stages of rehabilitation. Stretching of the calf, hamstring and quadriceps should also be considered if indicated depending on individual assessment. Adjuncts may include foot orthoses, massage, and PFJ mobilisation. These principles are summarised in the 'Best Practice Guide to Conservative Management of Patellofemoral Pain' which provides a foundation for discussion at the next International Patellofemoral Pain Research Retreat (Manchester, September 2015).

What is already known on this subject?

- ▶ Patellofemoral Pain (PFP) is a highly prevalent multifactorial condition.
- ▶ Numerous biomechanical and behavioural factors must be considered for effective management of PFP.
- ▶ Systematic reviews that do not consider expert clinical reasoning or provide definitive guides to management when making recommendations are barriers to knowledge translation.

What this study adds?

- ▶ This review of reviews uses only the best quality synthesised evidence, in combination with the world's experts' views.
- ▶ A clear 'Best Practice Guide to Conservative Management of Patellofemoral Pain' based on the combination of the current evidence base and synthesised international expert opinion.
- ▶ Effective and efficient management of PFP requires sound clinical reasoning to guide the provision of an individually tailored multimodal intervention programme including quadriceps and gluteal strengthening, patellar taping, and an emphasis on education and activity modification.

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REFERENCES

- 1 van Middelkoop M, van Linschoten R, Berger MY, *et al*. Knee complaints seen in general practice: active sport participants versus non-sport participants. *BMC Musculoskelet Disord* 2008;9:36.
- 2 Ireland ML, Willson JD, Ballantyne BT, *et al*. Hip strength in females with and without patellofemoral pain. *J Orthop Sports Phys Ther* 2003;33:671–6.
- 3 Feller JA, Amis AA, Andrich JT, *et al*. Surgical biomechanics of the patellofemoral joint. *Arthroscopy* 2007;23:542–53.
- 4 Powers CM. Rehabilitation of patellofemoral joint disorders: a critical review. *J Orthop Sports Phys Ther* 1998;28:345–54.
- 5 Rathleff CR, Baird WN, Olesen JL, *et al*. Hip and knee strength is not affected in 12–16-year-old adolescents with patellofemoral pain—a cross-sectional population-based study. *PLoS ONE* 2013;8:e79153.
- 6 Rathleff MS, Rasmussen S, Olesen JL. [Unsatisfactory long-term prognosis of conservative treatment of patellofemoral pain syndrome]. *Ugeskr Laeger* 2012;174:1008–13.
- 7 Nimon G, Murray D, Sandow M, *et al*. Natural history of anterior knee pain: a 14- to 20-year follow-up of nonoperative management. *J Pediatr Orthop* 1998;18:118–22.
- 8 Stathopoulos E, Baildam E. Anterior knee pain: a long-term follow-up. *Rheumatology (Oxford)* 2003;42:380–2.
- 9 Crossley KM. Is patellofemoral osteoarthritis a common sequela of patellofemoral pain? *Br J Sports Med* 2014;48:409–10.
- 10 Lankhorst NE, Bierma-Zeinstra SMA, van Middelkoop M. Risk Factors for patellofemoral pain syndrome: a systematic review. *J Orthop Sports Phys Ther* 2012;42:81–94.
- 11 Lankhorst NE, Bierma-Zeinstra SMA, van Middelkoop M. Factors associated with patellofemoral pain syndrome: a systematic review. *Br J Sports Med* 2013;47:193.
