Journal of Physiotherapy 71 (2025) 8–17

Journal of PHYSIOTHERAPY

journal homepage: www.elsevier.com/locate/jphys

Invited Topical Review

# Physiotherapy management of patellofemoral pain in adolescents

Michael Skovdal Rathleff [a,b,c], Natalie J Collins [d,e]

[a] Department of Health Science and Technology, Aalborg University, Aalborg, Denmark; [b] Center for General Practice at Aalborg University, Aalborg, Denmark; [c] Department of Physiotherapy and Occupational Therapy, Aalborg University Hospital, Aalborg, Denmark; [d] School of Health and Rehabilitation Sciences: Physiotherapy, The University of Queensland, Brisbane, Australia; [e] La Trobe Sport and Exercise Medicine Research Centre, La Trobe University, Melbourne, Australia

KEY WORDS

Patellofemoral pain syndrome
Adolescence
Physical therapy

**[Rathleff MS, Collins NJ (2025) Physiotherapy management of patellofemoral pain in adolescents. *Journal of Physiotherapy* 71:8–17]**



## Introduction

Patellofemoral pain (PFP) is the most prevalent non-traumatic knee pain condition in adolescents. It affects 6 to 7% of school-aged adolescents, with a higher prevalence among girls and those participating in sports.[1] The impact of PFP on adolescents is substantial as it affects their physical function, quality of life and social activities.[2] Adolescents with PFP often report moderate to severe pain that restricts participation in sports and recreational activities.[3] In many cases, this restriction extends beyond physical limitations, influencing social interactions and emotional well-being due to the inability to fully engage in peer-related activities.[2] Prospective cohort studies have shown that a considerable proportion of adolescents with PFP continue to experience symptoms years after their initial diagnosis.[4–6] Up to 40% of adolescents with PFP report ongoing pain and functional limitations after 5 years, challenging the assumption that PFP in adolescents is a self-limiting condition.[5]

Despite its prevalence and burden, PFP in adolescents remains underrepresented in the published literature, with much of the existing research focused on adults.[7] This gap leaves physiotherapists and other healthcare professionals without adequate resources to guide evidence-based decisions specific to adolescents with PFP. The limited adolescent-focused research also means that management strategies for PFP are often adapted from adult populations, which may not account for the unique developmental, social and psychological factors influencing adolescents, or that adolescents with PFP present with different characteristics to adults with PFP.[8,9]

This topical review aims to provide an up-to-date, evidence-based resource for physiotherapists and other healthcare professionals on managing PFP in adolescents, defined as ages 10 to 19 years.[10] It reviews current consensus on diagnosis and assessment, and summarises evidence regarding treatment and prevention. Drawing on a biopsychosocial approach and incorporating findings from recent research, it highlights adolescent-specific considerations, addresses common misconceptions in PFP management, and suggests best practices tailored to the adolescent population. The review concludes with a discussion on future research directions to improve clinical care for adolescents with PFP and support more effective, developmentally sensitive management strategies.

## What is patellofemoral pain in adolescents?

PFP is characterised by pain around or behind the patella, particularly during activities that load the patellofemoral joint (PFJ), such as running, squatting or climbing stairs.[11] Pain onset is typically insidious or non-traumatic, although PFP can occur after a traumatic injury (eg, anterior cruciate ligament tear).

Pain mapping studies have shown that adolescents with PFP can experience their pain in a variety of knee regions, and that pain can be local or more widespread.[12] Long-standing durations of pain are often associated with more widespread symptoms that may extend beyond the knee.[13,14] It is plausible that variable pain representation locally at the knee may represent different underlying structures involved in the pathology of PFP.[12]

## Which adolescents experience patellofemoral pain, and how does it impact them?

PFP can affect adolescents of all ages and genders, and across the spectrum of physical activity – from sedentary to highly active. A school-based cohort of Danish adolescents aged 15 to 19 years provided insight into the typical characteristics of adolescents with PFP.[4] Compared with adolescents with no knee pain, those with PFP were typically female, but they were no different in age, height, weight, body mass index, or sports participation.[4] Seventy per cent of adolescents with PFP participated in leisure-time sport, with an average of three sports sessions/week.[4]

Based on available evidence and our clinical experience, it is proposed that adolescents with PFP fall on a continuum from recent PFP to long-standing PFP (Figure 1). This continuum is not just representative of how long they have experienced PFP, but also

https://doi.org/10.1016/j.jphys.2024.11.018

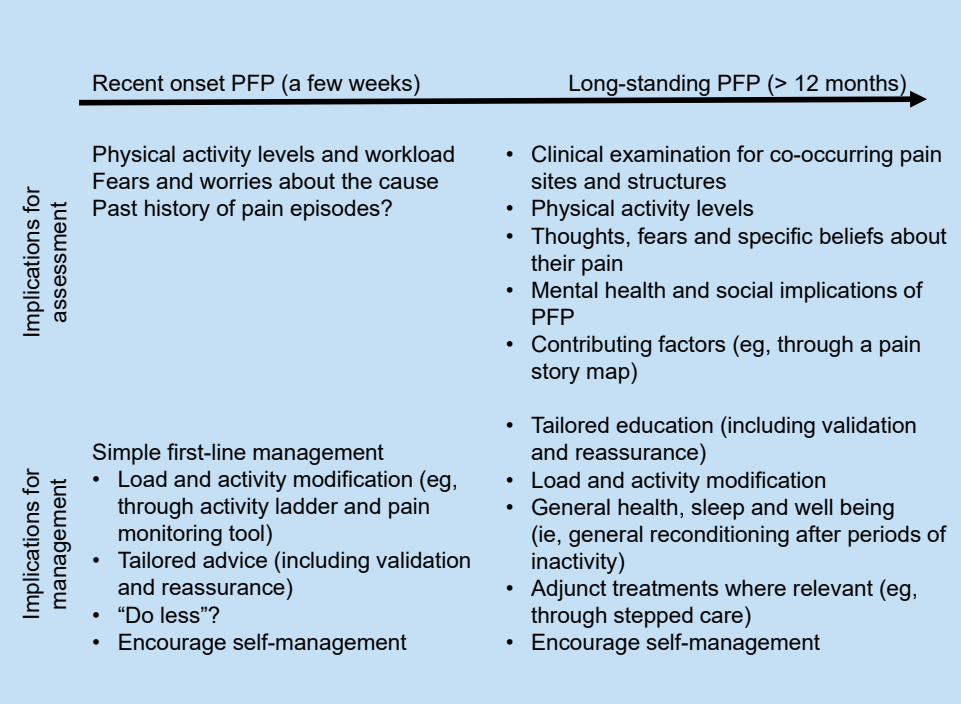


**Figure 1.** Concept figure to demonstrate assessment and management of recent-onset versus long-standing patellofemoral pain (PFP) in adolescents.

captures the different characteristics and behaviours of adolescents as they move along the continuum. It is important for clinicians to understand how adolescents may present along the continuum, as this will help to inform appropriate management strategies. On the left-hand side of the continuum are adolescents with recent-onset PFP; these adolescents are typically still actively participating in their sport or physical activities, despite their knee pain (79 to 93% remain active, median PFP duration 3 to 4.5 months[15–17]). It is believed that no studies have reported characteristics of adolescents with recent onset PFP or how PFP impacts them. Clinical experience suggests that adolescents with recent onset PFP may respond well to simple self-management strategies, such as education about the condition, and load management and activity modification, and may not need additional interventions (unless symptoms persist) (detailed below).

Adolescents who continue to experience PFP move along the continuum into long-standing PFP. The time period that defines the shift from recent to long-standing PFP is difficult to quantify, but could be considered to be around 12 months of symptoms (which may vary from day to day and week to week). The Danish cohort found that 73% of adolescents who had PFP for at least 2 years had pain at least once a week, and one-quarter experienced daily pain.[4] Scores on the Knee injury and Osteoarthritis Outcome Score (KOOS) demonstrate persistent impairments for up to 10 years after baseline assessment, particularly with sport and recreation function (KOOS-Sport/Rec: 2 years 69 out of 100, 10 years 61 out of 100) and knee-related quality of life (KOOS-QoL: 2 years 66 out of 100, 10 years 61 out of 100).[4,6] Approximately 70% of adolescents with PFP reduce or stop their participation in sport (compared with 55% with no knee pain and 52% who have other types of knee pain).[4] One in five adolescents with PFP of at least 2 years' duration use pain medication for their knee pain.[18] Bilateral PFP appears to be more common in adolescents with long-standing PFP (79%, median duration 3.25 years[19]) than recent PFP (35 to 39%, median duration 3 to 4.5 months[15–17]). There is also evidence that long-standing PFP in adolescents is associated with features consistent with nociplastic pain. Young adult females (mean age 23 years) with PFP since adolescence (median duration 7 years, IQR 7 to 10) have impaired conditioned pain modulation (indicating less descending pain inhibition), facilitated temporal summation of pain, and lower pressure pain thresholds at local (knee, shin) and distal (forearm) sites compared with controls with no history of knee pain.[13] These altered pain mechanisms also seem to persist after PFP has resolved.[13] A functional MRI study suggests that, compared with controls, adolescents with PFP have altered functional connectivity in their brain, particularly regions involved in pain, psychological function and sensorimotor control, and that these alterations are related to worse pain, function and kinesiophobia.[20]

