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# 2016 Patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 2: recommended physical interventions (exercise, taping, bracing, foot orthoses and combined interventions)

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## INTRODUCTION

Patellofemoral pain affects physically active and sedentary individuals, accounting for 11–17% of knee pain presentations to general practice<sup>1 2</sup> and 25–40% of all knee problems seen in a sports injury clinic.<sup>3 4</sup> Patellofemoral pain is characterised by anterior knee pain associated with activities such as squatting, rising from sitting and stair ambulation. While traditionally viewed as self-limiting, increasing research data suggest that patellofemoral pain is often recalcitrant and can persist for many years,<sup>5–8</sup> and may cause a decline in sports participation.<sup>8 9</sup>

Despite its high prevalence among active individuals<sup>9–12</sup> and frequent presentations for treatment, there are few published guidelines to help clinicians choose the appropriate evidence-based treatment for patellofemoral pain. The most recent and relevant paper from Barton and colleagues<sup>13</sup> combined systematic review findings with qualitative interviews from expert clinicians to provide a clinically relevant synthesis, covering the literature up to September 2013. At the International Patellofemoral Pain Research Retreat in Manchester 2015, we held a consensus meeting to update the current evidence base and produce consensus-based recommendations regarding treatment for patellofemoral pain. All retreat registrants were active researchers in patellofemoral pain and presented their research findings. Many of the world leading researchers (eg, 8 out of the top 10 researchers with the highest number of publications, when the term ‘patellofemoral pain’ was searched in Scopus, February 2016) were in attendance and contributed to the consensus meeting.

The consensus meeting during the retreat resulted in recommendations, based on evidence published between January 2010 and June 2015. These recommendations should be combined with information gathered from individual patients, regarding their preferences, experiences, presentation and values, along with the values, expertise and skills of individual practitioners to create a patient-centred treatment approach.

## METHODS

### Literature review

CJB searched EMBASE, MEDLINE, CINAHL and Current Contents for systematic reviews and randomised controlled trials (RCTs) published between

January 2010 and June 2015. To be eligible, publications were (i) the most current systematic reviews including meta-analyses and (ii) any RCTs published subsequent to the most recent systematic review.

Search terms used to search titles and abstracts of papers relating to patellofemoral pain in each database were (patella or patellofemoral) and (pain or syndrome or dysfunction).<sup>13</sup> To narrow the search to identify systematic reviews, these diagnostic terms were combined with the keyword *review*.

To narrow the search to identify any contemporary randomised trials, diagnostic terms were combined with (controlled trial or clinical trial) and additional searching was completed in the Physiotherapy Evidence Database (PEDro). Additionally, all authors on this consensus statement were consulted to identify any missing papers. To be included, randomised trials were required to evaluate one or more conservative intervention compared with a control or alternative conservative intervention, using an outcome measure related to pain (eg, pain visual analogue scale (VAS)) or patient-reported improvement, and using a randomised method for group allocation.

Data were extracted from each included paper. Where multiple systematic reviews were available for the same intervention from the same time period, findings from moderate–high quality reviews were used in preference to low-quality reviews. If no systematic reviews were available, all published RCTs related to the intervention were included. Findings from included reviews and trials were used to generate a summary table, which included study methodology, relevant outcomes and effect sizes.

The methodological quality of meta-analyses and systematic reviews was graded with the Assessment of Multiple Systematic Reviews (AMSTAR) tool; and RCTs were graded with the PEDro rating scale. Rating was completed by two independent reviewers (CJB and MvM), and discrepancies resolved through a consensus meeting. A third reviewer (KMC) was available to settle any disagreement but was not required.

### Quality of evidence

For systematic reviews, the following allocation was applied based on AMSTAR scores:

- ▶ High quality (HQ):  $\geq 7$
- ▶ Moderate quality (MQ): 4–6
- ▶ Low quality (LQ):  $\leq 3$

For RCTs, the following allocation was applied based on PEDro scores:

- ▶ High quality (HQ):  $\geq 7$
- ▶ Moderate quality (MQ): 4–6
- ▶ Low quality (LQ):  $\leq 3$

### Expert panel

The patellofemoral pain expert panel was composed of 35 of the 50 attendees at the 2015 International Patellofemoral Research Retreat (Manchester). All attendees were actively researching patellofemoral pain and included physiotherapists, doctors, podiatrists, biomechanists, epidemiologists and sports therapists.

### Recommendations

Literature summary tables were developed by the consensus group (KMC, MvM, MJC, NJC, MSR, CJB) and distributed to all panel members prior to the consensus meeting. The summaries contained the quality ratings and effect sizes. Duration of treatment effect was classified as follows: <6 months considered short term, between 6 and 12 months was medium term and >12 months considered long term, unless otherwise defined in the systematic review. Statements were generated by the consensus group regarding each intervention, which reflected the evidence, and with respect to the interventions' effect on pain, function and overall symptomatic improvement (ie, global rating of change). The panel was instructed to vote on the appropriateness of each statement.

The panel was instructed to integrate the evidence for each intervention with their expert opinions and knowledge in order to interpret the appropriateness of each intervention. At the Research Retreat, a 1-hour discussion of the summary tables (led by the consensus group) enabled clarification of the study elements, and finalisation of the statements. Following the discussion, panel members voted on the appropriateness of each intervention.

### Voting and scoring

A 10-point scale (0–9, where 0 is 'not appropriate' and 9 is 'appropriate') was used to evaluate the appropriateness of each intervention. This scale was based on one similar previously used to generate the Osteoarthritis Research Society International (OARSI) guidelines for the non-surgical management of knee osteoarthritis.<sup>14</sup>

Not appropriate					Appropriate				
0	1	2	3	4	5	6	7	8	9

A pooled score provided a median appropriateness score for each intervention. A score of 0–3 was considered 'inappropriate', 4–6 'uncertain' and 7–9 'appropriate'.

### Final recommendations

Final recommendations were made on interventions where the outcome was consistent between voting and the evidence associated with this statement.

