Females with patellofemoral pain syndrome have weak hip muscles: a systematic review

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Question: Do females with patellofemoral pain syndrome have decreased hip muscle strength compared with the unaffected side and with healthy controls? **Design**: A systematic review of observational studies published up to January 2008. **Participants**: Females with patellofemoral pain syndrome and healthy controls. **Outcome measures**: Strength for at least one hip muscle group had to be included in the study. Hip muscle strength was recorded as force or torque. **Results**: Five cross-sectional studies with a mean Newcastle-Ottawa Assessment Scale score of 6 out of 9 met the inclusion criteria. Strong evidence was found for a deficit in hip external rotation, abduction and extension strength, moderate evidence for a deficit in hip flexion and internal rotation strength, and no evidence for a deficit in hip adduction strength compared with healthy controls. Moderate evidence was found for a decrease in hip external rotation and abduction strength but no evidence for a decrease in hip extension, flexion, adduction and internal rotation strength compared with the unaffected side. **Conclusion**: Females with patellofemoral pain syndrome demonstrate a decrease in abduction, external rotation and extension strength of the affected side compared with healthy controls. **[Prins MR, Wurff van der P (2009) Females with patellofemoral pain syndrome have weak hip muscles: a systematic review. *Australian Journal of Physiotherapy* 55: 9–15]**

Key words: Patellofemoral pain syndrome, Hip, Muscle strength, Female, Systematic review

Introduction

Patellofemoral pain syndrome is a common orthopaedic complaint frequently seen in physiotherapy practice. The syndrome occurs particularly in athletes (Fredericson and Yoon 2006). In a study among 2002 people with running injuries, it was the most common disorder, accounting for 17% of the cases (Wilson 2007). Reliable clinical diagnostic tests are unavailable so the diagnosis of the disorder is made by exclusion of intra-articular pathologies, patellar tendinopathy, peripatellar bursitis, plica syndrome, Sinding-Larsen-Johansson, and Osgood-Slatter lesions (Ivkovic et al 2007, Thomee et al 1999). Several factors have been proposed to cause patellofemoral pain syndrome such as patellar malalignment (Fredericson and Yoon 2006, Powers 2003), an increased Q-angle (Elias et al 2004, Fredericson and Yoon 2006, Mizuno et al 2001, Naslund et al 2006), quadriceps weakness (Fredericson and Yoon 2006, Thomee et al 1995), decreased flexibility of the lower extremity (Fredericson and Yoon 2006, Piva et al 2005), overuse (Thomee et al 1999), and muscle imbalance (Thomee et al 1995) which have all been shown to result in an increase in cartilage and subchondral bone stress (Fredericson and Yoon 2006). However, only modest evidence exists in support of these proposals and there is little information about the nature of these potentially causal factors (Fredericson and Yoon 2006, Wilson 2007).

Wilson (2007) showed that females (62% of cases) are significantly more at risk of experiencing patellofemoral pain syndrome than men (38% of cases). It has been suggested that anatomic, hormonal, and neuromuscular factors contribute to the greater risk, with the anatomic factor being the most widely discussed (Arendt 2007). One of the neuromuscular factors may be a deficit in hip muscle strength. Cibulka and Threlkeld-Watkins (2005) postulated that hip muscle strength plays a major role in the development of patellofemoral pain syndrome. Leetun et al (2004) demonstrated that females have less hip external rotation and abduction strength than men. Athletes who sustained a lower extremity injury during the season had a significant deficit in hip abduction and external rotation strength at the beginning of the season compared with those not sustaining an injury. While this study supports the hypothesis that a decrease in hip muscle strength is more likely to result in injury, the diagnoses of the injuries were not presented. Therefore, it remains unclear if deficits in hip muscle strength contribute to the development of patellofemoral pain syndrome.

