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[Intervention Review]

Exercise for patellar tendinopathy

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ABSTRACT

Background

Patellar tendinopathy is a prevalent condition that commonly affects the tendon's origin, causing pain at the front of the knee. The main treatment for patellar tendinopathy involves different types of exercise (e.g. strengthening and stretching). The most common method of strengthening exercise is eccentric (lengthening) muscle loading. Strengthening exercises can be land-based or water-based, weight-bearing or non-weight-bearing, or both. Other treatments include surgery and glucocorticoid injections.

Objectives

To evaluate the benefits and harms of exercise for the treatment of patellar tendinopathy.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Embase, and two trials registers to 5 September 2023, with no restrictions by language.

Selection criteria

We included randomized controlled trials of strengthening exercise interventions compared to placebo or sham intervention; no treatment, usual care, or minimal intervention; or other active intervention. Strengthening exercises include concentric, eccentric, eccentric-concentric, and isometric exercises designed to enhance the strength and power of muscles.

Data collection and analysis

Two review authors independently selected studies for inclusion, extracted data, and assessed risk of bias and certainty of evidence using GRADE. Major outcomes included pain, function, participant-reported global assessment of treatment success, quality of life, return to sport, proportion of participants with adverse events, and proportion of participant withdrawals.

Main results

We included seven trials (211 participants with chronic patellar tendinopathy) comparing strengthening exercises with no treatment (3 trials, 93 participants), glucocorticoid injection (1 trial, 38 participants), surgery (1 trial, 40 participants), stretching exercise (1 trial, 15 participants), or pulsed ultrasound and transverse friction (1 trial, 30 participants). All trials included athletes (88% males, mean age

26 years) with a mean duration of symptoms of 41.6 months. Most trials were susceptible to bias, particularly selection bias/random sequence (57.1%), selection bias/allocation concealment (42.8%), detection bias (28.5%), attrition bias (71.4%), and selective reporting biases (28.5%). Given the nature of the intervention, neither participants nor investigators were blinded to group allocation in any trials (performance bias).

We did not find any studies that compared exercise with placebo or sham intervention.

Strengthening exercise versus no treatment

We are very uncertain whether strengthening exercise reduces pain compared to no treatment. Mean pain with no treatment was 62.00 points on a 0 to 100 scale (0 = no pain) compared to 27.06 points with exercise (mean difference (MD) 34.94 points better, 95% confidence interval (CI) 20.94 better to 48.94 better; 1 study, 39 participants; very low-certainty evidence (downgraded twice for imprecision and once for bias)). Strengthening exercise may make little or no difference to function compared to no treatment at the end of treatment. Mean function with no treatment was 65.00 points on a 0 to 100 scale (100 = best function) compared to 72.04 points with exercise (MD 7.04 points better, 95% CI 6.94 points worse to 21.02 points better; 2 studies, 95 participants; low-certainty evidence (downgraded once for imprecision and once for bias)).

The studies reported none of the other outcomes.

Strengthening exercise versus glucocorticoid injection

Strengthening exercise may make little or no difference to pain compared to glucocorticoid injection at the end of treatment. Mean pain with glucocorticoid injection was 18.00 points on a 0 to 100 scale (0 = no pain) compared to 24.04 points with exercise (MD 6.04 points worse, 95% CI 8.19 better to 20.26 better; 1 trial, 38 participants; low-certainty evidence (downgraded twice for imprecision)).

Strengthening exercise may make little or no difference to function compared to glucocorticoid injection at the end of treatment. Mean function with no treatment was 82.00 points on a 0 to 100 scale (100 = best function) compared to 76.25 points with exercise (MD 5.75 points worse, 95% CI 17.41 worse to 5.93 better; 1 trial, 38 participants; low-certainty evidence (downgraded twice for imprecision)).

The trial reported none of the other outcomes.

Strengthening exercise versus surgery

We are very uncertain whether strengthening exercise reduces pain compared to surgery at 12-month follow-up. Mean pain with surgery was 13.00 points on a 0 to 100 scale (0 = no pain) compared to 17.00 points with exercise (MD 4.00 points worse, 95% CI 4.06 better to 12.06 worse; 1 trial, 40 participants; very low-certainty evidence).

We are very uncertain whether strengthening exercise improves function compared to surgery. Mean function in the surgery group at the end of treatment was 45.10 points on a 0 to 100 scale (100 = best function) compared to 52.4 points in the exercise group (MD 7.30 points better, 95% CI 5.02 worse to 19.62 better; 1 trial, 40 participants; very low-certainty evidence (downgraded once for bias and twice for serious imprecision)).

Strengthening exercise may make little or no difference to treatment success compared to surgery at the end of treatment. The mean global assessment of treatment success with surgery was 0.2 points on a −5 to +5 scale (+5 maximum was improvement) compared to 1.76 points with exercise (MD 1.56 points better, 95% CI 0.52 worse to 3.64 better; 1 trial, 40 participants; low-certainty evidence (downgraded once for bias and once for imprecision)).

Strengthening exercise may make little or no difference to the rate of participants who returned fully or partially to sport when compared to surgery at 12-month follow-up. The return to sport rate with surgery was 86% compared to 85% with exercise (risk ratio 1.02, 95% CI 0.78 to 1.34; 1 trial, 40 participants; low-certainty evidence (downgraded once for bias and once for imprecision)).

The trial reported none of the other outcomes.

Authors' conclusions

We are very uncertain whether strengthening exercise reduces pain compared to no treatment. Strengthening exercise may make little or no difference to function compared to no treatment and to function or pain compared to glucocorticoid injection. Compared to surgery, we are very uncertain whether strengthening exercise reduces pain or improves function, and it may make little or no difference to treatment success and the proportion of athletes returning to sport. No trials measured adverse events. All trials analyzed in this review included participants who were athletes, limiting the findings to athletes rather than the general public.

PLAIN LANGUAGE SUMMARY

Do strengthening exercises help in the treatment of people with patellar tendinopathy (jumper's knee)?