## RESULTS

The initial literature search for systematic reviews yielded 586 citations. Following screening for eligibility, a total of 22

systematic reviews were identified. Consultation with consensus authors did not yield any additional reviews. The interventions were grouped into the following: (i) exercise therapy (with separate sections for exercise therapy targeting specific bodily regions, ie, knee or hip); (ii) combined interventions (combining two or more of exercise therapy, patellar taping, mobilisation or foot orthoses); (iii) foot orthoses (in-shoe orthotic devices); (iv) patellar taping and bracing and (v) other adjunctive interventions (eg, acupuncture, mobilisation, electrophysical agents). Some of the reviews covered several interventions.

### Available systematic reviews and available evidence

This included 13 (5 moderate; 1 high quality) reviews related to exercise therapy, 2 (1 moderate quality) related to combined interventions, 5 (3 moderate; 1 high quality) related to foot orthoses, 4 (2 moderate; 1 high quality) related to patellar taping and bracing, and 7 (2 moderate quality) related to other adjunctive interventions. AMSTAR ratings for each of these systematic reviews and the search date included in their methods are outlined in [table 1](#).

### Additional RCT evidence

Subsequent searching for RCTs since 2010 revealed an additional 1631 citations. After taking into account the literature covered by included systematic reviews, 36 of these were considered for inclusion. Of these 36, an additional 7 randomised trials were identified. These included 1 on exercise therapy, 2 on combined interventions, 2 on foot orthoses, 1 on patellar taping and 1 on other adjunctive interventions. PEDro ratings for each of these trials are outlined in [table 2](#).

### Recommendations

Twenty-four statements (separated into time points and primary outcomes) were voted on by the panel.

Results of this and associated evidence are outlined in [figures 1–7](#), including 12 statements related to exercise therapy ([figures 1–3](#)), 3 statements related to combined interventions ([figure 4](#)), 2 statements related to foot orthoses ([figure 5](#)), 4 statements related to patellar taping and bracing ([figure 6](#)) and 4 statements related to other adjunctive interventions ([figure 7](#)).

Key areas of uncertainty included combined interventions for adolescents, prioritisation of hip or knee exercise, acupuncture and patellar taping and bracing. We can make six recommendations based on consistency between consensus voting and the current evidence:

#### Exercise therapy

1. Exercise is recommended to reduce pain in the short, medium and long term, and improve function in the medium and long term.
2. Combining hip and knee exercises is recommended to reduce pain and improve function in the short, medium and long term, and this combination should be used in preference to knee exercises alone.

#### Combined interventions

1. Combined interventions are recommended to reduce pain in adults with patellofemoral pain in the short and medium term.

#### Foot orthoses

1. Foot orthoses are recommended to reduce pain in the short term.

## Consensus statement

**Table 1** AMSTAR quality assessment of included systematic reviews

Systematic review	Score per AMSTAR item											Total score	Search date
	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi		
<i>Exercise therapy</i>													
Bolgla and Boling <sup>15</sup>	0	CA	0	1	0	0	0	0	0	0	0	1	2010—December
Clijisen <i>et al</i> <sup>16</sup>	0	CA	1	0	0	0	1	1	1	1	0	5	2013—December
Collins <i>et al</i> <sup>17</sup>	0	0	1	0	0	0	1	1	1	0	0	4	2009—November
Frye <i>et al</i> <sup>18</sup>	0	CA	0	0	0	0	1	0	0	0	0	1	2010—September
Harvie <i>et al</i> <sup>19</sup>	0	CA	1	0	0	0	1	0	0	0	0	2	2010—January
Kooiker <i>et al</i> <sup>20</sup>	0	CA	1	CA	1	1	1	1	1	0	0	6	2014—January
Lack <i>et al</i> <sup>21</sup>	0	CA	1	CA	0	0	1	1	1	0	0	4	2014—December
Nobre <sup>22</sup>	0	CA	0	CA	0	0	0	0	0	0	0	0	2011—Unclear
Page <sup>23</sup>	0	CA	0	CA	0	0	0	0	0	0	0	0	2010—August
Peters and Tyson <sup>24</sup>	0	0	1	0	0	0	1	0	1	0	0	3	2013—January
Regelski <i>et al</i> <sup>25</sup>	0	CA	0	0	0	0	1	CA	0	0	0	1	Unclear
van der Heijden <i>et al</i> <sup>26</sup>	1	1	1	1	1	1	1	1	1	1	0	10	2014—May
Wasielewski 2011	0	1	0	0	1	1	1	1	1	0	0	6	2010—Unclear
<i>Combined intervention</i>													
Bolgla <i>et al</i> <sup>15</sup>	0	CA	0	1	0	0	0	0	0	0	0	1	2010—December
Collins <i>et al</i> <sup>17</sup>	0	0	1	0	0	0	1	1	1	0	0	4	2009—November
<i>Foot orthoses</i>													
Barton <i>et al</i> <sup>27</sup>	0	CA	1	0	1	1	1	1	1	0	0	6	2008—December
Bolgla <i>et al</i> <sup>15</sup>	0	CA	0	1	0	0	0	0	0	0	0	1	2010—December
Collins <i>et al</i> <sup>17</sup>	0	0	1	0	0	0	1	1	1	0	0	4	2009—November
Hossain <i>et al</i> <sup>28</sup>	1	1	1	CA	1	0	1	1	1	1	0	8	2010—March
Swart <i>et al</i> <sup>29</sup>	0	1	1	0	0	1	1	1	1	0	0	6	2010—January
<i>Patellar taping and bracing</i>													
Barton <i>et al</i> <sup>30</sup>	0	CA	1	CA	0	0	1	1	1	0	0	4	2013—January
Callaghan and Selfe <sup>31</sup>	1	1	1	1	1	1	1	1	1	0	0	9	2011—August
Kalron and Bar-Sela <sup>32</sup>	0	CA	1	0	0	0	1	0	1	0	0	3	2012—March
Swart <i>et al</i> <sup>29</sup>	0	1	1	0	0	1	1	1	1	0	0	6	2010—January
<i>Other adjunctive interventions</i>													
Bolgla <i>et al</i> <sup>15</sup>	0	CA	0	1	0	0	0	0	0	0	0	1	2010—December
Brantingham <i>et al</i> <sup>33</sup>	0	CA	0	0	0	0	0	0	0	0	0	0	2011—May
Collins <i>et al</i> <sup>17</sup>	0	0	1	0	0	0	1	1	1	0	0	4	2009—November
Dos Santos <i>et al</i> <sup>34</sup>	0	CA	0	CA	0	0	0	0	0	0	0	0	2011—Unclear
Lake and Wofford <sup>35</sup>	0	CA	1	0	0	0	1	0	0	0	0	2	2010—August
Wasielewski <i>et al</i> <sup>36</sup>	0	1	0	0	1	1	1	1	1	0	0	6	2010—Unclear

**Bold text**=Reviews considered to be moderate or high quality.

i='a priori' design; ii=duplicate study selection and data extraction; iii=comprehensive literature search; iv=search for grey literature; v=list of studies included and excluded provided; vi=characteristics of included studies provided; vii=scientific quality assessed; viii=scientific quality used to formulate conclusions; ix=methods to combine study findings appropriate; x=publication bias assessed; xi=conflict of interest.