Cichanowski et al (2007) and Ireland et al (2003) theorised that the kinematics of the lower extremity might change as a result of deficits in hip muscle strength. Females show a greater internal rotation of the femur during running than men and also have a tendency to larger hip adduction during activities such as running and single leg drop (Ferber et al 2003, Hewett et al 2006, Russell et al 2006). Powers (2003) suggested that larger hip adduction and internal rotation during weight bearing can lead to increased lateral patellar contact pressure as a result of an increase in the dynamic Q-angle. The Q-angle is formed by the intersection of the line drawn form the anterior superior iliac spine to the midpoint of the patella and a proximal extension of the line drawn from the tibial tubercle to the midpoint of the patella. Studies show that people with patellofemoral pain syndrome exhibit different kinematics of the lower extremity compared with healthy controls. During a weight bearing squat, the femur of people with patellofemoral pain syndrome tends to be more internally rotated (MacIntyre et al 2006, Powers 2003). The femur rotates underneath the patella displacing the patella laterally relative to the femur thus decreasing patellofemoral contact area (Powers 2003, Powers et al

2003, Lee et al 2003). As a result, patellofemoral contact pressure will increase on the lateral facets of the patella (Lee et al 2003, Salsich and Perman 2007). Repetition of these abnormal motions can sooner or later result in pain by overloading the patellar structures (Cichanowski et al 2007, Ireland et al 2003). An increased lateral displacement of the patella during a weight bearing squat of the knee in people with patellofemoral pain syndrome has been reported by some (MacIntyre et al 2006, Powers 2003), but not all, authors (Wilson 2007). Only one study has been performed in which participants with patellofemoral pain syndrome received hip muscle strengthening and flexibility exercises (Tyler et al 2006). After six weeks, 26 (60%) of extremities had improved. However, since a control group was not included this study provides limited evidence.

Bolgla et al (2008) tested the hypothesis that normal hip abductor and external rotator strength compensates for the tendency of the femur to internally rotate during weightbearing. They measured kinematics of the lower extremity in people with patellofemoral pain syndrome during stair descent and found no significant differences in kinematics compared with healthy controls. They concluded that the task was not challenging enough and that differences might occur during more intensive tasks such as a single leg drop. However, as yet, no study has been performed to support this conclusion.

Therefore, the specific research questions for this study were:

1. Do females with patellofemoral pain syndrome have decreased hip muscle strength compared with healthy controls?
2. Do females with patellofemoral pain syndrome have decreased hip muscle strength compared with the unaffected side?

A systematic review of observational studies was carried out to answer this question.

Method

Identification and selection of studies

In order to identify relevant literature, we conducted a comprehensive search in the PubMed, EMBASE, and PEDro databases, from the beginning of these databases up to January 2008. The full search strategy was developed in collaboration with an experienced librarian using a filter outlined by Deville et al (2000). However, using this filter in a preliminary search resulted in only a few hits in the area of the patellofemoral pain syndrome. Therefore, we broadened our search as outlined in Appendix 1 (see eAddenda for Appendix 1). We applied no restrictions with regard to year of publication or language. Case series and case reports, as well as animal and cadaveric studies, were excluded. Additionally, the reference sections of all articles selected for the review were scanned for potentially-relevant articles that were not identified by the original search.

Studies were selected using predetermined criteria (Box 1). To be included, studies had to investigate hip muscle strength of at least one muscle group in females diagnosed with patellofemoral pain syndrome. Studies were not selected on reported strength parameters. If both males and females were measured, studies had to report a subgroup analysis for female participants as well. Eligibility of studies on the basis of title, keywords and abstract was determined by the first author (MP). If uncertainty remained, the full text was reviewed. Selected articles were assessed and discussed by both authors and differences in judgment were resolved through a consensus procedure. Justifications for excluding studies were noted and discrepancies discussed. If no consensus was reached, a final decision was made by a third reviewer. The authors were not blinded to the name of the authors of the papers. Since the first author was not familiar with any formerly published work about the patellofemoral pain syndrome, we expected this would not influence the selection of studies.