The long-term impact of PFP can be profound for both the individual and society. A qualitative study of young adults, who had experienced PFP since adolescence, highlighted how having knee pain during this critical time impacted their identity, dreams about who they want to be, and major life decisions, such as education (eg, attending university), career path (eg, pursuing an active career as a physical education teacher) and housing choices (eg, purchasing a home without stairs).[21] The social impacts of long-standing knee pain include fear of being labelled as lazy, incompetent or attention-seeking, and feeling vulnerable to judgement from others if they modified, ceased or declined social activities because of their knee pain.[21] There are also broader consequences for physical and mental health into adulthood. Because physical activity behaviours in childhood and adolescence predict future physical activity participation,[22] lower physical activity in adolescents with PFP is likely to persist into adulthood. Physical inactivity is associated with a variety of physical and mental health conditions in adolescents, such as cardiovascular disease,[23] depression[24] and overweight/obesity.[25] Regular analgesic use in adolescence could lead to impaired pain coping strategies and dependence or misuse of pain medication in later life.[18] These factors can increase the burden on health service delivery and expenditure.

## Why do adolescents get patellofemoral pain?

Each adolescent with PFP is likely to have a unique set of factors that contribute to the onset and persistence of their knee pain. It is important for clinicians to work with each adolescent to identify potential contributing factors and whether these can or need to be addressed.

Prospective studies have identified risk factors for the development of PFP in adolescents, although it should be noted that the quality of these studies ranges from moderate to high, and the risk of bias from low to high.[26] Adolescent females who specialise in one

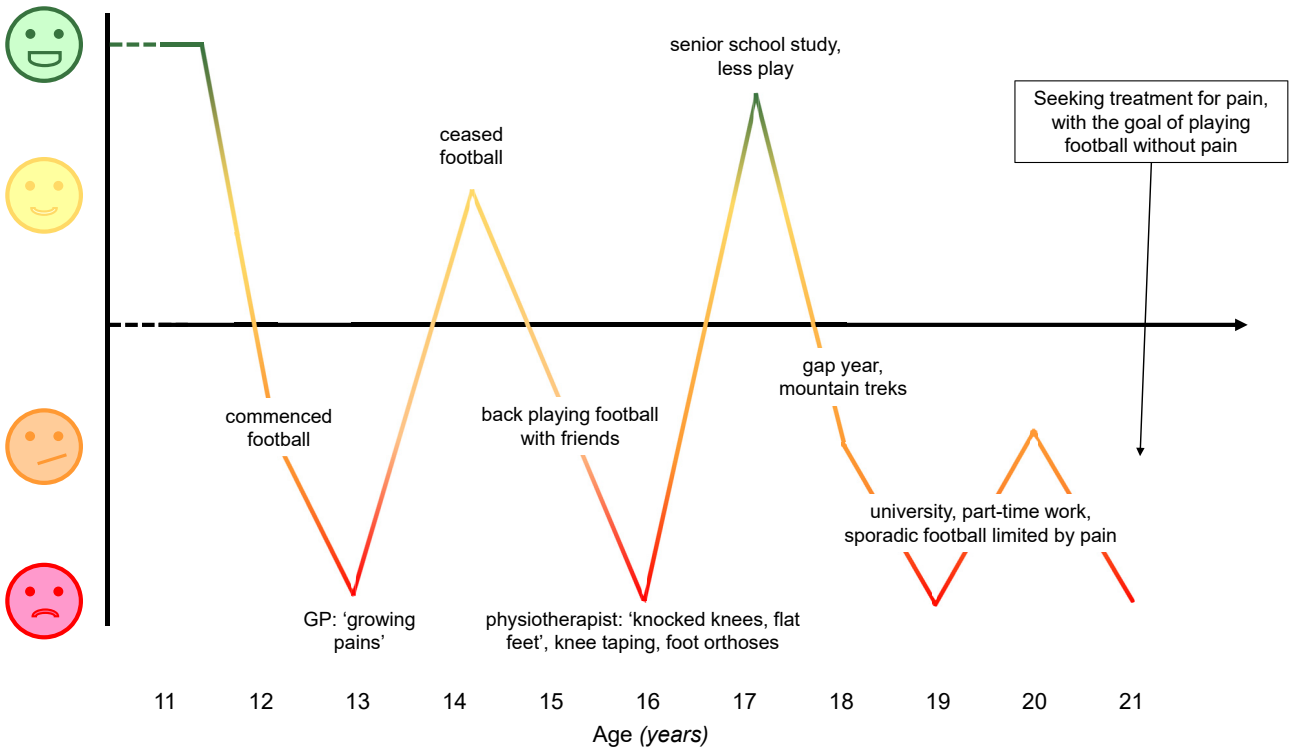


**Figure 2.** Example of a pain story map of an adolescent with patellofemoral pain. GP = general practitioner.

sport have a 1.5-fold higher relative risk of PFP incidence (95% CI 1 to 2.2) compared with those who participate in multiple sports.[27] Physical characteristics associated with the development of PFP include: greater hip abductor strength;[28,29] lower hip adductor strength (relative to hip abductor strength) and lower hip external rotator strength;[29] greater knee valgus displacement and higher knee abduction moment at initial contact during a drop vertical jump (in females);[30-32] and lower quadriceps muscle flexibility, shorter reflex response time of vastus medialis obliquus, poorer vertical jump performance and greater medial patellar mobility.[33] Body mass index and relative body fat percentage do not appear to be risk factors for PFP development in female adolescents (mean age 12.8 years).[34]

Load may play a key role in the onset and persistence of PFP in adolescents, although this is currently not supported by prospective data. Adolescents who are highly active in sport or physical activity, particularly those involving high PFJ loads such as running and jumping, likely expose their knees to high cumulative loads across a given period (eg, 1 week), often without adequate recovery between bouts of exercise. Load parameters such as frequency (ie, how often), volume (how long) and intensity (how hard) need to be considered, as each can contribute to higher cumulative load. Clinicians should also be mindful of sudden spikes in load, where the load in a given week exceeds the typical load across preceding weeks; this is common for adolescents competing at higher levels, who may have training and competition for school, club and representative teams occurring simultaneously. For adolescents participating in multiple sports, load spikes can occur when sports seasons overlap (eg, one sports season starts before the season for another sport has finished).

In contrast to active adolescents, some adolescents may develop PFP because of insufficient loading and/or not being prepared for loading. PFP can occur in more sedentary adolescents, who typically do not meet the recommended daily physical activity targets. Sedentary adolescents are likely to spend more time sitting, which often involves maintaining a flexed knee position for prolonged periods, and is a common aggravating activity for PFP.[35] Sedentary adolescents are also likely to be deconditioned in their musculoskeletal and cardiovascular systems, resulting in lower tissue tolerance to load compared with adolescents who regularly engage in physical activity. For these adolescents, even a relatively small increase in load, such as walking up and down hills while on vacation, may be sufficient to induce PFP.

There may also be psychosocial factors that contribute to adolescent PFP. Adolescence is a time of substantial life burden, such as schoolwork and academic performance, commencement of paid employment, sports participation, family commitments and social engagements (including social media). Physical and mental wellbeing of adolescents can be impacted by disruptions within their family unit, such as parents divorcing or moving to a new school. Young adults who had PFP since adolescence noted that their pain recurred with life-changing events, such as going to high school or university, or starting full-time work.[21] It is suggested that clinicians explore broader psychosocial factors and life events with adolescents who present with PFP, in a sensitive manner that allows identification of relevant contributors for the individual. This could be explored, for example, using a pain story map (Figure 2).

## Which adolescents with patellofemoral pain have a poor prognosis?

Several factors have been identified that may increase the risk of a poorer prognosis in adolescents with PFP (Box 1), based on a comprehensive analysis of baseline characteristics in studies of adolescents with PFP.[4,36] However, this research area is still under development and there are no strong cut-offs to be used for clinical practice.

The strength of the association between these baseline characteristics and outcomes varies depending on the study and choice of outcome. As an example, one study reported that adolescents with non-traumatic knee pain and low health-related quality of life had approximately 40 points lower KOOS-Sport/Rec scores and 30 mm higher pain intensity after 1 year compared with adolescents reporting no reduction in quality of life.[36] Importantly, none of these studies can be used to predict prognosis on an individual level. The strongest predictor of longer-term outcome currently seems to be short-term change in symptoms. A recent study showed that if adolescents with PFP reported that they were either 'improved' or 'much improved' at 4 weeks, using a 7-point Global Rating of Change (GROC) scale, they had a 26% higher risk of being improved after 1 year.[37]

**Box 1.** Factors that may increase the risk of a poorer prognosis in adolescents with PFP.

**Pain characteristics**
- High pain frequency (eg, pain on a near-daily basis), bilateral pain and longer pain duration are associated with a higher risk of poor prognosis.