Key messages

— The evidence for using strengthening exercises to treat patellar tendinopathy (pain at the front of the knee involving the tendon) is very uncertain, making it difficult to draw firm conclusions.

— For athletes, we are very uncertain whether exercise reduces pain compared to no treatment. Strengthening exercises may make little or no difference to function compared to no treatment, and little or no difference to function and pain compared to glucocorticoid injections (anti-inflammatory medications).

— It is unclear if these exercises are better than surgery for reducing pain or improving function. Athletes reported similar treatment success and return to sport with strengthening exercises and surgery.

What is patellar tendinopathy?

People with patellar tendinopathy (jumper's knee) usually have pain and tenderness upon pressing the tendon at the front of the knee (connects muscles to bones). This frequently affects people in activities requiring repetitive jumping, braking, kicking, or running. Patellar tendinopathy can cause disability in both athletes and non-athletes, significantly impacting athletic performance and career longevity.

How is patellar tendinopathy treated?

One of the main treatments for patellar tendinopathy is exercise, especially strengthening exercises. Other options include anti-inflammatory medications (such as glucocorticoid injections) and, in some cases, surgery. Additional treatments that have been used include platelet-rich plasma injections (a concentrated component of the blood injected into the knee), ultrasound therapy (which uses sound waves to reduce pain and support healing), laser therapy (which uses focused light to decrease pain and swelling, and speed up healing), and shockwave therapy (which uses high-energy sound waves to stimulate healing and reduce pain).

What did we do?

We searched for studies comparing exercises with other treatments (such as no treatment, anti-inflammatory medicines (for example, glucocorticoid injection), and surgery) in people with patellar tendinopathy. We collected data on pain, function, treatment success, quality of life, return to sport, and unwanted effects, and assessed how confident we were in the results.

What did we find?

We found seven studies published between 1989 and 2022, and reported in English. Two studies were from Norway, and one each from Denmark, Germany, Greece, Poland, and the US.

Key findings

Pain*(measured between 0 and 100, lower scores mean less pain) at end of treatment.*

We are very uncertain whether exercise reduces pain compared to no treatment.

– People in the exercise group rated their pain as 27 points.

– People in the no-treatment group rated their pain as 62 points.

Exercise may make little or no difference to pain compared to glucocorticoid injection.

– People in the exercise group rated their pain as 24 points.

– People in the glucocorticoid injection group rated their pain as 18 points.

We are very uncertain whether exercise reduces pain compared to surgery.

– People in the exercise group rated their pain as 13 points.

– People in the surgery group rated their pain as 17 points.

Function*(measured between 0 and 100, lower scores mean better function) at end of treatment.*

Exercise may make little or no difference to function compared to no treatment.

– People in the exercise group rated their knee function as 72 points.

– People in the no-treatment group rated their knee function as 65 points.

Exercise may make little or no difference to function compared to glucocorticoid injection.

– People in the exercise group rated their knee function as 76 points.

– People in the glucocorticoid injection group rated their knee function as 82 points.

We are very uncertain whether exercise reduces function compared to surgery.

– People in the exercise group rated their knee function as 52 points.

– People in the surgery group rated their knee function as 45 points.

Treatment success *(measured from −5 to +5, +5 means maximum improvement) at the end of treatment.*

Exercise may make little or no difference to treatment success compared to surgery.

– People in the exercise group rated their success as 1.7 points.

– People in the surgery group rated their success as 0.2 points.

Return to sport rate *measured at 12 months.*

Exercise may make little or no difference to the rate of return to sport compared to surgery.

– 85 out of 100 people returned to sport after exercise treatment.

– 86 out of 100 people returned to sport after surgery.

What are the limitations of the evidence?

The effectiveness of strengthening exercises for athletes is uncertain. There were few studies of varying quality, with a small number of people. All studies only included athletes, so the results may not apply to people who are not athletes. No studies reported unwanted effects.

How up to date is this evidence?

The evidence is up to date to 5 September 2023.

SUMMARY OF FINDINGS

Summary of findings 1. Strengthening exercise versus no treatment for patellar tendinopathy

Strengthening exercise versus no treatment for patellar tendinopathy

Patient or population: volleyball athletes with chronic tendinopathy
Setting: clinic and home
Intervention: strengthening exercise
Comparison: no treatment

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	No treatment	Strengthening exercise				
Pain Scale: 0–100, 0 = no pain Follow-up: end of treatment[a]	The mean pain intensity in the surgery group was **62.00 points**	The mean pain in the exercise group was **34.94 points better** (20.94 better to 48.94 better)	—	39 participants (1 RCT)	⊕⊖⊖⊖ **Very Low**[b,c,d]	We are very uncertain whether strengthening exercise reduces pain compared to no treatment.
Function[e] Scale: 0–100, 100 = best function Follow-up: end of treatment	The function in the no treatment group was **65.00 points**[f]	The mean function in the exercise group was **7.04 points better** (6.94 worse to 21.02 better)	—	95 participants (3 RCTs)	⊕⊕⊖⊖ **Low**[b,c]	Strengthening exercise may make little or no difference to function compared to no treatment.
Global assessment of treatment success	—	—	—	—	—	No studies reported this outcome.
Quality of life	—	—	—	—	—	No studies reported this outcome.
Withdrawals due to adverse events	—	—	—	—	—	No studies measured this outcome.
Adverse events	—	—	—	—	—	No studies measured this outcome.
Return to sport	—	—	—	—	—	No studies measured this outcome.

***The corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **RCT:** randomized controlled trial.

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]**Pain intensity** at the end of treatment assessed with the Visual Analogue Scale (VAS).
[b]Downgraded one level due to serious risk of bias (performance bias, selection bias, attrition bias, and reporting bias).
[c]Downgraded one level for imprecision: the 95% confidence intervals did not rule in or rule out a clinically important change (defined as 10 points on the 0- to 100-point Victorian Institute of Sport Assessment – Patella (VISA-P)).
[d]Downgraded one level for imprecision (a single trial with a small number of participants).
[e]**Function** assessed with VISA-P.
[f]Value in no treatment group at the end of treatment follow-up from Visnes 2005.