Box 1. Inclusion criteria

- Studies in peer reviewed journals
- No language restriction
- Human participants
- Participants presenting with patellofemoral pain syndrome
- Solely female participants or subgroup reported

Assessment of characteristics of studies

Quality: Two reviewers (MP, PvdW) assessed the quality of included studies using the Newcastle-Ottawa Scale for assessing the quality of nonrandomised studies in meta-analyses. Methods to assess the quality of observational studies have not been well worked out, and, although several assessment scales and checklists exist, none of them has been fully validated or shown to include criteria that are associated with the effect size (outcome) in empiric studies. The Newcastle-Ottawa Scale is quite comprehensive and has been partly validated (Wells et al 2001). The Newcastle-Ottawa Scale assesses nine criteria, and included studies were awarded 'yes' for each criterion that was clearly satisfied. Disagreement or indistinct issues were resolved by consensus or consultation with a third reviewer.

Participants: Age of participants with patellofemoral pain syndrome as well as of healthy controls was collected in order to evaluate the similarity of studies.

Measurement of hip muscle strength: Body position, type of proximal fixation, muscle action used, trials performed per muscle group, measuring instrument used, measurement units reported and process of normalisation used were collected in order to evaluate the similarity of studies.

Data analysis

The first author (MP) extracted data from each included study using a standard form developed for the review by both reviewers. The extracted data was checked by the second author (PvdW). If data were not available to calculate mean differences (95% CI), we requested additional information from the authors.

For the purpose of interpretation of results, the following levels of evidence were used (van Tulder et al 2003):
Strong evidence = consistent findings among multiple high quality studies (6 out of 9 on the Newcastle-Ottawa Scale);
Moderate evidence = consistent findings among multiple lower quality studies and/or one higher quality study;
Limited evidence = one lower quality study;
Conflicting evidence = inconsistent findings amongst multiple studies;
No evidence = no evidence among studies.

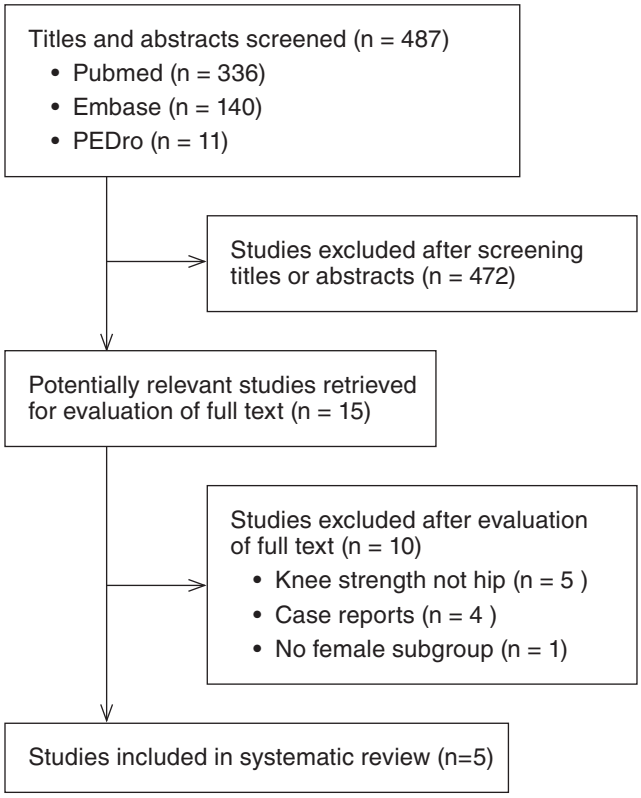

Figure 1. Flow of studies through the review.