**Health-related quality of life**
- Lower health-related quality of life measured by EQ5D is associated with worse prognosis across multiple cohort studies.

**Sex**
- Adolescent females with PFP are more likely to have worse long-term outcomes compared with males.

**Psychological factors**
- Anxiety, depression and fear behaviours contribute to a poor prognosis. Adolescents with moderate to severe anxiety or depressive symptoms are at higher risk of prolonged pain and reduced sports-related knee function.

EQ5D = EuroQoL 5-dimension questionnaire, PFP = patellofemoral pain.

Together, findings highlight the importance of intervening early after the onset of symptoms, using interventions that can improve pain function and quality of life, ideally within 4 weeks.

## What assessments are important in adolescents with patellofemoral pain?

When assessing adolescents with PFP, the most useful information to guide diagnosis and management comes from talking with the adolescent and their caregiver (ie, the patient interview). Research in adults with PFP does not support the use of physical tests to aid diagnosis,[38] although these studies have not been repeated in adolescents. In the absence of evidence to guide a structured assessment, a useful approach to assessing adolescents with PFP is to consider what information is needed to make a diagnosis of PFP and what information is needed to guide management.

### *Key assessments that guide diagnosis*

Diagnosing PFP can be challenging, as there are no definitive clinical, imaging or laboratory tests to confirm the condition. However, it is crucial to provide adolescents with a diagnosis for their knee pain, using language and terminology they understand,[39] to minimise anxiety, pain catastrophising and fear of pain, and to facilitate uptake of self-management strategies.[40–42] Diagnosis is typically based on a combination of clinical history, symptom presentation and exclusion of other potential sources of anterior knee pain in adolescents. It is important for clinicians to clearly explain to the adolescent what they are doing during the assessment, as some adolescents/caregivers may have expectations of what an assessment for knee pain would involve (eg, referral for imaging), and why such referrals are not important for a diagnosis.

The core criterion for diagnosing PFP is pain around or behind the patella that is aggravated by at least one PFJ loading activity involving weight-bearing knee flexion (eg, squatting, going up/down stairs, running, jumping, hopping).[11] This can be ascertained from both the patient interview and physical examination. Adolescents with PFP may also present with PFJ crepitus or grinding during knee flexion/extension, tenderness on palpation of the patellar facets, a small effusion, or pain associated with sitting (eg, pain during sitting, rising from sitting, or extending the knee after sitting), but these criteria are not essential for a diagnosis.[11]

Clinicians can use the Sorting non-trauMatIc adoLescent knEe pain (SMILE) tool to guide them through a structured assessment to help differentiate sources of non-traumatic anterior knee pain in adolescents.[43] The SMILE tool focuses on key aspects such as pain onset, symptom localisation and specific clinical tests to distinguish between common conditions such as PFP, Osgood-Schlatter disease, Sinding-Larsen-Johansson syndrome and patellar tendinopathy. By following the SMILE tool's algorithm, less-experienced clinicians can enhance diagnostic accuracy, give a specific 'name' to the condition, and ensure that appropriate management strategies are implemented.[43]

When assessing adolescents, it is critical to rule out other potential sources of nontraumatic anterior knee pain, including referred pain from the lumbar spine and hip, and red flags (Table 1). This is

**Table 1**
Key clinical features of differential diagnoses for adolescents presenting with non-traumatic anterior knee pain.

| Differential diagnosis | Key clinical features |
|---|---|
| Osgood Schlatter disease[82] | Pain and tenderness over the tibial tuberosity |
| Sinding-Larsen-Johansen syndrome[82] | Pain and tenderness over the inferior pole of the patella |
| Patellar tendinopathy[82] | Pain and tenderness over the patellar tendon<br>More common in adolescents involved in jumping sports |
| Infrapatellar fat pad | Pain reproduced by palpation and knee extension |
| Slipped capital femoral epiphysis[44,45] | Concurrent hip, groin or thigh pain that is poorly localised<br>Pain worsens with activity<br>Limp when walking or running, particularly after activity<br>May have had pain for several weeks or months before presentation<br>Limited hip internal rotation (± pain at end of range)<br>Obligatory hip external rotation during passive hip flexion to 90 deg |
| Legg-Calvé-Perthes Disease[83,84] | Intermittent hip, knee, groin or thigh pain<br>May have a painless limp or Trendelenburg gait<br>Hip stiffness on assessment, particularly a loss of hip internal rotation and abduction |
| Malignancy[43,45] | Pain unrelated to activity<br>Palpable mass, localised tender swelling<br>Night pain<br>Fever, fatigue<br>Weight loss |
| Inflammatory arthritis or infection[43,45] | Joint swelling<br>Joint pain and stiffness<br>Localised redness and warmth<br>Limping<br>Rash<br>Fever, malaise |
| Osteochondritis dissecans[43,45] | Pain during loading<br>Knee locking<br>Possible intermittent swelling |

particularly important for hip pathologies such as slipped capital femoral epiphysis and Legg-Calvé-Perthes disease, as these can have substantial lifelong consequences if not identified and managed early. Slipped capital femoral epiphysis should be considered in adolescents with non-traumatic knee pain who have concurrent hip, groin or thigh pain that is poorly localised,[44,45] but clinicians should be aware that approximately one-quarter of adolescents with slipped capital femoral epiphysis present with a primary complaint of knee pain, and minimal to no hip pain.[46] If slipped capital femoral epiphysis is suspected, the adolescent should remain strictly non-weight-bearing and be referred for urgent medical review.[45] Table 1 summarises key clinical features of differential diagnoses for adolescents presenting with non-traumatic anterior knee pain.

### *Key assessments that guide management*

An interview with the adolescent and their caregiver can be a valuable source of information to guide management. Taking sufficient time to discuss and explore potential contributors to the adolescent's pain and actively listening to their responses also helps adolescents to feel that they have been listened to and validates their pain experience.[39] Key topics that may be relevant to explore include: what the adolescent believes is causing their knee pain; current and past loading history (eg, what sport and physical activity they do, how often, what competition level or intensity, whether they have had a recent increase in their load); recovery, sleep and nutrition; their relationship with sport and physical activity (eg, why they participate in sport, identity); physical and mental health (eg, menstrual cycle and relationship to knee pain, diagnosed mental health disorders, mental health symptoms such as anxiety or depression); social or life circumstances (eg, school workload, recent major life events or changes); and any other factors that the adolescent, caregiver or physiotherapist thinks may be related to their knee pain. Clinicians can use this information to determine priorities for management (eg, load management in an adolescent whose pain onset coincides with a recent spike in sport participation), as well as the need for referral to other healthcare professionals, such as a psychologist, dietician, general practitioner or sports and exercise medicine physician.

A targeted physical examination can inform selection of appropriate management strategies, and has the benefit of making the adolescent feel that they have been thoroughly examined.[39] Guided by the interview and knowledge of typical impairments in adolescents with PFP, clinicians may select from a variety of tests, including strength and functional performance. A treatment direction test — where an intervention is applied during performance of an aggravating activity[19,47] — may also be useful, as it gives quick feedback to the adolescent, caregiver and clinician about whether the intervention is worth using. For example, if an adolescent gets pain climbing stairs, the clinician asks the adolescent to rate their knee pain during 5 repeated step-ups (eg, using a numerical rating scale), then repeats the test after applying an intervention aimed at reducing pain, such as patellar taping. A reduction in pain during the test with the intervention in situ (eg, at least 50% improvement[19]) suggests that it may be worth prescribing the intervention to relieve pain during daily function. Whichever tests are selected as part of the physical examination, the clinician should ensure that the adolescent understands why the test is being conducted, and how it relates to their presentation, goals and management strategies. For example, if assessment identifies low muscle strength, this can be used to create a narrative and understanding of why resistance exercises are important.