0, no; 1, yes; AMSTAR, Assessment of Multiple Systematic Reviews; CA, cannot assess.

#### Other adjunctive interventions

1. Patellofemoral, knee and lumbar mobilisations may not improve outcomes.
2. Electrophysical agents may not improve outcomes.

#### DISCUSSION

The International Patellofemoral Research Retreat Consensus meeting resulted in six evidence-based recommendations. These recommendations will guide medical and health practitioners when they treat patients with patellofemoral pain. Recommendations may also be taken up by patients, other care providers, and government agencies and other organisations responsible for funding patellofemoral pain treatment. The recommendations are not intended to standardise patient care, but to be used in combination with individualised assessments of patient's needs, preferences and presentations, and clinical expertise to inform patient-centred management.<sup>44</sup>

#### Six recommendations from the expert panel

The six recommendations were as follows:

1. Exercise-therapy is recommended to reduce pain in the short, medium and long term, and improve function in the medium and long term.
2. Combining hip and knee exercises is recommended to reduce pain and improve function in the short, medium and long term, and this combination should be used in preference to knee exercises alone.
3. Combined interventions are recommended to reduce pain in adults with patellofemoral pain in the short and medium term.
4. Foot orthoses are recommended to reduce pain in the short term.
5. Patellofemoral, knee and lumbar mobilisations are not recommended.
6. Electrophysical agents are not recommended.

**Table 2** PEDro quality assessment of included RCTs

Study	Score per PEDro item											Total score
	i*	ii	iii	iv	v	vi	vii	viii	ix	x	xi	
<i>Exercise therapy</i>												
Ferber et al <sup>37</sup>	1	1	1	0	0	0	0	0	1	1	1	5
<i>Combined intervention</i>												
Mason et al <sup>38</sup>	1	1	0	0	0	0	1	0	1	0	1	4
Rathleff et al <sup>39</sup>	1	1	1	1	0	0	0	1	1	1	1	7
<i>Foot orthoses</i>												
Lewinson et al <sup>40</sup>	1	1	0	1	1	0	0	1	0	1	1	5
Mills et al <sup>41</sup>	1	1	1	1	1	0	1	1	1	1	1	9
<i>Patellar taping and bracing</i>												
Osorio et al <sup>42</sup>	1	1	1	0	0	0	0	0	0	1	1	4
<i>Other adjunctive interventions</i>												
Hains and Hains <sup>43</sup>	0	1	1	1	1	0	1	1	1	1	1	9

i=eligibility criteria; ii=random allocation; iii=concealed allocation; iv=baseline comparability; v=blind subjects; vi=blind therapists; vii=blind assessors; viii=adequate follow-up; ix intention-to-treat analysis; x=between-group comparisons; xi=point estimates and variability.

\*Eligibility criteria item does not contribute to total score.

0, no or unable to determine; 1, yes; PEDro, Physiotherapy Evidence Database; RCTs, randomised controlled trials.

Our recommendations differ from those described in the 'Best Practice Guide to Conservative Management of Patellofemoral Pain'.<sup>13</sup> The best practice guide did not recommend exercise therapy as a stand-alone treatment, but recommended consideration of acupuncture, and provided no recommendations regarding treatments which may *not* improve outcomes. These differences likely reflect the qualitative input from clinicians in the paper.<sup>13</sup> In contrast, the consensus voting that led to our recommendations involved some researchers who had a clinical role and some who did not. For example, it appears that clinicians have a stronger preference for combined interventions (using a combination of exercise therapy, targeting knee and hip musculature, patellofemoral taping, mobilisation and foot orthoses), which was a recommendation from our consensus, than for stand-alone treatments, such as exercise therapy. However, exercise therapy has been evaluated considerably

within the scientific literature and remains a recommendation as a stand-alone treatment from our consensus based on the strength of evidence supporting it. In contrast, interventions such as acupuncture have very limited supporting evidence. Appropriateness of acupuncture was voted as uncertain, and hence was not recommended in the current consensus meeting. However, acupuncture is frequently used by clinicians who treat patellofemoral pain, and this highlights a nexus between evidence and practice which requires high-quality clinical trials. The consensus meeting has also made recommendations against interventions such as mobilisation and electrotherapy, which current evidence indicates are ineffective. The consensus meeting was also unable to make any recommendations related to patient education in isolation, due to a paucity of research in this area. Considering the perceived importance of providing patient education from clinicians,<sup>13</sup> further research and development on patient education interventions is encouraged.

### Exercise therapy: the treatment of choice

Exercise therapies had the most statements in support of their short-term, medium-term and long-term use, reflecting the large body of evidence underpinning this treatment. Exercise therapy was the only intervention tested in isolation to be supported by the expert group. The evidence clearly shows that exercise therapy is effective, regardless of the type of exercise (eg, in weight bearing or not; targeting hip or knee). There was also support for emerging but convincing evidence that combining a hip-focused with knee-focused exercise therapy regimen resulted in superior outcomes to isolated knee-focused exercise therapy. This is consistent with results from the combined intervention studies, which have included hip-focused and knee-focused exercise therapies. The uncertainty around the superiority of hip-focused when compared head-to-head with knee-focused treatments may reflect lack of clarity regarding implementation of targeted exercise therapies, and the potential for the reported exercise therapy regimens to truly only target either the hip or the knee. For example, knee-focused programmes including single-leg squatting or stair climbing activities will also target the hip, while standing exercises to target the hip with resistance will also involve a knee focus on the weight-bearing limb.