Results

Flow of studies through the review

In a PubMed database search we identified 336 potentially relevant articles. We excluded 324 studies on the basis of their titles and abstracts. Subsequently, we retrieved and reviewed 12 full reports for possible inclusion (Alaca et al 2002, Bolgla et al 2008, Callaghan et al 2000, Cibulka and Threlkeld-Watkins 2005, Cichanowski et al 2007, Hazneci et al 2005, Ireland et al 2003, Mascal et al 2003, Piva et al 2005, Robinson and Nee 2007, Thomee et al 1995, Tyler et al 2006). Four studies were excluded because they examined muscle strength of the knee flexors and extensors and not the hip muscles (Alaca et al 2002, Callaghan et al 2000, Hazneci et al 2005, Thomee et al 1995). Two studies appeared to be case reports (Cibulka and Threlkeld-Watkins 2005, Mascal et al 2003). One study investigated hip muscle strength in both men and females; however, the authors did not report the data on females separately (Tyler et al 2006). This resulted in five cross-sectional studies which fulfilled our inclusion criteria (Bolgla et al 2008, Cichanowski et al 2007, Ireland et al 2003, Piva et al 2005, Robinson and Nee 2007). A comprehensive search in the Embase and PEDro databases resulted in 352 and 11 hits respectively. After eliminating duplicates from PubMed, 140 references remained, of which only three full articles were included for further evaluation. However, none was included for this review because two studies were case reports (Fulkerson 2002, Whyte Ferguson 2006) and the other study only investigated knee muscles (Tiggelen van et al 2004). Agreement between the two reviewers was high (89%). All disagreements were resolved by consensus. Figure 1 shows the process of study selection and the number of studies excluded at each stage, with reasons for exclusion.

Table 1. Quality of included studies.

Study	Adequate definition	Representative cases	Selection controls	Definition controls	Comparability (important factor)	Comparability (additional factor)	Exposure ascertained	Same method ascertained	Non-response rate	Total (0 to 9)
Bolgla et al (2008)	Y	N	Y	N	Y	Y	Y	Y	Y	7
Cichanowski et al (2007)	Y	N	Y	N	Y	Y	Y	Y	Y	7
Robinson and Nee (2007)	Y	Y	Y	N	N	N	Y	Y	Y	6
Piva et al (2005)	Y	N	N	N	Y	N	Y	Y	Y	5
Ireland et al (2003)	Y	N	Y	N	Y	N	Y	Y	Y	6

Table 2 Summary of included studies.

Study	Participants		Measurement of hip muscle strength using handheld dynamometry					
	PFPS	Control	Body position	Proximal fixation	Muscle action	Trials per muscle group	Measurement units	Units normalised to
Bolgla et al (2008)	n = 18 Age (*yr*) = 25 (SD 3)	n = 18 Age (*yr*) = 24 (SD 3)	Abd = Side lying Ext rot = Sitting unsupported	Stabilisation straps	Isometric max (make test)	Average of 3	Torque	Height and Weight
Cichanowski et al (2007)	n = 13 Age (*yr*) = 19 (SD 1)	n = 13 Age (*yr*) = 20 (SD 1)	Ext rot, int rot, flex = Sitting unsupported Extension = Prone knee extended Abd, add = Side lying (hip neutral)	Manual	Isometric max (make test)	Best of 2	Force	Weight
Robinson and Nee (2007)	n = 10 Age (*yr*) = 21 (range 12–34)	n = 10 Age (*yr*) = 27 (range 16–35)	Abd = Side lying with grasp, slight external rotation hip Extension = Prone (knee 90° flexion slight external rotation hip) Ext rot = Sitting with grasp	Manual	Isometric max (make test)	Average of 3	Force	Weight
Piva et al (2005)	n = 16 Age (*yr*) = 26 (SD 6)	n = 17 Age (*yr*) = 26 (SD 6)	Ext rot = Prone Abd = Side lying (hip neutral)	Manual	Isometric max (make test)	Average of 2	Force	Weight
Ireland et al (2003)	n = 15 Age (*yr*) = 16 (SD 3)	n = 15 Age (*yr*) = 16 (SD 3)	Abd = Side lying Ext rot = Sitting unsupported	Stabilisation straps	Isometric max (make test)	Best of 1	Force	Weight

PFPS = Patellofemoral pain syndrome, Abd = abduction, Ext rot = external rotation, Int rot = internal rotation, Flex = flexion, Add = adduction

Characteristics of the studies

Quality: One study (Piva et al 2005) scored less than 6 out of 9, and overall there was a mean Newcastle-Ottawa Scale score of 6 out of 9. The scores on each of the nine criteria and total scores for each study are presented in Table 1. In general, blinded application of the strength measurements was not provided and the representativeness of the cases and the definition of the controls were unsatisfactory.