Patient-reported outcome measures (PROMs) can be used to capture the adolescent's perspectives of their knee condition and how it impacts them — at initial assessment and to track their condition over time. Clinicians should select PROMs that: measure the domain(s) of interest (eg, pain, function, quality of life); have adequate measurement properties in adolescents with nontraumatic knee pain; and are feasible to administer in the clinic (eg, take $<$ 5 to 10 minutes for adolescents to complete and clinicians to score; have no or minimal fees for clinical use). The pain numerical rating scale is a single item often used in clinical practice.[48] Adolescents rate the severity of their knee pain over a specific time on an 11-point scale from 0 (no pain) to 10 (worst pain imaginable). Clinicians should ask the question the same way each time to ensure repeatability (eg, 'how bad has your pain been at its worst over the past week?'). Global perceived effect and GROC are useful single-item tools to capture overall how the adolescent's condition is going.[49] Global perceived effect tends to consider the adolescent's knee condition as a whole: 'In relation to your knee condition, how do you feel now compared to before you started treatment?'. In comparison, GROC tends to be linked to a particular domain: 'In relation to your knee pain (or function, quality of life, etc), how do you feel now compared to before you received treatment?'.[50] Global perceived effect and GROC are typically scored on a Likert scale. For example, a 7-point Likert scale may have the following response options: 'completely recovered', 'much better', 'slightly better', 'same', 'slightly worse', 'much worse', 'very much worse'. The KOOS has been adapted for use in children and adolescents (from age 7 years), and is reliable, valid and responsive in adolescents with knee conditions.[51] The KOOS-Child consists of five subscales that evaluate pain, other symptoms, function during daily activities, function during sport and play, and knee-related quality of life, with each subscale scored from 0 (extreme knee problems) to 100 (no knee problems).[51] Because each subscale is scored separately, clinicians can choose to use all subscales (39 items in total) or select relevant subscales for the individual. Clinicians can also use PROMs to identify potential psychosocial impairments. PROMs that have been used in studies of adolescents with PFP include measures of kinesiophobia and fear of movement (eg, Tampa Scale for Kinesiophobia 13-item short form,[52] Fear Avoidance Beliefs Questionnaire Physical Activity subscale[53]); pain catastrophising (eg, Pain Catastrophising Scale Child version[54]); and pain self-efficacy (Pain Self-Efficacy Scale[55,56]).

When using PROMs, it is important to consider whether real or meaningful change has occurred. A recent study highlighted that when adolescents and adults with PFP indicate that they are 'a little better' on a GROC, this is unlikely to represent true change measured on the KOOS.[50] To be confident that true change in the adolescent's condition has occurred, clinicians should look for GROC responses that align with 'better', 'much better' or 'completely recovered'.[50]

## How can we best work with adolescents to help them manage their PFP?

Recent discoveries highlight multiple aspects that are important to help adolescents suffering from PFP. These include everything from optimising the initial clinical encounter and validating their experience, to giving them a vocabulary to explain their condition in their own words, and helping them navigate their condition and provide them with support for self-management. This section draws on scientific knowledge from multiple areas to provide key pointers on how to optimise the management of adolescents with PFP and, where possible, highlights distinctions between recent onset PFP and more long-standing PFP.

### *Optimising the initial clinical encounter*

The initial clinical encounter is a pivotal moment in the management of adolescents with PFP. Research consistently shows that how clinicians engage with young patients during the initial consultation has a profound impact on the trajectory of their care.[57,58] As demonstrated in recent studies, an effective clinical encounter should prioritise communication strategies that enhance the adolescent's ability to express their pain and concerns, fostering a therapeutic environment that empowers them.[59] Adolescents with PFP often face challenges in articulating their pain, particularly due to the complex nature of the condition and its impact on their daily lives and social interactions.[59] Creating space for adolescents to describe their 'pain story' in their own words allows clinicians to understand the psychosocial factors at play and address misconceptions (Figure 2).

One of the most crucial aspects of the clinical encounter is validating the adolescent's experience. Studies show that when adolescents feel that their pain and concerns are acknowledged, they are more likely to engage in their own care and adhere to treatment recommendations.[21] Acknowledging the emotional and psychological burden of long-standing PFP plays a key role in fostering a sense of partnership between the clinician and adolescent. Clinicians should actively explore any fears or anxieties that the adolescent may have about their pain — whether it's the fear of causing more damage through activity or concern that the pain will not improve. Openly addressing these fears is essential to supporting long-term self-management.

Optimising the clinical encounter also involves setting realistic expectations about the course of treatment. Adolescents with PFP often experience frustration due to the prolonged nature of their symptoms and the potential impact on their physical and social lives.[2] Adolescents are often concerned about the long-term implications of their condition, and clinicians must proactively counter these fears by explaining that PFP, while persistent, can be managed effectively with the right approach.[39,59] By focusing on shared decision-making, clinicians can guide adolescents through a structured discussion on management options, such as activity modification and progressive loading strategies, while aligning treatment goals with the adolescent's personal aspirations. This approach helps adolescents gain control over their condition, encouraging them to gradually reintroduce physical activities — such as sports — that are meaningful to them.

By establishing trust and demonstrating empathy during the initial encounter, clinicians may enhance the patient's engagement in their rehabilitation program, improving adherence with prescribed exercises and temporary activity modifications.[57,59] Additionally, the use of communication tools that facilitate shared language around pain, such as metaphors or patient-specific analogies, can further improve the quality of the clinician-patient relationship.[57]

### *Provide tailored education to all adolescents with patellofemoral pain*

Patient education is a fundamental component in the management of PFP, especially for adolescents. It provides the foundation for long-term self-management, which is critical given the persistent nature of the condition. Detailed and definitive guidelines on the content of patient education for PFP are not readily available in most studies,[60] but there are several consistent elements that should be included in an educational intervention and tailored to the individual and their context and experiences:[39] an explanation of the condition (a label, nature and possible contributing factors); advice on load management and activity modification; and strategies for self-management. Importantly, self-management underpins other components of treatment, as managing PFP is likely a long-term process for many adolescents.

*Credible explanation of patellofemoral pain*

The first and most important part of patient education is to provide a credible explanation of the condition. Adolescents with PFP often face diagnostic uncertainty, which can act as a barrier to self-management.[21] Addressing this early by giving the condition a name and explaining its nature helps to reduce fear and confusion. Research suggests that understanding 'why am I experiencing this pain?' is critical in facilitating the adolescent's acceptance of the condition and their ability to take action.[39]

This process can be understood through a four-phase trajectory that many young adults with PFP experience.[21] The first phase — apprehension — is when adolescents begin experiencing pain and struggle with frustration, doubts and a loss of valued activities. To move into the second phase — knowledge — they need recognition from a person of authority (eg, a physiotherapist), and a clear explanation and a name for their condition to reach acceptance and move towards managing their condition. Providing a name for the condition and explaining that the pain is linked to activities that load the PFJ can reassure adolescents that their condition is behaving in a predictable manner. This explanation should be personalised, linking the specific activities that aggravate symptoms to PFP, which gives the adolescent a clear understanding of why they feel pain and what can be done about it.

Adolescents should also be reassured that an increased pain response during loading of their knee is normal, and they should not fear movement (eg, kinesiophobia) or completely stop their physical activity. It is common to experience some knee discomfort or pain flares with loading, but this does not necessarily indicate worsening of their condition or a poorer prognosis.[39]

*Load management and activity modification*

Another core component of education is guidance on load management and activity modification.[61] Clinical guidelines recommend that individuals with PFP learn to manage the load on their PFJ by modifying activities to minimise aggravating their pain. For example, adolescents who are fearful of participating in activities that load the joint should be reassured that gradual increases in activity can build tissue capacity and improve function over time. Conversely, adolescents who are overloading the joint may need to reduce the intensity and/or volume of their activity temporarily to allow for recovery.

The concept of load management can be explained using tools such as the activity ladder and pain monitoring scale.[61] These tools help adolescents visualise a graded progression of activities, from less to more intense, enabling them to understand which activities may provoke pain and how to balance these against their rehabilitation goals. The pain monitoring scale allows adolescents to gauge whether their activity levels are appropriate, with a recommended pain threshold of 3 out of 10 on a numerical rating scale during or after exercise.

It is important to emphasise that complete rest is not recommended, as it can lead to reduced physical activity levels, negatively impact mood and diminish overall health.[62] Instead, adolescents should be encouraged to remain active within the guidelines provided, as physical activity offers extensive benefits for the musculoskeletal, cardiovascular and respiratory systems, as well as for psychological well-being.[62]

*Self-management strategies*

The final key component of education is promoting self-management. For adolescents with PFP, the ability to manage their condition independently is crucial for long-term success. Clinicians can provide tools such as the activity ladder to help adolescents structure their physical activity in a way that promotes a gradual increase in their activity level while minimising pain. Encouraging adolescents to track their progress and make adjustments based on pain levels helps to build autonomy and confidence in managing their symptoms.

Self-management is most effective when it is tailored to the individual. Adolescents often need clear, practical advice on how to modify their activities and manage flare-ups. Tools such as pain story mapping (Figure 2), where patients map their pain levels over time on a whiteboard or chart, can help both clinicians and adolescents to identify patterns and contextual factors that may influence pain. By understanding their own pain history, adolescents can better manage future symptoms and feel more in control of their condition.

Ultimately, the delivery of education is as important as its content. Evidence suggests that clinician-delivered education — where the information is personalised to the patient's specific experience — leads to better outcomes than providing generic written materials alone.[60] Engaging the adolescent in a dialogue about their symptoms and concerns, while providing them with the tools and knowledge to manage their condition independently, is essential to successful long-term management.