Summary of findings 2. Strengthening exercise versus glucocorticoid injection for patellar tendinopathy

Strengthening exercise versus glucocorticoid injection for patellar tendinopathy

Patient or population: male athletes with chronic patellar tendinopathy
Setting: clinic

Intervention: strengthening exercise
Comparison: glucocorticoid injection

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Glucocorticoid injection	Strengthening exercise				
Pain[a] Scale: 0–100, 0 = no pain Follow-up: end of treatment	The mean pain intensity in the glucocorticoid injection group was **18.00 points**[b]	The mean pain in the exercise group was **6.04 points worse** (8.19 better to 20.26 worse)	—	38 participants (1 RCT)[c]	⊕⊕⊖⊖ **Low**[d,e]	Strengthening exercise may make little or no difference to pain compared to glucocorticoid injection.

Function[a] Scale: 0–100, 100 = best function Follow-up: end of treatment	The mean function in the glucocorticoid injection group was **82.00 points**[b]	The mean function in the exercise group was **5.75 points** **worse** (17.42 worse to 5.93 better)	—	38 participants (1 RCT)[c]	⊕⊕⊖⊖ **Low**[d,f]	Strengthening exercise may make little or no difference to function compared to glucocorticoid injection.
Global assessment of treatment success	—	—	—	—	—	No studies reported this outcome.
Quality of life	—	—	—	—	—	No studies reported this outcome.
Withdrawals due to adverse events	—	—	—	—	—	No studies reported this outcome.
Adverse events	—	—	—	—	—	No studies measured this outcome.
Return to sport	—	—	—	—	—	No studies measured this outcome.

*__The corresponding risk__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **RCT:** randomized controlled trial.

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]Pain assessed with Visual Analogue Scale (VAS). Function assessed with the Victorian Institute of Sport Assessment – Patella (VISA-P) scale.
[b]Mean value in glucocorticoid injection group at the end of treatment follow-up from Kongsgaard 2009.
[c]One RCT with two comparisons using different types of exercises compared to glucocorticoid injection (eccentric decline squat training versus glucocorticoid injection; and squat, leg press, and hack squat exercises versus glucocorticoid injection).
[d]Downgraded one level for imprecision (a single trial with a small number of participants).
[e]Downgraded one level due to imprecision: the 95% confidence intervals did not rule in or rule out a clinically important change (defined as 10 points on the 0- to 100-point VAS).
[f]Downgraded one level due to imprecision: the 95% confidence intervals did not rule in or rule out a clinically important change (defined as 10 points on the 0- to 100-point VISA-P).

Summary of findings 3. Strengthening exercise versus surgery for patellar tendinopathy

Strengthening exercise versus surgery for patellar tendinopathy

Patient or population: athletes with patellar tendinopathy
Setting: home and surgery
Intervention: strengthening exercise
Comparison: surgery

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Surgery	Strengthening exercise				
Pain[a] Scale: 0–100, 0 = no pain Follow-up: 12 months' follow-up[a]	The mean pain intensity in the surgery group was **13.00 points**[b]	The mean pain in the exercise group was **4.00 points worse** (4.06 better to 12.06 worse)	—	35 participants (1 RCT)[c]	⊕⊖⊖⊖ **Very low**[d,e,f]	We are very uncertain whether strengthening exercise reduces pain compared to surgery.
Function[a] Scale: 0–100, 100 = best function Follow-up: end of treatment	The mean function in the surgery group was **45.00 points**[g]	The mean function in the exercise group was **7.30 points better** (5.02 worse to 19.62 better)	—	35 participants (1 RCT)[c]	⊕⊖⊖⊖ **Very low**[d,f,h]	We are very uncertain whether strengthening exercise improves function compared to surgery.
Global assessment of treatment success[a] Scale from: −5 to +5, +5 = maximum improvement Follow-up: end of treatment	The mean global assessment treatment success in the surgery group was **0.20 points**[b]	The mean global assessment treatment success in the exercise group was **1.56 points better** (0.52 worse to 3.64 better)	—	35 participants (1 RCT)[c]	⊕⊕⊖⊖ **Low**[d,f]	Strengthening exercise may make little or no difference to the global assessment of treatment success compared to surgery.
Quality of life	—	—	—	—	—	No studies reported this outcome.
Withdrawals due to adverse events	—	—	—	—	—	No studies reported this outcome.
Adverse events	—	—	—	—	—	No studies measured adverse events.
Return to sport[i]	86%	85%	**RR 1.02** (0.78 to 1.34)	35 participants (1 RCT)[c]	⊕⊕⊖⊖ **Low**[d,f]	Strengthening exercise may make little or no difference to the

Number of participants who returned fully or partially to sport with or without pain Follow-up: 12 months				rate of participants who return to sport.

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

CI: confidence interval; **RCT:** randomized controlled trial; **RR:** risk ratio.

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]**Pain intensity** at 12 months' follow-up during standing jump test and assessed with Visual Analogue Scale (VAS). The trial did not measure pain intensity at the end of the treatment. **Function** assessed with the Victorian Institute of Sport Assessment – Patella (VISA-P). **Global assessment of treatment success** assessed with an 11-point Visual Numerical Scale, with +5 representing maximum improvement (no symptoms), 0 representing no change, and –5 representing maximum worsening (severe symptoms).
[b]Mean value in surgery group at 12 months' follow-up from Bahr 2006.
[c]35 participants (40 knees).
[d]Downgraded one level for imprecision (a single trial with a small number of participants).
[e]Downgraded one level for imprecision: the 95% confidence intervals did not rule in or rule out a clinically important change (defined as 10 points on the 0- to 100-point VAS).
[f]Downgraded one level for serious risk of bias (selection bias, performance bias, detection bias, and reporting bias).
[g]Mean value in surgery group at the end of treatment follow-up from Bahr 2006.
[h]Downgraded one level for imprecision: the 95% confidence intervals did not rule in or rule out a clinically important change (defined as 10 points on the 0- to 100-point VISA-P).
[i]Return to sport assessed classified into five categories: training fully and had no symptoms, training fully but had mild or moderate symptoms, training at a reduced level, and not training at all because of the knee problem.