Participants: In four studies (Bolgla et al 2008, Cichanowski et al 2007, Ireland et al 2003, Robinson and Nee 2007) all participants were female. One study (Piva et al 2005) examined both males and females. The mean age of participants ranged from 16 (SD 3) years (Ireland et al 2003) to 27 (range 16 to 35) years (Robinson and Nee 2007). Table 2 provides a summary of participant characteristics.

Measurement of hip muscle strength: All studies measured hip muscle strength of the affected leg of participants with patellofemoral pain syndrome and compared it to a control group. Two studies also compared the affected leg with the uninvolved limb in the same participants (Cichanowski et al 2007, Robinson and Nee 2007). In all five studies hip abduction and external rotation muscle strength were measured. Cichanowski et al (2007) and Robinson and Nee (2007) investigated extension strength. Flexion, adduction, and internal rotation strength were exclusively tested by Cichanowski et al (2007). All studies measured peak hip muscle strength using a handheld dynamometer. Three authors (Cichanowski et al 2007, Piva et al 2005, Robinson and Nee 2007) handled the dynamometer manually, and two authors (Bolgla et al 2008, Ireland et al 2003) used stabilisation straps. All authors tested the maximum isometric strength using the make test. Both the participants' body position and whether the trunk was supported during the measurement differs between studies.

Most studies performed multiple tests on each muscle group (Bolgla et al 2008, Cichanowski et al 2007, Piva et al 2005, Robinson and Nee 2007). The study by Bolgla et al (2008) is the only one to calculate units of torque applied to the handheld dynamometer instead of using units of force. Three studies (Bolgla et al 2008, Piva et al 2005, Robinson and Nee 2007) calculated the average strength from multiple tests, the other two studies (Cichanowski et al 2007, Ireland et al 2003) used maximum strength. All studies normalised strength to body weight ([Force (N) / body weight (N)] × 100) and reported it as a percentage of body weight before comparison between groups. After comparing the affected leg of participants with patellofemoral pain syndrome to their unaffected leg Robinson and Nee (2007) reported the Limb Symmetry Index ([strength in the affected limb / strength in the unaffected limb] × 100) instead of normalised strength data for both limbs. On our request, all authors responded and four submitted additional data (Bolgla et al 2008, Cichanowski et al 2007, Ireland et al 2003, Piva et al 2005). Values that were still missing were calculated where possible. Table 2 provides a summary of measurement procedures.

Strength of hip muscles versus healthy controls

The strength of hip muscles versus healthy controls is presented in Table 3. The data from individual trials were not pooled to determine a weighted estimate due mainly to clinical heterogeneity. All studies reported a decrease in muscle strength for all hip muscles measured, although not all decreases were statistically significant. Five studies reported a decrease in external rotation strength, four of

Table 3 Mean (SD) hip muscle strength (% of body weight) for each group and mean (95% CI) difference between groups.