### Exercise therapy:

#### 1. Reduces pain in the short-term (<6 months)

**Evidence:** High quality [21] and moderate quality [39] systematic reviews including meta-analysis reported moderate-large pain reduction with exercise therapy compared to control and placebo interventions in the short term

#### 2. Improves function and symptoms in the short-term (<6 months)

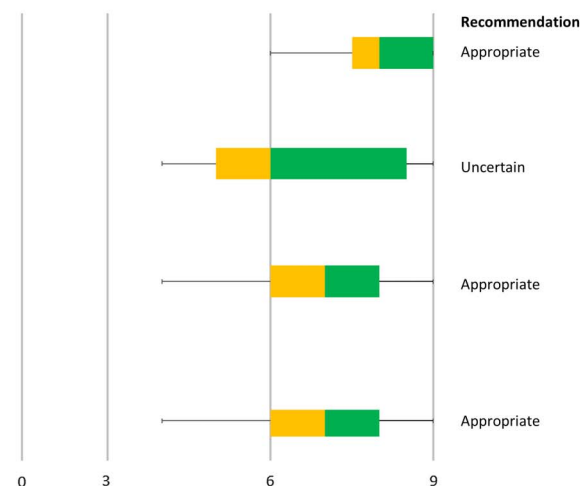
**Evidence:** High quality [21] and moderate quality [39] systematic reviews including meta-analysis reported moderate improvements to function with exercise therapy compared to control and placebo interventions in the short term

#### 3. Reduces pain in the medium (6-12 months)- to long (>12 months)-term

**Evidence:** High quality [21] and moderate quality [39] systematic reviews including meta-analysis reported large pain reduction with exercise therapy compared to control and placebo interventions at 12 months

#### 4. Improves function and symptoms in the medium (6-12 months)- to long (>12 months)-term

**Evidence:** High quality [21] and moderate quality [39] systematic reviews including meta-analysis reported large improvements to function and symptoms with exercise therapy compared to control and placebo interventions at 12 months



**Figure 1** Synthesis of current evidence with consensus voting and recommendations for exercise therapy. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker.



## Consensus statement

## Combined hip and knee targeted exercise therapy:

## 1. Reduces pain compared to knee targeted exercise therapy in the short-term

**Evidence:** High quality[21] and moderate quality [16] systematic reviews including meta-analysis reported small pain reduction when combining hip with knee exercises compared to knee exercises alone in the short term. One moderate quality randomised trial[32] reported earlier recovery with hip targeted compared to knee targeted exercise therapy.

## 2. Improves function compared to knee targeted exercise therapy in the short-term

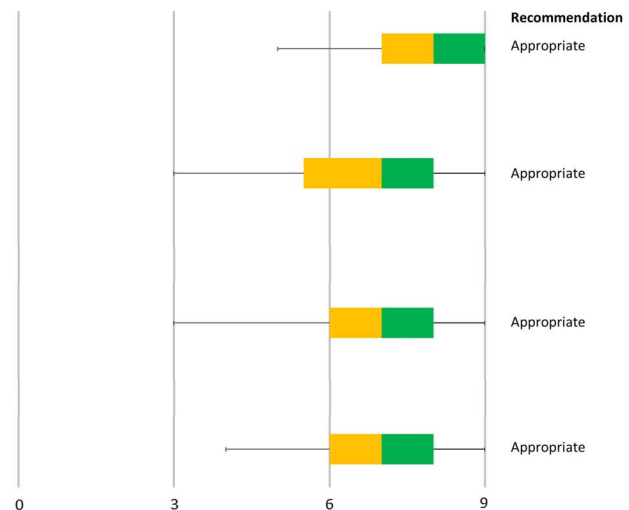
**Evidence:** When combining hip with knee exercises compared to knee exercises alone in the short term, one high quality[21] systematic review reports superior outcomes for single legged hopping but not patient reported function, whilst one moderate quality[16] systematic review reports superior outcomes for patient reported function, but not hopping.

## 3. Reduces pain compared to knee targeted exercise therapy in the medium- to long-term

**Evidence:** High quality[21] and moderate quality[16] systematic reviews reported small pain reduction when combining hip with knee exercises compared to knee exercises alone in the medium and long term

## 4. Improves function compared to knee targeted exercise therapy in the medium- to long-term

**Evidence:** When combining hip with knee exercises compared to knee exercises alone in the short term, one moderate quality[16] systematic review reports superior patient reported function outcomes in the medium and long term, whilst one high quality[21] systematic review reported no difference in the long term. High quality[21] and moderate quality[16] systematic reviews reported improvements in single legged hopping in the medium to long term.



**Figure 2** Synthesis of current evidence with consensus voting and recommendations for hip combined with knee targeted exercise therapy. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker.

The terms ‘exercise’ and ‘exercise therapy’ were discussed at length at the meeting. There is distinct lack of clarity regarding the taxonomy and reporting of exercise therapy treatments. Even when well reported, the type of exercise in the current evidence base varies with respect to the targets of the exercise (eg, strength, cardiovascular fitness, coordination/neuromuscular retraining).<sup>21</sup> Furthermore, measurement of the effectiveness of such interventions to achieve their target, such as increasing strength, endurance and neuromuscular coordination, was rarely undertaken. Perhaps most importantly, the lack of detailed description of the exercise therapy interventions limits the translation of the research findings into clinical practice. This lack of reporting rigour for exercise therapy extends to other interventions described in this consensus statement. As a result of this discussion, a recommendation was made to adopt minimum

reporting standards for patellofemoral pain studies, similar to those published for groin pain studies,<sup>45</sup> and these standards are published by Morrissey *et al.*

## Combined interventions

Combined interventions (combining exercise therapy, targeting knee and hip musculature, patellofemoral taping, mobilisation and foot orthoses) were considered appropriate for patients with patellofemoral pain, which is consistent with the strongest recommendation from the ‘Best Practice Guide’.<sup>13</sup> A combined approach to management best reflects clinical practice and provides the treating practitioner with the scope to address a number of contributing factors (not just one in isolation). However, an important recommendation made in the ‘Best Practice Guide’ regarding combined interventions is the need to

## Hip targeted exercise therapy:

## 1. Reduces pain compared to knee targeted exercise therapy in the short-term

**Evidence:** High quality[21] and moderate quality[16] systematic reviews reported small pain reductions when comparing hip with knee exercises in the short term