### *Use additional interventions in conjunction with education*

There are several additional interventions that clinicians can consider when managing adolescents with PFP. Below, we present evidence from single randomised controlled trials (RCTs), along

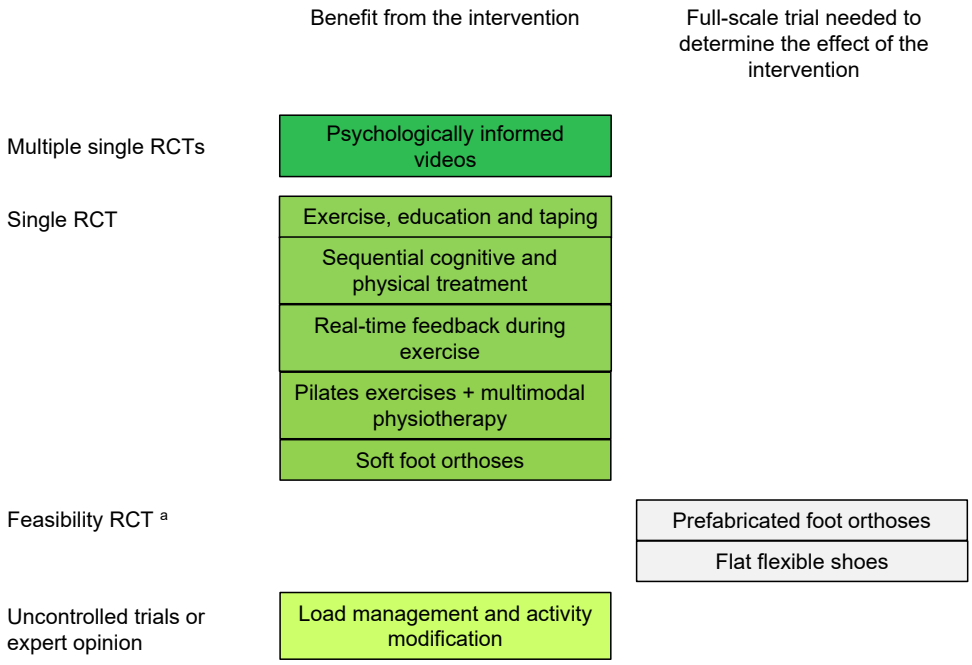


**Figure 3.** Interventions for managing patellofemoral pain in adolescents, with associated levels of evidence. RCT = randomised controlled trial. [a] Note that feasibility trials were not powered to determine efficacy of the intervention.

with findings from other study designs that provide additional insight to guide management (summarised in Figure 3). The limited number of trials involving adolescents with PFP precluded pooling of data.

*Exercise*

The largest clinical trial was a cluster RCT of 121 adolescents with PFP aged 15 to 19 years, in which exercise therapy combined with education was compared with education alone.[19] The exercise intervention consisted of: supervised group training sessions held at school three times a week (neuromuscular training of the foot, knee and hip; knee and hip strengthening and stretching; patellofemoral soft tissue mobilisation); unsupervised home exercises on non-group training days (quadriceps and hip muscle retraining and stretching); and patellar taping.[63] Education was delivered by a physiotherapist in a 30-minute individual session with the adolescent and their parent(s), and covered pain management, modifying physical activity using pacing and load management strategies, optimal knee alignment during daily activities, and questions. Adolescents who received exercise with education were more likely to have recovered at 3 months (OR 1.88, 95% CI 1.25 to 2.18); they were also more likely to have recovered (OR 1.73, 95% CI 1.02 to 2.93, number needed to treat of 11). Similar benefits were sustained to 2 years (OR 2.52, 95% CI 1.65 to 3.86), with a number needed to treat of 5. Adolescents who completed their home exercises on > 70% of the prescribed days were more likely to have recovered at 1 year (OR 4.04, 95% CI 1.42 to 11.55).

A small RCT involving 34 adolescents with PFP evaluated Pilates-based exercises.[64] All participants received multimodal physiotherapy (hip and knee strengthening and stretching exercises, ultrasound, infrared) in three 1-hour sessions/week for 3 months. The Pilates group also completed 25-minute sessions comprising mat, resistance band and ball exercises targeting core and lower limb muscle control and strength. The Pilates group had greater improvements in all outcomes (pain severity, hip and knee muscle strength, functional capacity, quality of life) compared with the group who only received multimodal physiotherapy, although it is not clear whether these between-group differences were clinically meaningful. However, given that the paper did not provide sufficient detail to replicate the multimodal program or state the frequency of Pilates sessions, it is difficult to recommend Pilates exercises for adolescents with PFP.

Riel et al[65] evaluated the effect of real-time feedback during exercises in 40 adolescents with PFP. Sensors were integrated into resistance bands used to complete seated knee extension, standing hip extension and standing hip abduction exercises.[66] The intervention group received feedback on contraction time and pulling force, while the control group received feedback only on pulling force. Exercises were completed once a week in a group session and twice a week independently at home for 6 weeks. Compared with the control group, the intervention group: deviated less from the prescribed contraction time; received a greater percentage of the prescribed exercise dose (35% versus 20% of contraction time); and had greater increases in isometric knee and hip strength. Providing adolescents with PFP with real-time feedback on contraction time may be beneficial for enhancing strength gains.

*Psychologically informed interventions*

Three RCTs have evaluated psychologically informed interventions for adolescents with PFP.[15–17] Selhorst and colleagues evaluated the effect of adding psychologically informed videos to a physiotherapy program of flexibility, strength and neuromuscular exercises in two RCTs.[16,17] The first study (n = 66) involved one 8.5-minute video that addressed beliefs about pain-related fear and pain catastrophising, compared with a control video of equal length that presented information on anatomy and biomedical contributors to PFP.[16] The second study (n = 68) used a series of three videos delivered over 2 weeks, targeting: fear avoidance, kinesiophobia and pain catastrophising beliefs (8.5 minutes); ways to manage pain and graded return to activity (5 minutes); and simple cognitive restructuring methods (5.5. minutes).[17] The control video series were the same length and covered: lower limb anatomy and function; lower limb biomechanics; and basic lower limb exercises.[17] Taken together, the findings indicate that, compared with the control videos, a series of three psychologically informed videos results in greater improvements in symptoms, function, kinesiophobia, fear-avoidance beliefs and pain catastrophising at 6 weeks and 3 months, but a single video only results in short-term benefits (2 weeks). Between-group differences in symptoms and function (measured using the Anterior Knee Pain Scale and pain numerical rating scale) were less than reported minimum clinically important differences in adults with PFP.[67]

In another RCT (n = 55), a sequential treatment algorithm that considered psychosocial impairments first before addressing physical impairments was compared with treatment based only on physical

impairments.[15] The experimental group were sequentially evaluated for activity-related fear, lower limb flexibility, lower limb functional alignment and functional strength using criteria outlined in a pre-specified algorithm. Treatment focused on addressing the first impairment detected before progressing to the next subgroup. The comparator group received individualised treatment consisting of exercise, manual therapy, patellar taping and foot orthoses that targeted physical impairments such as hip and knee strength and flexibility, and lower limb mechanics during squatting, jumping and running (not conducted in a sequential order). Both groups received treatment twice a week for 6 weeks. Greater improvements in symptoms and function occurred in the experimental group at 6 weeks, based on intention-to-treat analysis, but were too small for the intervention to be considered clinically worthwhile. Secondary as-treated analyses found that the experimental group had greater improvements in pain, symptoms and function at 6 weeks that were clinically important, but both groups were the same at 6 months. The findings suggested that addressing activity-related fear, where necessary, before progressing to treatments that target physical impairments may have small short-term benefits on symptoms and function for adolescents with PFP, although the effect on psychosocial measures is unknown.

*Footwear interventions*

Footwear interventions may be ideal for adolescents with PFP, who typically spend long periods of time in shoes (eg, for school, sport or work), as they impose minimal burden on their time or effort compared with exercise interventions.[68] Current RCT literature on footwear interventions for adolescents with PFP is limited to pilot and feasibility studies, making it inappropriate to draw conclusions regarding efficacy.

The first pilot RCT to evaluate foot orthoses in adolescents with PFP was published in 1993. Eng and Pierrynowski[69] compared soft foot orthoses (constructed from a flat shoe insole with medial rubber wedges posted at the forefoot and rearfoot) with flat shoe insoles in 20 adolescent females with PFP. Both groups also received quadriceps and hamstring strengthening and stretching exercises. After 8 weeks, the foot orthoses group had significantly greater improvements in pain with running, stair ambulation and squatting, which typically exceeded 2 on a 10-cm visual analogue scale.[67] While these findings provide preliminary support for using foot orthoses in adolescents with PFP, the orthoses that were evaluated do not reflect contemporary prescription methods,[70] and the effect in males is unknown.