Study	Groups		Difference between groups
	PFPS	Control	PFPS minus control
External rotation			
Bolgla et al (2008)	11 (3)	15 (3)	–4 (–6 to –2), –24%
Cichanowski et al (2007)	17 (4)	20 (3)	–3 (–6 to 0), –15%
Robinson and Nee (2007)	16 (6)	23 (4)	–7 (–12 to –2), –30%
Piva et al (2005)	21 (4)	22 (5)	–1 (–5 to 2), –5%
Ireland et al (2003)	11 (4.0)	17 (6)	–6 (–10 to –2), –36%
Abduction			
Bolgla et al (2008)	23 (6)	30 (10)	–8 (–13 to –2), –26%
Cichanowski et al (2007)	29 (8)	37 (6)	–8 (–14 to –2), –21%
Robinson and Nee (2007)	16 (8)	22 (3)	–6 (–12 to –1), –27%
Piva et al (2005)	18 (9)	20 (4)	–2 (–7 to 2), –12%
Ireland et al (2003)	23 (7)	31 (6)	–8 (–13 to –3), –26%
Extension			
Cichanowski et al (2007)	30 (8)	36 (5)	–6 (–11 to –1), –16%
Robinson and Nee (2007)	23 (9)	48 (13)	–25 (–36 to –14), –52%
Flexion			
Cichanowski et al (2007)	27 (7)	33 (5)	–6 (–10 to –1), –17%
Adduction			
Cichanowski et al (2007)	20 (7)	24 (4)	–4 (–8 to 1), –16%
Internal rotation			
Cichanowski et al (2007)	18 (4)	21 (3)	–3 (–6 to 0), –15%

PFPS = patellofemoral pain syndrome

which were significant decreases, with deficits ranging from 5% to 36%. Five studies reported a decrease in abduction strength, four of which were significant decreases, with deficits ranging from 12% to 27%. Two studies reported a decrease in extension strength, both of which were significant, with deficits of 16% and 52%. One study reported a significant decrease in flexion strength of 17% and internal rotation strength of 15% and a non-significant decrease in adduction strength of 16%.

Strength of hip muscles versus unaffected side

The strength of hip muscles versus unaffected side is presented in Table 4. The data from individual trials were not pooled to determine a weighted estimate due mainly to clinical heterogeneity. The two studies reporting hip muscle strength of the unaffected side, mostly reported a decrease in hip muscle strength compared with the unaffected side, although not all were statistically significant. In one study, significance could not be estimated because of missing SD values. Both studies reported a decrease in external rotation strength, with deficits of 7% and 21%. Both studies reported a decrease in abduction strength, with deficits of 12% and 22%. Both studies reported a decrease in extension strength, with deficits of 2% and 29%. One study reported a non-significant decrease in flexion strength of 3% and internal rotation strength of 6% and a non-significant increase in adduction strength of 2%.

Discussion

This study aimed to investigate whether females with patellofemoral pain syndrome have decreased hip muscle strength compared with the unaffected side or with healthy controls. In general, the results of this review show that there are deficits in hip muscle strength in females with patellofemoral pain syndrome. Strong evidence was found for a decrease in hip external rotation, abduction, and extension strength, moderate evidence for a decrease in flexion and internal rotation strength, but no evidence for a decrease in hip adduction strength compared with healthy controls. Moderate evidence was found for a decrease in hip external rotation and abduction strength, but no evidence for a decrease in hip extension, flexion, adduction, and internal rotation strength compared with the unaffected side.

All studies reported a decrease in hip abduction and external rotation strength of the affected leg of participants with patellofemoral pain syndrome. However, considerable differences in the size of the deficits were observed depending on the comparison – healthy controls or the unaffected side. Both Cichanowski et al (2007) and Robinson and Nee (2007) reported substantial deficits in the strength of the affected hip muscles compared with healthy controls, but smaller deficits when compared with the unaffected side. Perhaps participants with patellofemoral pain syndrome preserve their knees by undertaking smaller amounts of daily activities thus developing a muscle strength deficit in both hips. Another explanation is that participants with patellofemoral pain syndrome already have less muscle strength in both hips before developing patellofemoral pain syndrome in one leg, which would make them more likely to develop patellofemoral pain syndrome in the unaffected leg in the long term.

Only one study (Piva et al 2005) did not report a significant decrease in external rotation nor abduction strength in participants with patellofemoral pain syndrome compared to healthy controls. Maybe this was due to the use of different body positions during measurement of muscle strength. Piva et al (2005) measured external rotation

Table 4 Mean (SD) hip muscle strength (% of body weight) for each side and mean difference (95% CI) between sides.