- 12 Collins NJ, Bisset LM, Crossley KM, *et al*. Efficacy of nonsurgical interventions for anterior knee pain systematic review and meta-analysis of randomized trials. *Sports Med* 2012;42:31–49.
- 13 Barton CJ, Webster KE, Menz HB. Evaluation of the scope and quality of systematic reviews on nonpharmacological conservative treatment for patellofemoral pain syndrome. *J Orthop Sports Phys Ther* 2008;38:529–41.
- 14 Barton C, Hemmings S, Morrissey D. The influence of published evidence on physiotherapists' clinical reasoning when treating patellofemoral pain syndrome: a mixed-methods study. *J Orthop Sports Phys Ther* 2012;42:A49–50.
- 15 Sackett DL, Rosenberg WMC, Gray JAM, *et al*. Evidence based medicine: what it is and what it isn't. *BMJ* 1996;312:71–2.
- 16 Dissemination C.f.R.a. Systematic Reviews: CRD's guidance for undertaking reviews in health care. 2009. http://www.york.ac.uk/inst/crd/pdf/Systematic_Reviews.pdf
- 17 Rowe V, Hemmings S, Barton C, *et al*. Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic and clinical reasoning. *Sports Med* 2012;42:941–67.
- 18 Oxman AD. Checklists for review articles. *BMJ* 1994;309:648–51.
- 19 Sackett D, Straus S, Richardson W. *Evidence-based medicine: how to practice and teach EBm*. 2nd edn. Edinburgh, UK: Churchill Livingstone, 2000.
- 20 Seers K. Systematic review. In: Dawes M, *et al*, eds. *Evidence-based practice: a primer for health care professionals*. London, UK: Churchill Livingstone, 1999:85–100.
- 21 Davis IS, Powers CM. Patellofemoral pain syndrome: proximal, distal, and local factors, an international retreat, April 30-May 2, 2009, Fells Point, Baltimore, MD. *J Orthop Sports Phys Ther* 2010;40:A1–16.
- 22 Powers CM, Bolgla LA, Callaghan MJ, *et al*. Patellofemoral pain: proximal, distal, and local factors, 2nd International Research Retreat. *J Orthop Sports Phys Ther* 2012;42:A1–54.
- 23 N M, C P. *Qualitative research in healthcare: analysing qualitative data*. 2nd edn. BMJ Books, 1999.
- 24 Bolgla LA, Boling MC. An update for the conservative management of patellofemoral pain syndrome: a systematic review of the literature from 2000 to 2010. *Int J Sports Phys Ther* 2011;6:112–25.
- 25 Fagan V, Delahunt E. Patellofemoral pain syndrome: a review on the associated neuromuscular deficits and current treatment options. *Br J Sports Med* 2008;42:789–95.
- 26 Frye JL, Ramey LN, Hart JM. The effects of exercise on decreasing pain and increasing function in patients with patellofemoral pain syndrome: a systematic review. *Sports Health* 2012;4:205–10.
- 27 Page P. Effectiveness of elastic resistance in rehabilitation of patients with patellofemoral pain syndrome: what is the evidence? *Sports Health* 2011;3:190–4.
- 28 Lake DA, Wofford NH. Effect of therapeutic modalities on patients with patellofemoral pain syndrome: a systematic review. *Sports Health* 2011;3:182–9.
- 29 Al-Hakim W, Jaiswal PK, Khan W, *et al*. The non-operative treatment of anterior knee pain. *Open Orthop J* 2012;6:320–6.
- 30 Collins NJ, Bisset LM, Crossley KM, *et al*. Efficacy of nonsurgical interventions for anterior knee pain: systematic review and meta-analysis of randomized trials. *Sports Med* 2012;42:31–49.
- 31 Warden SJ, Hinman RS, Watson MA, *et al*. Patellar taping and bracing for the treatment of chronic knee pain: a systematic review and meta-analysis. *Arthritis Rheum* 2008;59:73–83.