To address these limitations, a feasibility RCT compared commercially available prefabricated (off-the-shelf) foot orthoses with flat shoe insoles in 36 adolescents (27 females) with PFP.[71] Foot orthoses were fit to comfort using a prescription algorithm.[72] The primary outcome was feasibility of conducting a full-scale RCT. Foot orthoses were a credible and acceptable intervention in adolescents with PFP, and were associated with only minor and transient adverse effects. Secondary outcomes (eg, pain, function, quality of life) were reported as descriptive statistics, as the study was not designed or powered for between-group comparisons. Qualitative interviews with 14 participants revealed that the foot orthoses and flat insoles were easy to wear, but the adolescents preferred an option for warmer weather (eg, thongs or sandals) to increase wear time.[68]

Mazzella et al[73] investigated the feasibility of flat flexible school shoes as an intervention for adolescents with PFP. For 3 months, 24 Australian adolescents (15 males) were randomly assigned to wear: flat flexible shoes[a], which were lightweight (180 g), and had no heel-toe offset or stability/motion control features; or traditional school shoes[b], which were heavier (350 g), had a 12-mm heel-toe offset, and a stiff midsole and heel counter.[73] Primary outcomes for feasibility indicated that both shoe types were credible and acceptable to adolescents with PFP, with $>$ 90% of adolescents wearing their allocated footwear for $\geq$ 75% of their of total weekly time spent in school shoes. A parallel laboratory study found that PFJ reaction force was immediately reduced when adolescents with PFP walked and ran on a treadmill in the flat flexible shoes compared with the traditional shoes, suggesting that flat flexible shoes may reduce PFJ load.[74] Following these feasibility trials, full-scale RCTs are now required to determine the efficacy of foot orthoses and flat flexible shoes for adolescents with PFP, so that recommendations can be made to inform clinical practice.

*Other adjunct interventions*

Patellar taping may be a useful adjunct treatment to reduce pain in adolescents with PFP. First described by Jenny McConnell,[75] patellar taping can reduce PFP during PFJ-loading tasks (step up, step down, squat) in young adults.[76] In the RCT by Rathleff et al,[19] patellar taping was prescribed as an adjunct to exercise and education for 28 of 62 (45%) adolescents, who experienced $\geq$ 50% improvement in pain when performing a squat with the tape in situ. Four components of the McConnell approach were applied in a standardised order (anterior tilt, medial tilt, medial glide, fat pad deload) until 50% pain reduction was achieved.[63] Adolescents were taught how to apply the tape themselves, and instructed to tape daily for the 3-month intervention period.[63] Based on evidence from adults with PFP,[76] and our clinical experience regarding ease of self-application by adolescents and/or caregivers, we recommend trialling the medial glide tape in the first instance, and adding the fat pad deload component if 50% pain reduction is not achieved with medial glide tape alone. Given the short-term effects of patellar tape on pain,[77] as well as the potential for skin irritation with daily or long-term taping,[78] clinicians should advise adolescents to tape when needed for pain relief (eg, during a pain flare, or during a non-typical high load task such as hiking).

## Can patellofemoral pain be prevented in adolescents?

It is unknown whether PFP can be prevented in adolescents. It is believed that no studies have investigated strategies to prevent PFP in the general adolescent population. Prevention studies conducted in older adolescents completing basic military training (mean age 18 to 19 years[79]) are unlikely to be generalisable due to the very high and specific loads experienced in a concentrated period (eg, 6 weeks).

In the absence of evidence regarding effective prevention strategies for PFP, clinicians and other stakeholders who work with adolescents (eg, parents, coaches, teachers) can be guided by potential contributors to PFP in adolescents discussed above. A key example is load. Workload data can be collected over several days and across different activities, and used to decide whether modifications need to be made to prevent injury onset or recurrence. A variety of tools are available to track workload, as appropriate for the adolescent and their typical activities. For example, a cross-country runner may measure the distance run (using a GPS device) and intensity (using a rating of perceived exertion scale[80]), while a basketball player may measure the number of jumps in each training session and game (using an inertial device). While coaches may do this for their individual sport, adolescents involved in multiple sports need a system to monitor all their activities across the week, and a strategy to communicate this cumulative workload to all their coaches when in excess. Adolescents should be involved in selecting an appropriate workload measure that meets their preferences.

## Future directions for research and practice

PFP in adolescents presents unique challenges that require a tailored approach to management. Current evidence suggests that interventions recommended for adults with PFP are not as effective in adolescents.[8] There is a clear need for further exploration of strategies to optimise outcomes for adolescents across the spectrum of PFP presentations, from recent-onset to long-standing PFP, as well as RCT evidence to inform clinical guidelines. Part of this is understanding why adolescents often do not seek care for their knee pain until months or years after the onset of symptoms,[81] and co-designing strategies to promote the importance of early intervention. Future research also needs to differentiate between recent and

long-standing cases, and should investigate simple early interventions. This could pave the way for more targeted management.

Preventing PFP remains an underexplored area, particularly in adolescent populations. Research into prevention strategies should account for the differences between active and inactive adolescents. For highly active adolescents, monitoring training loads and providing guidance on recovery and cross-training may reduce the risk of developing PFP. Conversely, for less active or sedentary adolescents, interventions targeting physical activity engagement and general conditioning could help mitigate their susceptibility to PFP. Co-designing and testing tailored prevention programs for these distinct groups will be essential for reducing the prevalence and burden of PFP among these different adolescent populations.

## Conclusion

Patellofemoral pain in adolescents is a prevalent and burdensome condition that extends beyond their knees, affecting physical function, quality of life, social interactions and long-term participation in physical activity. Despite its impact, PFP in adolescents remains underrepresented in research, leaving clinicians with limited evidence to guide management tailored to this unique population.

Adolescents with recent-onset PFP often respond well to simple self-management strategies, including education, load management and activity modification. Recognising and addressing PFP early can prevent progression to long-standing, more complex presentations. Effective management of long-standing PFP requires addressing not just physical impairments but also the psychosocial factors that influence their pain and behaviours. Tailored education, reassurance, resistance exercises, footwear interventions and psychologically informed strategies seem like promising avenues for clinicians to explore when managing adolescents with PFP.

***Footnotes:*** [a] Vivobarefoot Primus Lite or RA II, Freiburg, Germany. [b] Clarks Daytona, Street, England.

***Ethics approval:*** Nil.

***Competing interests:*** Nil.

***Source(s) of support:*** Danish Research Council (Grant ID: 2096-00166B) and TRYG Foundation (Grant ID: 118547).

***Acknowledgements:*** Nil.

***Provenance:*** Commissioned. Peer reviewed.

***Correspondence:*** Michael Skovdal Rathleff**,** Department of Health Science and Technology, Aalborg University, Aalborg, Denmark. Email: misr@hst.aau.dk