## 2. Improves function compared to knee targeted exercise therapy in the short-term

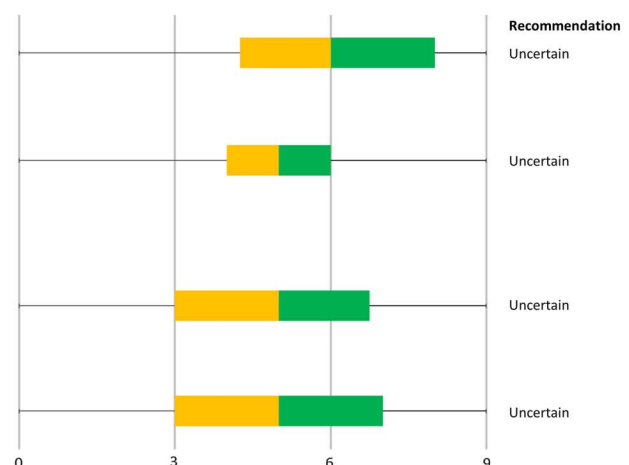
**Evidence:** When comparing hip with knee exercises, one high quality[21] systematic review reported improved patient reported function, whilst one moderate quality[16] systematic review reported no difference. One moderate quality[16] systematic review reported improved single legged hopping performance with hip exercise compared to knee exercise.

## 3. Reduces pain compared to knee targeted exercise therapy in the medium- to long-term

**Evidence:** High quality[21] and moderate quality[16] systematic reviews reported greater pain reductions when comparing hip with knee exercises in the long term

## 4. Improves function compared to knee targeted exercise therapy in the medium- to long-term

**Evidence:** High quality[21] and moderate quality[16] systematic reviews reported greater improvements in patient reported function when comparing hip with knee exercises in the long term



**Figure 3** Synthesis of current evidence with consensus voting and recommendations for hip targeted exercise therapy. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker.

**Combined interventions:****1. Reduces pain in the short term (<6 months)**

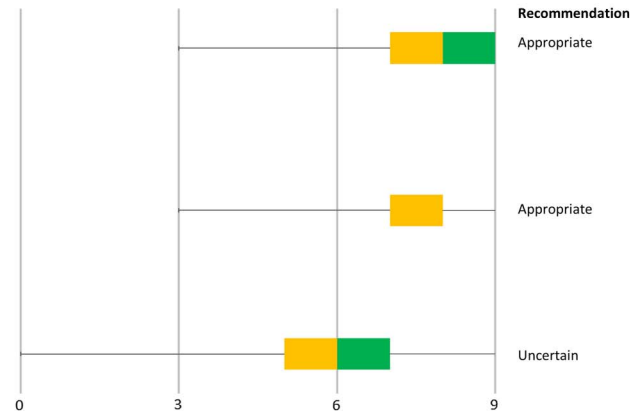
**Evidence:** A moderate quality systematic review[39] including meta-analysis reported moderate pain reduction with multimodal treatment compared to control and placebo interventions at 6 and 12 weeks. Further supporting evidence from one contemporary moderate quality randomised trial[33] supports a combined approach including taping, strengthening and stretching compared to these interventions provided independently.

**2. Reduces pain in the medium term (6-12 months)**

**Evidence:** A moderate quality systematic review[39] including meta-analysis reported small-moderate pain reduction with multimodal treatment compared to control and placebo interventions at 12 months

**3. Reduces pain in the long term (> 12 months) among adolescents with patellofemoral pain**

**Evidence:** A high quality RCT[34] reported a greater chance of recovery with the addition of exercise therapy to patient education compared to patient education alone at 12 and 24 months



**Figure 4** Synthesis of current evidence with consensus voting and recommendations for combined interventions. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker. RCT, randomised controlled trial.

individualise treatments to each patient, as not all patients will require all treatments.<sup>13</sup> Current research evidence to guide the tailoring of interventions is very limited,<sup>46</sup> and efforts to address this are encouraged. Uncertainty around the recommendation supporting combined interventions for adolescents with patellofemoral pain most likely reflected the lack of studies, as there is currently only one RCT<sup>39</sup> and no systematic reviews. Outcomes for adolescents were consistent with the pooled standardised mean difference (SMD) for a similar intervention in adults,<sup>47</sup> but the overall rates of recovery after treatment may be lower in adolescents than in adults.<sup>48</sup> We welcome further studies investigating treatment options in this group, especially given evidence of symptoms persisting well beyond adolescence.<sup>49</sup>

**Foot orthoses**

Foot orthoses were recommended for short-term pain relief in people with patellofemoral pain, and this is consistent with the 'Best Practice Guide'.<sup>13</sup> However, an important consideration is that the average pain reduction facilitated by prefabricated foot orthoses may be considered to lack clinical significance, due to substantial individual variability in response.<sup>50</sup> The key point is that foot orthoses may not be beneficial for all patients with patellofemoral pain, and identifying those most likely to benefit from foot orthoses is important. Published studies have reported clinical features that can be used to predict success with foot orthoses intervention, including greater midfoot mobility,<sup>41 51</sup>

less ankle dorsiflexion and immediate improvements in patellofemoral pain when performing a single-leg squat with foot orthoses.<sup>52</sup>

**Patellar taping**

Whether patellar taping should be first-line treatment for patellofemoral pain was unclear to this expert panel. This conclusion was consistent with the 'Best Practice Guide'<sup>13</sup> findings. Patellar taping approaches vary considerably with respect to the type and duration of taping, and the systematic reviews<sup>29-31</sup> that synthesise these studies have dealt with the variability inconsistently. Lack of clarity from systematic reviews may partially explain the uncertainty around the consensus voting and associated recommendations to support patellar taping.