Study	Sides		Difference between sides
	PFPS side	Unaffected side	PFPS side minus unaffected side
External rotation			
Cichanowski et al (2007)	17 (4)	18 (4)	–1 (–2 to 0), –7%
Robinson and Nee (2007)	16 (6)	20# (*)	–4, –21%
Abduction			
Cichanowski et al (2007)	29 (8)	33 (7)	–4 (–6 to –2), –12%
Robinson and Nee (2007)	16 (8)	21# (*)	–5, –22%
Extension			
Cichanowski et al (2007)	30 (8)	31 (9)	–1 (–2 to 1), –2%
Robinson and Nee (2007)	23 (9)	32# (*)	–9, –29%
Flexion			
Cichanowski et al (2007)	27 (7)	28 (6)	–1 (–3 to 1), –3%
Adduction			
Cichanowski et al (2007)	20 (7)	20 (5)	0 (–1 to 2), 2%
Internal rotation			
Cichanowski et al (2007)	18 (4)	19 (4)	–1 (–3 to 0), –6%

PFPS = patellofemoral pain syndrome, # = hip muscle strength of unaffected side reported as (100 x PFPS side) / Limb Symmetry Index, * = SD not reported

strength in prone with the hip in neutral, whereas the other four studies measured this strength in sitting with both hips flexed to 90 degrees. These two positions produce different lines of actions for some muscles which could have an effect on their ability to generate force.

Since all the included studies were cross-sectional, it remains unclear if the deficits in hip muscle strength are the cause or effect of patellofemoral pain syndrome. Furthermore, in none of the studies was muscle endurance of the hip the subject of investigation. Deficits in muscle endurance may be an important causal factor in the development of patellofemoral pain syndrome since the syndrome occurs predominantly in endurance sports. Perhaps the hip muscles of participants with patellofemoral pain syndrome have a greater deficit in endurance than strength. In addition, these cross-sectional studies do not provide any evidence about the usefulness of increasing hip muscle strength in patellofemoral pain syndrome. Future research is desirable to investigate these questions.

This review has some limitations. There was quite a degree of variability between the methods of the included studies. Two studies (Cichanowski et al 2007, Robinson and Nee 2007) compared the affected side with the unaffected side as well as with the hips of healthy controls, while three studies (Bolgla et al 2008, Ireland et al 2003, Piva et al 2005) compared the affected side only with the hips of healthy controls. Three studies stabilized the pelvis or upper leg manually during testing, in contrast to Ireland et al (2003) and Bolgla et al (2008) who used stabilisation straps. These two studies also operated the handheld dynamometer with stabilisation straps; in the other studies it was operated manually. The position of participants during hip muscle strength measurement differs between studies, particularly during the measurement of hip external rotation strength. One study (Piva et al 2005) measured external rotation strength with participants in prone, one study (Robinson and Nee 2007) with participants in sitting with trunk support, and three studies (Bolgla et al 2008, Cichanowski et al 2007, Ireland et al 2003) with participants sitting unsupported. Because of this variability and the fact that there were insufficient data reported for some hip muscles, no meta-analysis was implemented. However, all studies reported deficits in hip muscle strength in participants with patellofemoral pain syndrome compared with healthy controls.

In conclusion, we found strong evidence for a decrease in hip external rotation, abduction, and extension strength, moderate evidence for a decrease in flexion and internal rotation strength, but no evidence for a decrease in hip adduction strength compared with healthy controls. Evidence for a decrease in hip muscle strength compared with the unaffected side was weaker. Longitudinal studies are needed to ascertain whether this decrease in hip muscle strength is a cause or effect of patellofemoral pain syndrome. Furthermore, studies are warranted to investigate the effect of increasing the strength of hip muscles in patellofemoral pain syndrome, particularly in external rotation, abduction and extension. ■

eAddenda: Appendix 1 at AJP.physiotherapy.asn.au

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