## References

1. Smith BE, Selfe J, Thacker D, Hendrick P, Bateman M, Moffatt F, et al. Incidence and prevalence of patellofemoral pain: A systematic review and meta-analysis. *PloS one*. 2018;13:e0190892.
2. Nielsen MG, Lyng KD, Holden S, Johansen SK, Winters M, Rathleff MS. Item generation for a new patient-reported outcome measure: The non-traumatic anterior knee pain (AKP)-YOUTH scale. *Musculoskelet Sci Pract*. 2024;73:103151.
3. Rathleff MS, Winiarski L, Krommes K, Graven-Nielsen T, Holmich P, Olesen JL, et al. Pain, sports participation, and physical function in adolescents with patellofemoral pain and Osgood-Schlatter disease: a matched cross-sectional study. *J Orthop Sports Phys Ther*. 2020;50:149–157.
4. Rathleff MS, Rathleff CR, Olesen JL, Rasmussen S, Roos EM. Is knee pain during adolescence a self-limiting condition? Prognosis of patellofemoral pain and other types of knee pain. *Am J Sports Med*. 2016;44:1165–1171.
5. Rathleff MS, Holden S, Straszek CL, Olesen JL, Jensen MB, Roos EM. Five-year prognosis and impact of adolescent knee pain: a prospective population-based cohort study of 504 adolescents in Denmark. *BMJ open*. 2019;9:e024113.
6. Rathleff MS, Brondum P, Roos EM, Sorensen LB, Larsen JB, Olesen JL, et al. From adolescence to adulthood: 10-year follow-up of patellofemoral and other types of knee pain - a prospective cohort study. *7th International Patellofemoral Research Retreat*. 1. Bologna, Italy. *J Orthop Sport Phys Ther Open*. 2023:102.
7. Rathleff MS. Patellofemoral pain during adolescence: much more prevalent than appreciated. *Br J Sports Med*. 2016;50:831–832.
8. Rathleff MS, Vicenzino B, Middelkoop M, Graven-Nielsen T, van Linschoten R, Holmich P, et al. Patellofemoral Pain in Adolescence and Adulthood: Same Same, but Different? *Sports Med*. 2015;45:1489–1495.
9. van Middelkoop M, van der Heijden RA, Bierma-Zeinstra SMA. Characteristics and outcome of patellofemoral pain in adolescents: do they differ from adults? *J Orthop Sports Phys Ther*. 2017;47:801–805.
10. World Health Organization. Adolescent health; 2024. https://www.who.int/health-topics/adolescent-health. Accessed November 14, 2024.
11. Crossley KM, Stefanik JJ, Selfe J, Collins NJ, Davis IS, Powers CM, et al. 2016 Patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 1: terminology, definitions, clinical examination, natural history, patellofemoral osteoarthritis and patient-reported outcome m. *Br J Sports Med*. 2016;50:839–843.
12. Boudreau SA, Royo AC, Matthews M, Graven-Nielsen T, Kamavuako EN, Slabaugh G, et al. Distinct patterns of variation in the distribution of knee pain. *Sci Rep*. 2018;8:16522.
13. Holden S, Straszek CL, Rathleff MS, Petersen KK, Roos EM, Graven-Nielsen T. Young females with long-standing patellofemoral pain display impaired conditioned pain modulation, increased temporal summation of pain, and widespread hyperalgesia. *Pain*. 2018;159:2530–2537.
14. Holden S, Roos EM, Straszek CL, Olesen JL, Jensen MB, Graven-Nielsen T, et al. Prognosis and transition of multi-site pain during the course of 5 years: Results of knee pain and function from a prospective cohort study among 756 adolescents. *PloS one*. 2021;16:e0250415.
15. Selhorst M, Rice W, Jackowski M, Degenhart T, Coffman S. A sequential cognitive and physical approach (SCOPA) for patellofemoral pain: a randomized controlled trial in adolescent patients. *Clin Rehabil*. 2018;32:1624–1635.
16. Selhorst M, Fernandez-Fernandez A, Schmitt L, Hoehn J. Effect of a psychologically informed intervention to treat adolescents with patellofemoral pain: a randomized controlled trial. *Arch Phys Med Rehabil*. 2021;102:1267–1273.
17. Selhorst M, Hoehn J, Schmitt L, Benedict J, Fernandez-Fernandez A. The effect of a psychologically informed video series to treat adolescents with patellofemoral pain: a randomized controlled trial. *J Orthop Sports Phys Ther*. 2023;53:634–642.
18. Andreucci A, Roos EM, Rasmussen S, Olesen JL, Holmich P, Thorborg K, et al. Analgesic use in adolescents with patellofemoral pain or Osgood-Schlatter disease: a secondary cross-sectional analysis of 323 subjects. *Scand J Pain*. 2022;22:543–551.
19. Rathleff MS, Roos EM, Olesen JL, Rasmussen S. 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;49:406–412.
20. Diekfuss JA, Grooms DR, Nissen KS, Coghill RC, Bonnette S, Barber Foss KD, et al. Does central nervous system dysfunction underlie patellofemoral pain in young females? Examining brain functional connectivity in association with patient-reported outcomes. *J Orthop Res*. 2022;40:1083–1096.
21. Johansen SK, Holden S, Pourbordbari N, Jensen MB, Thomsen JL, Rathleff MS. PAINSTORIES - Exploring the temporal developments in the challenges, barriers, and self-management needs of adolescents with longstanding knee pain: a qualitative, retrospective interview study with young adults experiencing knee pain since adolescence. *J Pain*. 2021;23:577–594.
22. Rangul V, Holmen TL, Bauman A, Bratberg GH, Kurtze N, Midthjell K. Factors predicting changes in physical activity through adolescence: the Young-HUNT Study, Norway. *J Adolesc Health*. 2011;48:616–624.
23. Andersen LB, Sardinha LB, Froberg K, Riddoch CJ, Page AS, Anderssen SA. Fitness, fatness and clustering of cardiovascular risk factors in children from Denmark, Estonia and Portugal: the European Youth Heart Study. *Int J Pediatr Obes*. 2008;3(Suppl 1):58–66.
24. Lu S, Sun J, Guo Z, Yi M, Zhang Y, Wang J, et al. Instrumented measures of sedentary behavior and physical activity are associated with depression among children and adolescents: a systematic review and dose-response meta-analysis of observational studies. *Front Psychol*. 2024;15:1465974.
25. Hills AP, Andersen LB, Byrne NM. Physical activity and obesity in children. *Br J Sports Med*. 2011;45:866–870.
26. Neal BS, Lack SD, Lankhorst NE, Raye A, Morrissey D, van Middelkoop M. Risk factors for patellofemoral pain: a systematic review and meta-analysis. *Br J Sports Med*. 2019;53:270–281.
27. Hall R, Barber Foss K, Hewett TE, Myer GD. Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. *J Sport Rehabil*. 2015;24:31–35.
28. Herbst KA, Barber Foss KD, Fader L, Hewett TE, Witvrouw E, Stanfield D, et al. Hip strength is greater in athletes who subsequently develop patellofemoral pain. *Am J Sports Med*. 2015;43:2747–2752.
29. Finnoff JT, Hall MM, Kyle K, Krause DA, Lai J, Smith J. Hip strength and knee pain in high school runners: a prospective study. *PM R*. 2011;3:792–801.
30. Myer GD, Ford KR, Barber Foss KD, Goodman A, Ceasar A, Rauh MJ, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. *Clin Biomech*. 2010;25:700–707.
31. Myer GD, Ford KR, Di Stasi SL, Foss KD, Micheli LJ, Hewett TE. High knee abduction moments are common risk factors for patellofemoral pain (PFP) and anterior cruciate ligament (ACL) injury in girls: is PFP itself a predictor for subsequent ACL injury? *Br J Sports Med*. 2015;49:118–122.
32. Holden S, Boreham C, Doherty C, Delahunt E. Two-dimensional knee valgus displacement as a predictor of patellofemoral pain in adolescent females. *Scand J Med Sci Sports*. 2017;27:188–194.
33. Witvrouw E, Lysens R, Bellemans J, Cambier D, Vanderstraeten G. Intrinsic risk factors for the development of anterior knee pain in an athletic population. A two-year prospective study. *Am J Sports Med*. 2000;28:480–489.
34. Barber Foss KD, Hornsby M, Edwards NM, Myer GD, Hewett TE. Is body composition associated with an increased risk of developing anterior knee pain in adolescent female athletes? *Phys Sportsmed*. 2012;40:13–19.
35. Collins NJ, Vicenzino B, van der Heijden RA, van Middelkoop M. Pain during prolonged sitting is a common problem in persons with patellofemoral pain. *J Orthop Sports Phys Ther*. 2016;46:658–663.
36. Holden S, Kasza J, Winters M, van Middelkoop M, Rathleff MS, Adolescent Knee Health G. Prognostic factors for adolescent knee pain: an individual participant data meta-analysis of 1281 patients. *Pain*. 2021;162:1597–1607.
37. Rathleff MS, Thorborg K, Andreucci A, Riel H. Association of self-reported improvement after 4 weeks and outcomes after 52 weeks among adolescents