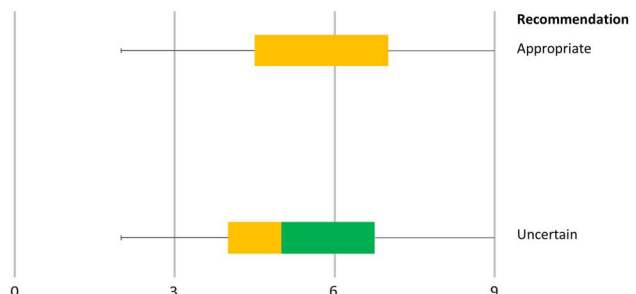
Uncertainty around the recommendations for taping might also reflect that greater consideration of individual patient needs may be required. For example, in Barton *et al*'s<sup>13</sup> synthesis, the experts described that targeting the taping to suit individual patient presentations was an important consideration. Patellar taping and bracing could play a role in patellofemoral pain management in combination with other treatments (ie, as part of a combined intervention as described above), but their role in isolation is yet to be fully determined. Other adjunctive treatments, such as joint mobilisations (patella, knee, lumbar), and electro-physical agents were not recommended for use in patellofemoral pain.

**Prefabricated foot orthoses:****1. Reduces pain in the short-term**

**Evidence:** High quality[23] and moderate quality[22] systematic reviews reported small pain reductions with prefabricated foot orthoses when compared with a placebo or control in the short term, and this has been further supported by an additional high quality randomised trial[36] comparing prefabricated foot orthoses to wait and see over 6 weeks. One additional contemporary moderate quality randomised trial[35] reported no significant difference in pain outcome between a 6mm medially and a 3 mm laterally wedged foot orthoses.

**2. Improves function in the short-term**

**Evidence:** High quality[23] and moderate quality[22] systematic reviews reported small improvements in function with prefabricated foot orthoses when compared with a placebo or control in the short term



**Figure 5** Synthesis of current evidence with consensus voting and recommendations for prefabricated foot orthoses. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker.

## Consensus statement

## Patellar taping and bracing:

**1. Tailored or untailored patellar taping to reduce pain immediately during functional tasks**

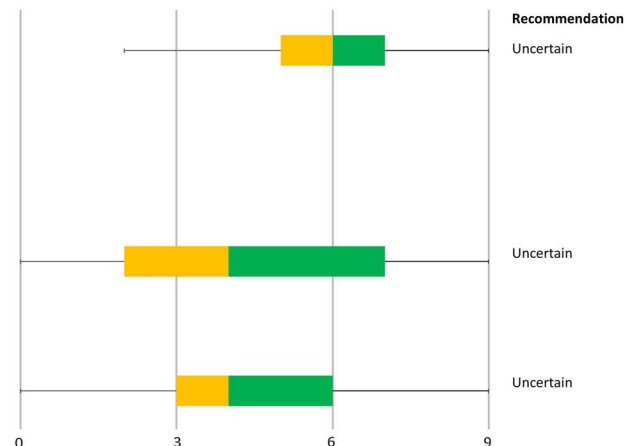
**Evidence:** One moderate quality systematic review[22] including meta-analysis reported immediate pain reduction of large effect with tailored (based on tilt, glide and rotation, with the aim of reducing pain by 50%) patellar taping, and small effect with untailored medially directed patellar taping. One contemporary moderate quality randomised cross-over trial[37] reported no difference in immediate pain outcomes between medially directed and Kinesiology Spider® taping.

**2. Combine untailored patellar taping with exercise to further reduce pain in the long-term**

**Evidence:** One high quality[26] and two moderate quality[22, 24] systematic reviews reported combining untailored medially directed patellar taping with exercise was no more effective than exercise in the long term.

**3. Patellar bracing to reduce pain in short- and medium-term**

**Evidence:** One moderate quality systematic review[24] reported no benefit of a knee brace combined with exercise compared to exercise alone, or a knee brace compared to a placebo brace in the short term.



**Figure 6** Synthesis of current evidence with consensus voting and recommendations for patellar taping and bracing. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker.

## LIMITATIONS

Our consensus on physical and exercise treatments for patellofemoral pain was limited to the treatments with evidence regarding their usefulness. The inclusion of evidence stemming from moderate-quality and high-quality systematic reviews means that not all potentially valuable interventions were covered. For example, while gait retraining shows emerging evidence supporting its use in patellofemoral pain,<sup>53</sup> more rigorous research is required before it can be considered as a recommended intervention.

Our expert panel self-selected participants who attended the International Patellofemoral Pain Research Retreat. While all participants were active in patellofemoral research and most of the productive researchers worldwide were in attendance, the panel was not specifically chosen, based on their expertise. The inclusion of researchers and clinicians is a strength (ensuring expertise with research methodology and respect for scientific

rigour) as well as a limitation (some members have no experience in patient management). Furthermore, there was no patient input into the voting on our recommendations, and we recommend that their values and preferences be considered when applying recommendations clinically.<sup>44</sup>

## FUTURE DIRECTIONS

Our consensus group recommended some future directions regarding interventions for patellofemoral pain. We recognised the need for minimum reporting standards for clinical research on patellofemoral pain, similar to that published for groin pain in athletes,<sup>45</sup> which is being undertaken. We recommended that future trials should publish details of the intervention in sufficient detail to enable clinicians to apply these in clinical practice (possibly as supplementary files). We require greater understanding of potential mechanisms underpinning treatment effects. We recognise that there is uncertainty regarding the usefulness of

## Other adjunctive interventions:

**1. Acupuncture reduces pain in the medium term**

**Evidence:** One moderate quality systematic review [39] reported acupuncture to reduce pain more than a control at 5 months

**2. PFJ and knee mobilisation improves pain or functional outcomes in the short term \***

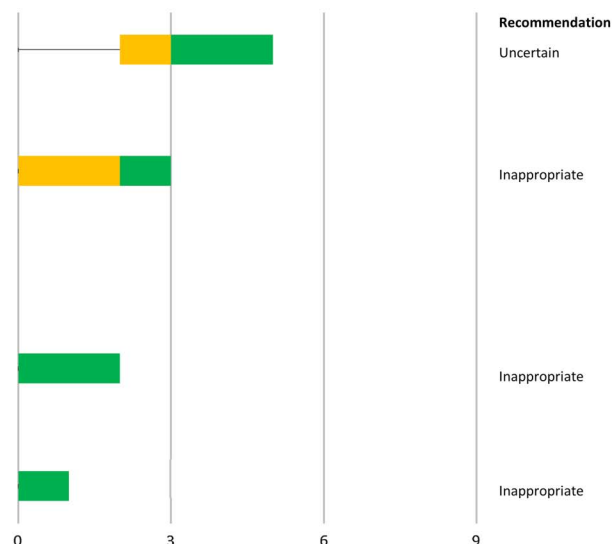
**Evidence:** One moderate quality systematic review[39] reported no improvements to pain following 2 weeks of PFJ mobilisations when compared to no intervention; and no added benefits for either knee manipulation or full lower limb kinetic chain manipulation when added to exercise and soft tissue treatment at 6 or 14 weeks. One high quality randomised trial[38] reported greater improvements in pain following 15 sessions of retro- and peripatellar ischemic pressure when compared to 15 sessions of ischemic pressure to the hip musculature, but no control group was included.