BACKGROUND

Description of the condition

Patellar tendinopathy (jumper's knee) is a prevalent condition that most commonly affects the tendon's origin on the inferior pole of the patella (Mendonça 2020; Visnes 2007). People with patellar tendinopathy usually present pain at the front of the knee and tenderness to palpation (physical examination by touching) over the tendon (Murtaugh 2013; Rabin 2006). Typical findings on magnetic resonance imaging include abnormalities of the posterior border of the patellar tendon and thickening of the patellar tendon (Bahr 2006; Panni 2000; Rees 2006). Patellar tendinopathy has also been considered an inflammatory or degenerative process (or both) due to disrupted collagen fibres (Malliaras 2013; Stasinopoulos 2004; Tan 2008).

Patellar tendinopathy commonly occurs in individuals participating in activities requiring repetitive jumping, braking, kicking, or running (Stasinopoulos 2004). The prevalence of patellar tendinopathy in sports can reach up to 50% of athletes, depending on the sport (Murtaugh 2013; Saithna 2012; van der Worp 2011). The general population has a relatively low prevalence and incidence of patellar tendinopathy at 0.1% (Albers 2016; Riel 2019).

This injury can lead to disability in both athletes and non-athletes, and can impact the performance and longevity of athletic careers (Jonsson 2005; Warden 2008; Wasielewski 2007). The aetiology and pathogenesis of tendinopathy are not fully understood, making choosing effective treatment options challenging for clinicians (Jonsson 2005; Rees 2006; Visnes 2007).

Description of the intervention

Conservative treatment for patellar tendinopathy includes rest, anti-inflammatory drugs, weight reduction, taping, massage, electrotherapy, percutaneous electrolysis, platelet-rich plasma, lifestyle change, ultrasound, laser therapy, extracorporeal shock wave therapy, and exercises. Evidence does not show clear superiority of any treatment (Abat 2014; Cook 2001; de Vos 2010; Dragoo 2014; Furia 2013; Gaida 2011; Mendonça 2020). Surgery is another treatment for patellar tendinopathy (Bahr 2006). During the surgical procedure, the patellar tendon is exposed, and any abnormal or damaged tissue is surgically excised and removed (Bahr 2006).

One study described a conservative treatment approach that emphasized the use of gradually incremented exercises to strengthen the quadriceps femoris muscle-patellar tendon unit for patellar tendinopathy (Stanish 1986). Since the 1980s, progressive eccentric muscle loading has become the dominant conservative intervention strategy for patellar tendinopathy (Malliaras 2013; Wasielewski 2007). However, some authors recommend other types of muscle contractions, such as isolated concentric and eccentric-concentric exercises, to increase knee extensor muscle strength (Frohm 2007; Malliaras 2013). Strengthening exercises for patellar tendinopathy are conducted using squats, leg-presses, or leg extensions (Cannell 2001; Gaida 2011). Usually, the exercises are delivered as part of a treatment package that also includes other components (e.g. electrotherapy, Visnes 2005; Visnes 2007), platelet-rich plasma (Dragoo 2014; van Ark 2013), extracorporeal shockwave therapy (van der Worp 2011), and others (Abat 2014; Coombes 2010; de Vos 2010; Steunebrink 2013).

Strengthening exercise interventions can be land-based or water-based. They could also be performed when weight-bearing, non-weight-bearing, or a combination of these. This review included all types of strengthening exercises: concentric (contracting the muscle while it is shortening), eccentric (contracting the muscle while it is lengthening), isometric (contractions where there is no change in the length of the muscle), and isokinetic (contracting the muscle at a constant and consistent rate of speed).

How the intervention might work

The exact way in which strengthening exercises help in the rehabilitation of patellar tendinopathy is not fully understood (Rees 2009; Saithna 2012). One possible explanation is that these exercises increase the tensile strength of the tendon, which means that it can withstand more stress before failing (Rees 2006). This increased strength can reduce the amount of overload on the tendon, which in turn can reduce pain (Wasielewski 2007; Young 2005). As the training progresses and becomes pain-free, the load can be increased by first increasing the speed of the eccentric phase and then by adding extra resistance to the movements (Dimitrios 2012; Stasinopoulos 2004; Visnes 2007). Some authors believe that eccentric contraction strengthening exercises could more effectively reorganize tendon fibres and stimulate collagen production than concentric contraction (Rees 2006; Rees 2009).

Why it is important to do this review

To date, there are no robust estimates of the size of the effect of strengthening exercises to treat patellar tendinopathy despite these interventions being very popular in clinical practice. There are numerous systematic reviews on strengthening exercises for patellar tendinopathy (Challoumas 2021; Doelen 2020; Everhart 2017; Gaida 2011; Larsson 2012; Lim 2018; Malliaras 2013; Murtaugh 2013; Núñez-Martínez 2022; Rodriguez-Merchan 2013; Saithna 2012; Vang 2020). Most of these reviews concluded that these exercises were effective or showed promise despite the lack of studies comparing exercises for patellar tendinopathy with other interventions (e.g. no intervention or placebo). It is generally assumed that these exercises are effective for patellar tendinopathy, and the main focus of these studies is to determine the best exercises to use when treating this condition. One systematic review was dedicated to identifying the appropriate dose for the treatment of tendinopathy, including patellar tendinopathy protocols (Pavlova 2023). This is the first time that a systematic review has been conducted and did not include trials that used exercises for both treatment arms. We decided to conduct the first Cochrane review of strengthening exercise interventions for patella tendinopathy to address the uncertainty arising from conflicting results reported in previous reviews.