with patellofemoral pain and Osgood-Schlatter disease. *Orthop J Sports Med*. 2024;12:23259671241280581.
38. Nunes GS, Stapait EL, Kirsten MH, de Noronha M, Santos GM. Clinical test for diagnosis of patellofemoral pain syndrome: Systematic review with meta-analysis. *Phys Ther Sport*. 2013;14:54–59.
39. Djurtoft C, Bruun MK, Riel H, Hoegh MS, Darlow B, Rathleff MS. How do we explain painful non-traumatic knee conditions to adolescents? A multiple-method study to develop credible explanations. *Eur J Pain*. 2024;28:659–672.
40. Joslin R, Donovan-Hall M, Roberts L. Exploring the outcomes that matter most to young people treated for chronic pain: a qualitative study. *Children*. 2021;8:1170.
41. Neville A, Jordan A, Beveridge JK, Pincus T, Noel M. Diagnostic uncertainty in youth with chronic pain and their parents. *J Pain*. 2019;20:1080–1090.
42. Tanna V, Heathcote LC, Heirich MS, Rush G, Neville A, Noel M, et al. Something else going on? Diagnostic uncertainty in children with chronic pain and their parents. *Children*. 2020;7:165.
43. Guldhammer C, Holden S, Sorensen ME, Olesen JL, Jensen MB, Rathleff MS. Development and validation of the Sorting non-trauMatIc adoLescent knEe pain (SMILE) tool - a development and initial validation study. *Pediatr Rheumatol Online J*. 2021;19:110.
44. Peck DM, Voss LM, Voss TT. Slipped capital femoral epiphysis: diagnosis and management. *Am Fam Physician*. 2017;95:779–784.
45. Wolf M. Knee pain in children, Part II: Limb- and life-threatening conditions, hip pathology, and effusion. *Pediatr Rev*. 2016;37:72–76.
46. Rosenbaum DG, Cooper AP. Slipped capital femoral epiphysis: emphasis on early recognition and potential pitfalls. *Skeletal Radiol*. 2024:1–12.
47. Vicenzino B. Foot orthotics in the treatment of lower limb conditions: a musculoskeletal physiotherapy perspective. *Man Ther*. 2004;9:185–196.
48. Birnie KA, Hundert AS, Lalloo C, Nguyen C, Stinson JN. Recommendations for selection of self-report pain intensity measures in children and adolescents: a systematic review and quality assessment of measurement properties. *Pain*. 2019;160:5–18.
49. Kamper SJ, Maher CG, Mackay G. Global rating of change scales: a review of strengths and weaknesses and considerations for design. *J Man Manip Ther*. 2009;17:163–170.
50. de Vasconcelos GS, Andreucci A, Vicenzino B, Thorborg K, Mikkelsen M, Serrao FV, et al. Global rating of change for better or worse-–What does it mean when patients who are treated for patellofemoral pain rate their change? *J Orthop Sports Phys Ther*. 2024;54:657–671.
51. Ortqvist M, Iversen MD, Janarv PM, Brostrom EW, Roos EM. Psychometric properties of the Knee injury and Osteoarthritis Outcome Score for Children (KOOS-Child) in children with knee disorders. *Br J Sports Med*. 2014;48:1437–1446.
52. Rosenbloom BN, Page MG, Isaac L, Campbell F, Stinson JN, Cribbie R, et al. Fear of movement in children and adolescents undergoing major surgery: A psychometric evaluation of the Tampa Scale for Kinesiophobia. *Eur J Pain*. 2020;24:1999–2014.
53. Waddell G, Newton M, Henderson I, Somerville D, Main CJ. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain*. 1993;52:157–168.
54. Crombez G, Bijttebier P, Eccleston C, Mascagni T, Mertens G, Goubert L, et al. The child version of the pain catastrophizing scale (PCS-C): a preliminary validation. *Pain*. 2003;104:639–646.
55. Nicholas MK. The pain self-efficacy questionnaire: Taking pain into account. *Eur J Pain*. 2007;11:153–163.
56. Stahlschmidt L, Hubner-Mohler B, Dogan M, Wager J. Pain self-efficacy measures for children and adolescents: a systematic review. *J Pediatr Psychol*. 2019;44:530–541.
57. Jordan A, Williams M, Jones A, Noel M, Neville A, Clinch J, et al. Pediatrician explanations of pediatric pain in clinical settings: a delicate craft. *J Pain*. 2023;24:1396–1405.
58. Feinstein AB, Brown K, Dunn AL, Neville AJ, Sokol O, Poupore-King H, et al. Where do we start? Health care transition in adolescents and young adults with chronic primary pain. *Pain*. 2024. early online.
59. Johansen SK, Kanstrup AM, Haseli K, Stenmo VH, Thomsen JL, Rathleff MS. Exploring user visions for modeling mhealth apps toward supporting patient-parent-clinician collaboration and shared decision-making when treating adolescent knee pain in general practice: workshop study. *JMIR Hum Factors*. 2023;10:e44462.
60. de Oliveira Silva D, Pazzinatto MF, Rathleff MS, Holden S, Bell E, Azevedo F, et al. Patient education for patellofemoral pain: a systematic review. *J Orthop Sports Phys Ther*. 2020;50:388–396.
61. Rathleff MS, Graven-Nielsen T, Holmich P, Winiarski L, Krommes K, Holden S, et al. Activity modification and load management of adolescents with patellofemoral pain: a prospective intervention study including 151 adolescents. *Am J Sports Med*. 2019;47:1629–1637.
62. van Sluijs EMF, Ekelund U, Crochemore-Silva I, Guthold R, Ha A, Lubans D, et al. Physical activity behaviours in adolescence: current evidence and opportunities for intervention. *Lancet*. 2021;398:429–442.
63. Rathleff MS, Roos EM, Olesen JL, Rasmussen S. Early intervention for adolescents with patellofemoral pain syndrome–a pragmatic cluster randomised controlled trial. *BMC Musculoskelet Disord*. 2012;13:9.
64. Azab AR, Abdelbasset WK, Basha MA, Mahmoud WS, Elsayed AE, Saleh AK, et al. Incorporation of Pilates-based core strengthening exercises into the rehabilitation protocol for adolescents with patellofemoral pain syndrome: a randomized clinical trial. *Eur Rev Med Pharmacol Sci*. 2022;26:1091–1100.
65. Riel H, Matthews M, Vicenzino B, Bandholm T, Thorborg K, Rathleff MS. Feedback leads to better exercise quality in adolescents with patellofemoral pain. *Med Sci Sports Exerc*. 2018;50:28–35.
66. Riel H, Matthews M, Vicenzino B, Bandholm T, Thorborg K, Rathleff MS. Efficacy of live feedback to improve objectively monitored compliance to prescribed, home-based, exercise therapy-dosage in 15 to 19 year old adolescents with patellofemoral pain- a study protocol of a randomized controlled superiority trial (The XRCISE-AS-INSTRUcted-1 trial). *BMC Musculoskelet Disord*. 2016;17:242.
67. Crossley KM, Bennell KL, Cowan SM, Green S. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Arch Phys Med Rehabil*. 2004;85:815–822.
68. O'Sullivan IC, da Costa NC, Franettovich Smith MM, Vicenzino B, Crossley KM, Kamper SJ, et al. Adolescent perspectives on participating in a feasibility trial investigating shoe inserts for patellofemoral pain. *J Foot Ankle Res*. 2022;15:37.
69. Eng JJ, Pierrynowski MR. Evaluation of soft foot orthotics in the treatment of patellofemoral pain syndrome. *Phys Ther*. 1993;73:62–68.
70. Chapman LS, Redmond AC, Landorf KB, Rome K, Keenan AM, Waxman R, et al. A survey of foot orthoses prescription habits amongst podiatrists in the UK, Australia and New Zealand. *J Foot Ankle Res*. 2018;11:64.
71. O'Sullivan IC, Crossley KM, Kamper SJ, van Middelkoop M, Vicenzino B, Franettovich Smith MM, et al. HAPPi Kneecaps! A double-blind, randomised, parallel group superiority trial investigating the effects of sHoe inserts for adolescents with patellofemoral PaIn: phase II feasibility study. *J Foot Ankle Res*. 2021;14:64.
72. O'Sullivan IC, Crossley KM, Kamper SJ, van Middelkoop M, Vicenzino B, Franettovich Smith MM, et al. HAPPi Kneecaps! Protocol for a participant- and assessor-blinded, randomised, parallel group feasibility trial of foot orthoses for adolescents with patellofemoral pain. *J Foot Ankle Res*. 2020;13:50.
73. Mazzella N, Fox A, Trowell D, Saunders N, Vicenzino B, Bonacci J. Flat flexible school shoes for adolescents with patellofemoral pain: a randomised, assessor-blinded, parallel-group feasibility trial. *BMJ Open Sport Exerc Med*. 2023;9:e001717.
74. Mazzella N, Trowell D, Fox A, Saunders N, Vicenzino B, Bonacci J. The immediate biomechanical effects of a flat, flexible school shoe in adolescents with patellofemoral pain. *Med Sci Sports Exerc*. 2024;56:745–752.
75. McConnell J. Management of patellofemoral problems. *Man Ther*. 1996;1:60–66.
76. Lesher JD, Sutlive TG, Miller GA, Chine NJ, Garber MB, Wainner RS. Development of a clinical prediction rule for classifying patients with patellofemoral pain syndrome who respond to patellar taping. *J Orthop Sports Phys Ther*. 2006;36:854–866.
77. Collins NJ, Bisset LM, Crossley KM, Vicenzino B. Efficacy of nonsurgical interventions for anterior knee pain: systematic review and meta-analysis of randomized trials. *Sports Med*. 2012;42:31–49.
78. Collins N, Crossley K, Beller E, Darnell R, McPoil T, Vicenzino B. Foot orthoses and physiotherapy in the treatment of patellofemoral pain syndrome: randomised clinical trial. *BMJ*. 2008;337:a1735.
79. Van Tiggelen D, Witvrouw E, Roget P, Cambier D, Danneels L, Verdonk R. Effect of bracing on the prevention of anterior knee pain–a prospective randomized study. *Knee Surg Sports Traumatol Arthrosc*. 2004;12:434–439.
80. Liu H, Yang W, Liu H, Bao D, Cui Y, Ho IMK, et al. A meta-analysis of the criterion-related validity of Session-RPE scales in adolescent athletes. *BMC Sports Sci Med Rehabil*. 2023;15:101.
81. Rathleff MS, Skuldbol SK, Rasch MN, Roos EM, Rasmussen S, Olesen JL. Care-seeking behaviour of adolescents with knee pain: a population-based study among 504 adolescents. *BMC Musculoskelet Disord*. 2013;14:225.
82. Wolf M. Knee pain in children, Part III: Stress Injuries, benign bone tumors, growing pains. *Pediatr Rev*. 2016;37:114–118.
83. Schroeder PB, Nicholes MA, Schmitz MR. Hip injuries in the adolescent athlete. *Clin Sports Med*. 2021;40:385–398.
84. Kocher MS, Tucker R. Pediatric athlete hip disorders. *Clin Sports Med*. 2006;25:241–253, viii.