- 32 Barton CJ, Munteanu SE, Menz HB, *et al.* The efficacy of foot orthoses in the treatment of individuals with patellofemoral pain syndrome: a systematic review. *Sports Med* 2010;40:377–95.
- 33 Swart NM, van Linschoten R, Bierma-Zeinstra SMA, *et al.* The additional effect of orthotic devices on exercise therapy for patients with patellofemoral pain syndrome: a systematic review. *Br J Sports Med* 2012;46:570–7.
- 34 Hossain M, Alexander P, Burls A, *et al.* Foot orthoses for patellofemoral pain in adults. *Cochrane Database Syst Rev* 2011(1):CD008402.
- 35 Callaghan MJ, Selfe J. Patellar taping for patellofemoral pain syndrome in adults. *Cochrane Database Syst Rev* 2012;4:CD006717.
- 36 Ferenci K. [Patellofemoral pain syndrome] [German]. *Zeitschrift für Physiotherapeuten* 2010;62:6–14.
- 37 Crossley KM, Bennell KL, Cowan SM, *et al.* Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Arch Phys Med Rehabil* 2004;85:815–22.
- 38 Van Tiggelen D, Cowan S, Coorevits P, *et al.* Delayed vastus medialis obliquus to vastus lateralis onset timing contributes to the development of patellofemoral pain in previously healthy men: a prospective study. *Am J Sports Med* 2009;37:1099–105.
- 39 Chester R, Smith TO, Sweeting D, *et al.* The relative timing of VMO and VL in the aetiology of anterior knee pain: a systematic review and meta-analysis. *BMC Musculoskelet Disord* 2008;9:64.
- 40 Barton CJ, Menz HB, Levinger P, *et al.* Greater peak rearfoot eversion predicts foot orthoses efficacy in individuals with patellofemoral pain syndrome. *Br J Sports Med* 2011;45:697–701.
- 41 Mills K, Blanch P, Dev P, *et al.* A randomised control trial of short term efficacy of in-shoe foot orthoses compared with a wait and see policy for anterior knee pain and the role of foot mobility. *Br J Sports Med* 2012;46:247–52.
- 42 Vicenzino B, Collins N, Cleland J, *et al.* A clinical prediction rule for identifying patients with patellofemoral pain who are likely to benefit from foot orthoses: a preliminary determination. *Br J Sports Med* 2010;44:862–6.
- 43 Vicenzino B. Foot orthotics in the treatment of lower limb conditions: a musculoskeletal physiotherapy perspective. *Man Ther* 2004;9:185–96.
- 44 Østerås B, Østerås H, Torstensen TA, *et al.* Dose-response effects of medical exercise therapy in patients with patellofemoral pain syndrome: a randomised controlled clinical trial. *Physiotherapy* 2013;99:126–31.
- 45 Boling MC, Padua DA, Marshall SW, *et al.* A prospective investigation of biomechanical risk factors for patellofemoral pain syndrome: the Joint Undertaking to Monitor and Prevent ACL Injury (JUMP-ACL) cohort. *Am J Sports Med* 2009;37:2108–16.
- 46 Noehren B, Hamill J, Davis I. Prospective evidence for a hip etiology in patellofemoral pain. *Med Sci Sports Exerc* 2013;45:1120–4.
- 47 Barton CJ, Lack S, Malliaras P, *et al.* Gluteal muscle activity and patellofemoral pain syndrome: a systematic review. *Br J Sports Med* 2013;47:207–14.
- 48 Prins MR. Females with patellofemoral pain syndrome have weak hip muscles: a systematic review. *Aust J Physiother* 2009;55:9–15.
- 49 Khayambashi K, Mohammadkhani Z, Ghaznavi K, *et al.* The effects of isolated hip abductor and external rotator muscle strengthening on pain, health status, and hip strength in females with patellofemoral pain: a randomized controlled trial. *J Orthop Sports Phys Ther* 2012;42:22–9.
- 50 Dolak KL, Silkman C, McKeon JM, *et al.* Hip strengthening prior to functional exercises reduces pain sooner than, quadriceps strengthening in females with patellofemoral pain syndrome: a randomized clinical trial. *J Orthop Sports Phys Ther* 2011;41:560.
- 51 Ferber R, Kendall KD, Farr L. Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome. *J Athl Train* 2011;46:142–9.
- 52 Cowan SM, Crossley KM, Bennell KL. Altered hip and trunk muscle function in individuals with patellofemoral pain. *Br J Sports Med* 2009;43:584–8.
- 53 Nakagawa TH, Moriya ÉTU, Maciel CD, *et al.* Trunk, pelvis, hip, and knee kinematics, hip strength, and gluteal muscle activation during a single-leg squat in males and females with and without patellofemoral pain syndrome. *J Orthop Sports Phys Ther* 2012;42:491–501.
- 54 Noehren B, Pohl MB, Sanchez Z, *et al.* Proximal and distal kinematics in female runners with patellofemoral pain. *Clin Biomech* 2012;27:366–71.
- 55 White LC, Dolphin P, Dixon J. Hamstring length in patellofemoral pain syndrome. *Physiotherapy* 2009;95:24–8.
- 56 Whyte EF, Moran K, Shortt CP, *et al.* The influence of reduced hamstring length on patellofemoral joint stress during squatting in healthy male adults. *Gait Posture* 2010;31:47–51.
- 57 Witvrouw E, Lysens R, Bellemans J, *et al.* Intrinsic risk factors for the development of anterior knee pain in an athletic population. A two-year prospective study. *Am J Sports Med* 2000;28:480–9.
- 58 Hudson Z, Darthuy E. Iliotibial band tightness and patellofemoral pain syndrome: a case-control study. *Man Ther* 2009;14:147–51.
- 59 Noehren B, Davis I. The effect of gait retraining on hip mechanics, pain, and function in runners with patellofemoral pain syndrome... Patellofemoral pain syndrome: proximal, distal, and local factors, an international research retreat, April 30-May 2, 2009, Fells Point, Baltimore, MD. *J Orthop Sports Phys Ther* 2010;40:A40–1.
- 60 Willy RW, Scholz JP, Davis IS. Mirror gait retraining for the treatment of patellofemoral pain in female runners. *Clin Biomech (Bristol, Avon)* 2012;27:1045–51.
- 61 Cheung RT, Davis IS. Landing pattern modification to improve patellofemoral pain in runners: a case series. *J Orthop Sports Phys Ther* 2011;41:914–9.