OBJECTIVES

To evaluate the benefits and harms of strengthening exercises for the treatment of patellar tendinopathy.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomized controlled trials and quasi-randomized trials.

Types of participants

We included trials that studied participants with patellar tendinopathy. Trial participants were either athletes or non-athletes. Athletes typically participate in organized sports or physical activities, ranging from amateur to professional levels. We excluded trials that included combined injuries (e.g. participants diagnosed with patellar tendinopathy and patellofemoral pain syndrome).

Types of interventions

We included trials assessing the effects of strengthening exercises. These interventions aimed to strengthen the muscles of the lower limb. The interventions included any contraction types (i.e. concentric, eccentric, eccentric-concentric, and isometric exercises). We accepted trials with any exercise content, duration, frequency, or intensity. We included trials regardless of whether exercises were delivered in group or individual classes, land- or water-based, and whether exercises were supervised. We did not exclude any trial due to co-interventions, provided they were equally applied.

Comparisons

1. Strengthening exercise versus placebo or sham intervention
2. Strengthening exercise versus no treatment, usual care, or minimal intervention
3. Strengthening exercise versus other active interventions
   a. Strengthening exercise compared to glucocorticoid injection
   b. Strengthening exercise compared to surgery
   c. Strengthening exercise compared to stretching exercise
   d. Strengthening exercise compared to pulsed ultrasound and transverse friction
   e. Addition of strengthening exercise over any other treatment versus other treatment alone

We excluded trials that only compared different strengthening exercises without comparing exercise with other interventions.

Types of outcome measures

Major outcomes

1. **Pain**, preferably overall pain, measured as mean pain or mean change in pain using a Visual Analogue Scale (VAS), Numerical or Categorical Rating Scale.
2. **Function or disability**, preferably measured with validated instruments (including the Victorian Institute of Sport Assessment – Patella (VISA-P) questionnaire).
3. **Participant-reported global assessment of treatment success**.
4. **Quality of life**, measured by generic measures (such as components of the 36-item Short Form (SF-36) or disease-specific tools).
5. **Return to sport**.
6. **Proportion of participants with adverse events** (including injury and recurrence during the training programme).
7. **Proportion of participant withdrawals, or overall dropouts**.

Minor outcomes

1. **Recurrence**.
2. **Muscle strength**.

Time points

We collected data at short-term (immediately after the intervention), medium-term (six months after randomization), and long-term (i.e. 12 months or more) follow-up. The primary time point was at the end of treatment.

Search methods for identification of studies

Electronic searches

We searched for randomized controlled trials from the following electronic databases without restrictions on language or date of publication.

1. Cochrane Central Register of Controlled Trials (CENTRAL; 2023, Issue 9) (via EBM reviews in Ovid) (Appendix 1)
2. MEDLINE via Ovid (1950 to 5 September 2023) (Appendix 2)
3. Embase via Ovid (1980 to 5 September 2023) (Appendix 3)
4. ClinicalTrials.gov (https://www.clinicaltrials.gov) up to 5 September 2023 (Appendix 4)
5. International Clinical Trials Registry Platform (ICTRP) (https://www.who.int/clinical-trials-registry-platform) up to 5 September 2023 (Appendix 5)

Searching other resources

We searched the reference lists of eligible studies, included trials, and previously published systematic reviews related to patellar tendinopathy.

Data collection and analysis

Selection of studies

Two review authors (ADL and RRR) independently screened titles and abstracts for potentially eligible studies. We assessed the full-text papers of potentially relevant trials to determine the final inclusion in the review. We resolved disagreements between review authors through discussion or arbitration by a third review author (LCH). We recorded the selection process in sufficient detail to complete a PRISMA flow diagram (Page 2021), and Characteristics of excluded studies table.

Data extraction and management

Two review authors (ADL and RRR) independently performed data extraction using a standardized data extraction form containing the following information.

1. Bibliometric data: authors, year of publication, language.
2. Trial characteristics: trial design, sample size, description of the sample, country, recruitment method, and funding.
3. Characteristics of the participants: gender, age, duration of symptoms, severity of the condition at baseline, other baseline clinical characteristics, inclusion and exclusion criteria.
4. Description of the exercise interventions, including type of exercise, exercise content, number of sessions, duration of each treatment session, length of programme, supervision, group or individual, setting, comparisons, and co-interventions. A detailed description of the interventions followed the guidance of a checklist for exercise interventions suggested by the Consensus on Exercise Reporting Template (CERT) (Slade 2016).

5. Outcomes: major and minor outcomes at all time points, including a description of the measurement tool (scale of tool and direction of effect).
6. Trial results on outcomes of interest: number of participants in the analyses, mean and standard deviation per treatment group for continuous outcomes, and number of events and number of participants per treatment group for dichotomous outcomes.
7. Notes: funding and notable declarations of interest of trial authors.

If a trial reported data on more than one pain outcome, we extracted data for the measure that was highest on the following hierarchy: pain overall, pain at rest, pain with activity, unspecified. From possible measures of pain, we preferentially extracted data from the VAS.

If a trial reported data on more than one physical function scale, we extracted data according to the following hierarchy: the most prevalent measure, the second-most prevalent measure, and so on. We also preferred validated to unvalidated instruments.

If studies reported data on more than one quality-of-life instrument, we preferentially extracted data from the SF-36.

If studies reported both final values and change from baseline values for the same outcome, we selected final values. We performed a meta-analysis of mean differences (MDs) even if we had a mix of change and final scores.

We collected data at short-term (immediately after the intervention), medium-term (six months after randomization), and long-term (i.e. 12 months or more) effects. In the case of trials that collected data at several time points within each category, we used the data from the closest time point.

We selected unadjusted values over adjusted values but included adjusted if unadjusted were not reported. We selected data from intention-to-treat analysis first, then per-protocol, if intention to treat was not reported. We selected the closest to immediate post-treatment (end of treatment).

Assessment of risk of bias in included studies

Two review authors (ADL and RRR) independently performed the risk of bias assessment of the included studies using the Cochrane RoB 1 tool (Higgins 2023a). We assessed the following methodological domains.