**3. Lumbar mobilisation/manipulation improves pain or functional outcomes in the short term \***

**Evidence:** One moderate quality systematic review [39] reported there was no significant effect when adding spinal manipulation to patellar mobilization over 4 weeks

**4. Electro-physical agents (e.g. ultrasound, phonophoresis, laser therapy, etc.) improves pain or functional outcomes in the short term \***

**Evidence:** One low quality systematic review[30] reported no difference between laser and sham laser; or any evidence to support the use of ultrasound and ice massage, ice bags, phonophoresis, and iontophoresis modalities



**Figure 7** Synthesis of current evidence with consensus voting and recommendations for other adjunctive interventions. First quartile=left whisker; second quartile=yellow box; median=yellow and green box intersection; third quartile=green box; fourth quartile=right whisker. \*Statement worded opposite for voting, that is, based on evidence (eg, does not improve pain).

subgroups,<sup>54</sup> or individualised (clinical reasoning) approaches to optimise treatments. As with all exercise interventions, adherence is paramount, and methods to advance adherence are urgently needed. It is still unclear which specific pain pathways (local and central pain mechanisms) are primarily involved in patellofemoral pain, but it appears that central pain mechanisms may be altered in people with patellofemoral pain.<sup>55–57</sup> This clearly indicates the need to evaluate non-mechanical interventions to address these factors in some individuals. We recommend future trials investigating interventions for patellofemoral pain across the lifespan (ie, adolescents and those with patellofemoral osteoarthritis).

There was overarching support from the International Patellofemoral Pain Research Retreat for the Enhancing the Quality And Transparency Of health Research (EQUATOR) guidelines (<http://www.equator-network.org>) for reporting, and we encourage investigators to follow the appropriate reporting guideline in future patellofemoral pain publications.

## CONCLUSION

The consensus meeting at the 4th International Patellofemoral Pain Research Retreat (Manchester 2015) provided six recommendations for use in patients with patellofemoral pain: exercise therapy, particularly combining hip and knee exercises, combined interventions and foot orthoses. Patellofemoral, knee and lumbar mobilisations and electrophysical agents were not recommended. The 5th International Patellofemoral Pain Research Retreat is scheduled for Brisbane, Australia, July 2017.

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## REFERENCES

- Wood L, Muller S, Peat G. The epidemiology of patellofemoral disorders in adulthood: a review of routine general practice morbidity recording. *Prim Health Care Res Dev* 2011;12:157–64.
- 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.
- Kannus P, Aho H, Järvinen M, et al. Computerised recording of visits to an outpatient sports clinic. *Am J Sports Med* 1987;15:79–85.
- Taunton JE, Ryan MB, Clement DB, et al. A retrospective case-control analysis of 2002 running injuries. *Br J Sports Med* 2002;36:95–101.
- Sandow MJ, Goodfellow JW. The natural history of anterior knee pain in adolescents. *J Bone Joint Surg Br* 1985;67:36–8.
- Lankhorst NE, van Middelkoop M, Crossley K, et al. Factors that predict a poor outcome 5–8 years after the diagnosis of patellofemoral pain: a multicentre observational analysis. *Br J Sports Med* 2016;50:881–86.
- Collins NJ, Bierma-Zeinstra SM, Crossley KM, et al. Prognostic factors for patellofemoral pain: a multicentre observational analysis. *Br J Sports Med* 2013;47:227–33.
- Rathleff MS, Rathleff CR, Olsen JL, et al. Is knee pain during adolescence a self-limiting condition?: prognosis of patellofemoral pain and other types of knee pain. *Am J Sports Med* 2016;44:1165–71.
- Hall R, Barber Foss K, Hewett TE, et al. Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. *J Sport Rehabil* 2015;24:31–5.
- Myer GD, Ford KR, Barber Foss KD, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. *Clin Biomech (Bristol, Avon)* 2010;25(7):700–7.
- Rathleff MS, Skuldbøl SK, Rasch MN, et al. Care-seeking behaviour of adolescents with knee pain: a population-based study among 504 adolescents. *BMC Musculoskelet Disord* 2013;14:225.
- Boling M, Padua D, Marshall S, et al. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scand J Med Sci Sports* 2010;20:725–30.
- Barton CJ, Lack S, Hemmings S, et al. The 'Best practice guide to conservative management of patellofemoral pain': incorporating level 1 evidence with expert clinical reasoning. *Br J Sports Med* 2015;49:923–34.
- McAlindon TE, Bannuru RR, Sullivan MC, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. *Osteoarthritis Cartilage* 2014;22:363–88.
- Bolgia 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.
- Clijns R, Fuchs J, Taeymans J. Effectiveness of exercise therapy in treatment of patients with patellofemoral pain syndrome: systematic review and meta-analysis. *Phys Ther* 2014;94:1697–708.
- 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.
- 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.
- Harvie D, O'Leary T, Kumar S. A systematic review of randomized controlled trials on exercise parameters in the treatment of patellofemoral pain: what works? *J Multidiscip Healthc* 2011;4:383–92.
- Kooiker L, van de Port IG, Weir A, et al. Effects of physical therapist-guided quadriceps-strengthening exercises for the treatment of patellofemoral pain syndrome: a systematic review. *J Orthop Sports Phys Ther* 2014;44:391–B1.
- Lack S, Barton C, Sohan O, et al. Proximal Muscle Rehabilitation is effective for patellofemoral pain: a systematic review with meta-analysis. *Br J Sports Med* 2015;49:1365–76.
- Nobre T. Comparison of exercise open kinetic chain and closed kinetic chain in the rehabilitation of patellofemoral dysfunction: an updated revision. *Clin Med Diagn* 2012;2:7–11.
- Page P. Effectiveness of elastic resistance in rehabilitation of patients with patellofemoral pain syndrome: what is the evidence? *Sports Health* 2011;3:190–4.
- Peters JS, Tyson NL. Proximal exercises are effective in treating patellofemoral pain syndrome: a systematic review. *Int J Sports Phys Ther* 2013;8:689–700.
- Regelski C, Ford B, Hoch M. Hip strengthening compared with quadriceps strengthening in conservative treatment of patients with patellofemoral pain: a critically appraised topic. *Int J Athl Ther Train* 2015;20:4–12.
- van der Heijden RA, Lankhorst NE, van Linschoten R, et al. Exercise for treating patellofemoral pain syndrome. *Cochrane Database Syst Rev* 2015;1:CD010387.
- 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.
- Hossain M, Alexander P, Burls A, et al. Foot orthoses for patellofemoral pain in adults. *Cochrane Database Syst Rev* 2011;(1):CD008402.
- Swart NM, van Linschoten R, Bierma-Zeinstra SM, 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.
- Barton C, Balachandrar V, Lack S, et al. Patellar taping for patellofemoral pain: a systematic review and meta-analysis to evaluate clinical outcomes and biomechanical mechanisms. *Br J Sports Med* 2014;48:417–24.
- Callaghan MJ, Selfe J. Patellar taping for patellofemoral pain syndrome in adults. *Cochrane Database Syst Rev* 2012;4:CD006717.
- Kalron A, Bar-Sela S. A systematic review of the effectiveness of Kinesio Taping—fact or fashion? *Eur J Phys Rehabil Med* 2013;49:699–709.
- Brantingham JW, Bonnefin D, Perle SM, et al. Manipulative therapy for lower extremity conditions: update of a literature review. *J Manipulative Physiol Ther* 2012;35:127–66.
- Dos Santos R, Souza M, Dos Santos F. Neuromuscular electric stimulation in patellofemoral dysfunction: literature review. *Acta Orthop Bras* 2013;21:52–8.