1. Random sequence generation.
2. Allocation concealment.
3. Blinding of participants and personnel.
4. Blinding of outcome assessment.
5. Incomplete outcome data.
6. Selective outcome reporting.
7. Other bias: unexplained baseline imbalance (i.e. not explained by suboptimal randomization), unit of analysis issues, inappropriate or unequal application of co-interventions across treatment groups.

We graded each potential source of bias as high risk, low risk, or unclear risk (either lack of information or uncertainty over the potential for bias). We presented the figures generated by the RoB 1 tool to provide summary assessments of the risk of bias. We resolved disagreements between review authors by discussion, or arbitration by a third review author (LOC).

Measures of treatment effect

If studies measured continuous outcome measures, including pain, disability, and quality of life, with the same scale, we presented the mean difference (MD) and 95% confidence intervals (CIs). If studies used different scales, we presented the standardized mean difference (SMD) and 95% CIs. SMD was back-translated to a common scale (e.g. 0 to 10 for pain) by multiplying the SMD by a typical among-person standard deviation (e.g. the standard deviation of the control group at baseline from the most representative trial) (Higgins 2023b).

For dichotomous outcomes, including adverse events and return to work or sport, we presented risk ratio (RR) and 95% CI. In interpreting the results, we assumed a minimal clinically important difference of 1.5 points on 10-point continuous VAS pain scale and 10 points on 100-point function and quality of life scales (van der Roer 2006).

Unit of analysis issues

We did retrieve cluster-randomized trials or cross-over trials for this population. We included only the relevant arms where a trial had multiple arms. If two comparisons (e.g. exercise A versus placebo and exercise B versus placebo) were combined in the same meta-analysis, we halved the control group to avoid double-counting.

Dealing with missing data

First, review authors contacted trial authors by email requesting any necessary data not reported in the manuscript. In cases where data were reported as a median and interquartile range, we assumed that the median was equivalent to the mean, and the width of the interquartile range was equivalent to 1.35 times the standard deviation (Higgins 2023b). We estimated data from graphs if this information was not presented in tables or text using WebPlotDigitizer (WebPlotDigitizer).

For dichotomous outcomes that measured adverse events (e.g. number of withdrawals due to adverse events), we calculated the withdrawal rate using the number of participants who received treatment as the denominator. For dichotomous outcomes that measured benefits (e.g. proportion of participants with 30% or more reduction in pain), we calculated the proportion using the number of randomized participants as the denominator.

For continuous outcomes (e.g. mean change in pain score), we calculated the MD or SMD based on the number of participants analyzed at that time point. If the number of participants analyzed was not presented for each time point, we used the number of randomized participants in each group at baseline. If any information regarding standard deviations was missing, we calculated them from CIs or standard errors. Finally, if there was no measure of variability in the text, we estimated the standard deviation from another trial in the meta-analysis; we preferentially used the trial with the lowest risk of bias to estimate this standard deviation.

Assessment of heterogeneity

Assessment of heterogeneity was based upon visual inspections of the forest plot (e.g. overlapping CIs) and on the Chi^2 test

and I^2 statistic as recommended by the *Cochrane Handbook for Systematic Reviews of Interventions* (Page 2023). As recommended in Chapter 10 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Deeks 2023), the interpretation of an I^2 value of 0% to 40% might not be important, 30% to 60% may represent moderate heterogeneity, 50% to 90% may represent substantial heterogeneity, and 75% to 100% represents considerable heterogeneity.

As noted in the *Cochrane Handbook for Systematic Reviews of Interventions,* we kept in mind that the importance of the I^2 statistic depends on the magnitude and direction of effects, and the strength of evidence for heterogeneity. The Chi^2 test was interpreted where a P value of 0.10 or less indicated evidence of statistical heterogeneity.

Assessment of reporting biases

We planned to create funnel plots (if we retrieved at least 10 trials) to determine possible reporting biases (i.e. small-study effects) (Page 2023). To assess outcome reporting bias, we checked trial protocols against published reports. We searched online clinical trial registries, including ClinicalTrials.gov (https://clinicaltrials.gov) and the ICTRP (https://www.who.int/clinical-trials-registry-platform), to identify unpublished, completed trials to detect potential publication bias.

Data synthesis

We combined the results from individual trials, when possible, via meta-analysis for the following comparisons.

1. Strengtheningexercise versus placebo or sham intervention
2. Strengthening exercise versus no treatment, usual care, or minimal intervention such as education
3. Strengthening exercise versus other active interventions (e.g. surgery, shockwave therapy, electrotherapy, medication, another exercise intervention)
4. Addition of strengthening exercise over any other treatment (including but not limited to stretching, electrotherapy, medication) versus other treatments alone

This pooling of the data was dependent on whether the trials were sufficiently similar in terms of participants and interventions. We combined results in a meta-analysis using a random-effects model. If the I^2 was greater than 90%, we did not combine the results, but presented them as a narrative synthesis.

Subgroup analysis and investigation of heterogeneity

We planned the following subgroup analyses.

1. Duration of symptoms: if there were sufficient continuous data from at least 10 studies, we considered meta-regression to assess if symptom duration modified the effect of the intervention.
2. Population (i.e. athletes versus non-athletes, defined by the authors of the manuscripts); adults (aged 18 years or over) versus adolescents (aged 13 to 17 years) versus children (aged 12 years or younger).

Due to insufficient data, subgroup analyses were not performed.

Sensitivity analysis

We planned to perform sensitivity analyses for studies at low risk of selection and detection bias using the pain outcome. Due to an insufficient number of studies, this was not done.

Summary of findings and assessment of the certainty of the evidence

We followed the guidelines in the *Cochrane Handbook for Systematic Reviews of Interventions*, Chapters 14 and 15 (Schünemann 2023b; Schünemann 2023a), for interpreting results, and were aware of distinguishing a lack of evidence of effect from a lack of effect. We based our conclusions only on findings from the quantitative or narrative synthesis of the included studies for this review. We avoided making recommendations for practice, and our implications for research suggest priorities for future research and outlines what the remaining uncertainties are in the area.