## Consensus statement

- 35 Lake DA, Wofford NH. Effect of therapeutic modalities on patients with patellofemoral pain syndrome: a systematic review. *Sports Health* 2011;3:182–9.
- 36 Wasielewski NJ, Parker TM, Kotsko KM. Evaluation of electromyographic biofeedback for the quadriceps femoris: a systematic review. *J Athl Train* 2011;46:543–54.
- 37 Ferber R, Bolgia L, Earl-Boehm JE, et al. Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: a multicenter randomized controlled trial. *J Athl Train* 2015;50:366–77.
- 38 Mason M, Keays SL, Newcombe PA. The effect of taping, quadriceps strengthening and stretching prescribed separately or combined on patellofemoral pain. *Physiother Res Int* 2011;16:109–19.
- 39 Rathleff MS, Roos EM, Olesen JL, et al. Exercise during school hours when added to patient education improves outcome for 2 years in adolescent patellofemoral pain: a cluster randomised trial. *Br J Sports Med* 2015;49:406–12.
- 40 Lewinson RT, Wiley JP, Humble RN, et al. Altering knee abduction angular impulse using wedged insoles for treatment of patellofemoral pain in runners: a six-week randomized controlled trial. *PLoS ONE* 2015;10:e0134461.
- 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 Osorio JA, Vairo GL, Rozea GD, et al. The effects of two therapeutic patellofemoral taping techniques on strength, endurance, and pain responses. *Phys Ther Sport* 2013;14:199–206.
- 43 Hains G, Hains F. Patellofemoral pain syndrome managed by ischemic compression to the trigger points located in the peri-patellar and retro-patellar areas: a randomized clinical trial. *Clin Chiropr* 2010;13:201–9.
- 44 Barton CJ, Crossley KM. Sharing decision-making between patient and clinician: the next step in evidence-based practice for patellofemoral pain? *Br J Sports Med* 2016;50:833–4.
- 45 Delahunt E, Thorborg K, Khan KM, et al. Minimum reporting standards for clinical research on groin pain in athletes. *Br J Sports Med* 2015;49:775–81.
- 46 Lack S, Barton C, Vicenzino B, et al. Outcome predictors for conservative patellofemoral pain management: a systematic review and meta-analysis. *Sports Med* 2014;44:1703–16.
- 47 Collins NJ, Bisset LM, Crossley KM, et al. Efficacy of nonsurgical interventions for anterior knee pain: systematic review and meta-analysis of randomised trials. *Sports Med* 2012;42:31–49.
- 48 Rathleff MS, Vicenzino B, Middelkoop M, et al. Patellofemoral pain in adolescence and adulthood: same same, but different? *Sports Med* 2015;45:1489–95.
- 49 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.
- 50 Collins N, Crossley K, Beller E, et al. Foot orthoses and physiotherapy in the treatment of patellofemoral pain syndrome: randomised clinical trial. *BMJ* 2008; 337:a1735.
- 51 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.
- 52 Barton CJ, Menz HB, Crossley KM. Clinical predictors of foot orthoses efficacy in individuals with patellofemoral pain. *Med Sci Sports Exerc* 2011;43: 1603–10.
- 53 Neal BS, Barton CJ, Gallie R, et al. Runners with patellofemoral pain have altered biomechanics which targeted interventions can modify: a systematic review. *Gait Posture* 2016;45:69–82.
- 54 Selfe J. "Measurement properties of patient-reported outcome measures (PROMS) in patellofemoral pain syndrome: a systematic review." Green et al. (in press corrected proof). *Man Ther* 2015;20:e6.
- 55 Rathleff MS, Roos EM, Olesen JL, et al. Lower mechanical pressure pain thresholds in female adolescents with patellofemoral pain syndrome. *J Orthop Sports Phys Ther* 2013;43:414–21.
- 56 Rathleff MS, Petersen KK, Arendt-Nielsen L, et al. Impaired conditioned pain modulation in young female adults with long-standing patellofemoral pain: a single blinded cross-sectional study. *Pain Med* 2015;17:980–8.
- 57 Noehren B, Shuping L, Jones A, et al. Somatosensory and biomechanical abnormalities in females with patellofemoral pain. *Clin J Pain* 2015. epub ahead of print PMID:26626291