We created three summary of findings tables.

1. Strengthening exercise compared to no treatment for patellar tendinopathy
2. Strengthening exercise compared to glucocorticoid injection for patellar tendinopathy
3. Strengthening exercise compared to surgery for patellar tendinopathy

We did not find any studies that compared exercise with placebo or sham intervention.

Each summary of findings table analyzed the following outcomes for the end of the treatment follow-up.

1. Pain, preferably overall pain, measured as mean pain or mean change in pain using a VAS, Numerical or Categorical Rating Scale
2. Function or disability, preferably measured with validated instruments
3. Participant-reported global assessment of treatment success
4. Quality of life, measured by generic measures (such as components of the SF-36 or disease-specific tools)
5. Return to sports
6. Proportion with adverse events (including injury and recurrence during the training programme)

Two review authors (ADL, RRR) independently assessed the certainty of the evidence across all studies contributing to the meta-analysis for each outcome. We used the five GRADE considerations (study limitations (overall risk of bias), consistency of effect, imprecision, indirectness, and publication bias) to assess the certainty of the body of evidence as it related to the studies which contributed data to the analyses for the prespecified outcomes, and reported the certainty of evidence as high, moderate, low, or very low. We developed the summary of findings tables using the GRADEpro GDT software (GRADEpro GDT). We justified the decisions to downgrade the certainty of evidence for each outcome using footnotes.

RESULTS

Description of studies

Results of the search

A comprehensive search across multiple databases, including CENTRAL (301 records), MEDLINE (309 records), and Embase (498 records), yielded 1108 records. A search of trial registries yielded 90 records, including 21 from ClinicalTrial.gov and 69 from ICTRP. After removing duplicates, 849 records remained. The screening process resulted in 36 full-text articles for assessment. From these, we excluded 26 full-text articles based on various criteria, such as focusing solely on comparing strengthening exercises without considering other interventions (18 articles), implementing the same exercise protocol for both groups (five articles), having a population without patellar tendinopathy (two articles), or lacking exercise as an intervention (one article). Ultimately, seven studies met the criteria for inclusion in the qualitative synthesis (Bahr 2006; Biernat 2014; Jensen 1989; Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005), and six studies were included in the quantitative synthesis through meta-analysis (Bahr 2006; Biernat 2014; Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005). We found three ongoing studies (CTRI/2019/08/020643; NCT02597660; PACTR202304561563965). No studies are awaiting classification. Figure 1 describes the flow of included and excluded studies.

Figure 1. Study flow diagram.

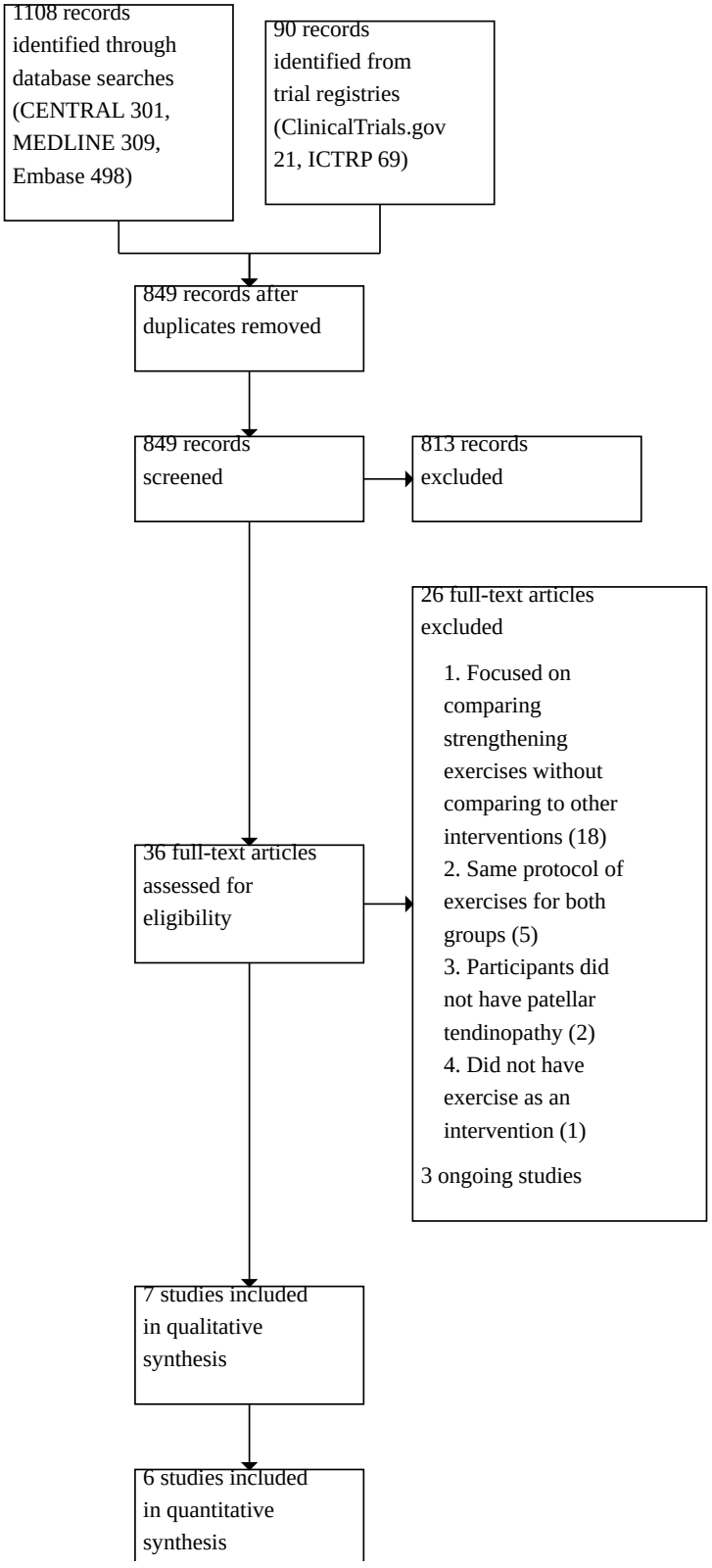


Figure 1. (Continued)

in quantitative synthesis (meta-analysis)

Included studies

We included seven randomized control trials (Bahr 2006; Biernat 2014; Jensen 1989; Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005).

Trial design

Four were two-arm trials (Bahr 2006; Biernat 2014; Jensen 1989; Visnes 2005), and three were three-arm trials (Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004).

The oldest trial was published in 1989 (Jensen 1989), and the most recent trial was published in 2022 (Rieder 2022). All trials were published in English. Two studies were from Norway (Bahr 2006; Visnes 2005), one from Denmark (Kongsgaard 2009), one from Germany (Rieder 2022), one from Greece (Stasinopoulos 2004), one from Poland (Biernat 2014), and one from the US (Jensen 1989). One trial was prospectively registered (Kongsgaard 2009).

Participants

The seven trials included 211 participants. Sample sizes ranged from 15 (Jonsson 2005) to 39 (Kongsgaard 2009) participants. Across the included trials, most participants were male (185 (87.6%) men, 26 (12.3%) women). Three studies only included men (Biernat 2014; Kongsgaard 2009; Stasinopoulos 2004). The mean age of participants was 26.3 years (range 18 to 32 years). Two trials included volleyball athletes with chronic tendinopathy (Biernat 2014; Visnes 2005), two included athletes with patellar tendinopathy (Bahr 2006; Kongsgaard 2009), and three included recreational athletes with patellar tendinopathy (Jensen 1989; Rieder 2022; Stasinopoulos 2004).

The trials had similar inclusion criteria. They included people after clinical examination, which verified a history of pain localized in the patellar tendon, tenderness in the patellar tendon during palpation, and a history of exercise-associated knee pain during exercise and loading activity. Three trials confirmed the diagnosis of patellar tendinopathy using ultrasonography or magnetic resonance imaging (Bahr 2006; Kongsgaard 2009; Rieder 2022). The main exclusion criteria were a history of previous surgery and use of corticosteroid injection. The main symptoms were pain localized in the patellar tendon and tenderness in the patellar tendon during palpation. The mean symptom duration was 41.6 months (range 18 to 73 months). Three trials did not report the duration of the symptoms (Biernat 2014; Jensen 1989; Stasinopoulos 2004).

Interventions

Three trials applied twice-daily exercise sessions seven days a week (Bahr 2006; Kongsgaard 2009; Visnes 2005). The average length of exercise programmes was 12 weeks, ranging from eight (Jensen 1989) to 24 weeks (Biernat 2014). Most studies did not report if the exercise programme was applied in groups or individually. Four trials reported the setting of the exercise programme (Bahr 2006; Biernat 2014; Jensen 1989; Stasinopoulos 2004). In one trial, participants engaged in activities at home, supplemented by weekly physiotherapy clinic visits for professional support and progress monitoring (Bahr 2006). In one trial, participants underwent the exercise sessions in a volleyball sport-specific setting (Biernat 2014). Participants in one trial performed prescribed activities within their own homes, integrating interventions into their daily routines (Jensen 1989). In one trial, participants received sessions in a clinic, ensuring access to professional care and controlled conditions (Stasinopoulos 2004). Two studies used a home-based protocol (Bahr 2006; Visnes 2005), and one trial described a hybrid setting, combining home-based and clinic-based care (Jensen 1989).

All studies provided a detailed description of the type of exercise equipment used (Bahr 2006; Biernat 2014; Jensen 1989; Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005). Only Bahr 2006 and Jensen 1989 described whether exercises were performed individually or in a group. Bahr 2006, Kongsgaard 2009, and Stasinopoulos 2004 specified whether exercises were supervised or unsupervised. Decision rules for exercise progression were described in most studies except for Jensen 1989 and Stasinopoulos 2004. Three trials provided detailed exercise descriptions for replication (Biernat 2014; Kongsgaard 2009; Stasinopoulos 2004). Only Bahr 2006 included details about any home programme components. Two trials reported non-exercise components (Kongsgaard 2009; Stasinopoulos 2004). Most studies described the exercise setting except Kongsgaard 2009 and Rieder 2022. Four trials provided detailed descriptions of the exercise intervention (Bahr 2006; Biernat 2014; Kongsgaard 2009; Stasinopoulos 2004). None of the studies detailed the qualifications of exercise instructors, adherence measurements, motivation strategies, adverse events, or whether exercises were tailored to individuals. A summary of exercise interventions for each trial is provided in Appendix 6 and Appendix 7 using the Consensus on Exercise Reporting Template (CERT) (Slade 2016).

Bahr 2006 involved a 12-week strengthening exercise programme focusing on eccentric exercises performed at home on a 25° decline board without prior warm-up. Participants used the affected leg for the downward movement and the asymptomatic leg for the upward movement, with the knee flexed to at least 60° despite the pain, stopping only if the pain became disabling or exceeded 5 on a 0 to 10 scale. Progression criteria included adding a 5 kg load if pain was less than 3 and reducing weight if pain exceeded 5. After four weeks, participants could cycle and jog if pain-free, and after eight weeks, they could gradually return to their sport with no or minimal pain. Each session consisted of three sets of 15 repetitions, performed twice daily at home, with weekly supervision by a physiotherapist. The setting included home exercises supplemented with weekly physiotherapy visits.

Biernat 2014 focused on a 24-week strengthening exercise programme, where participants performed eccentric squats on a 25° decline board, unilaterally flexing the knee to 60°. The concentric phase was performed bilaterally. Exercises were done with pain kept below 4 on a 0 to 10 VAS scale. From the fourth week, an unstable surface was introduced to increase difficulty. If pain increased, the exercise load was reduced, or repetitions were limited. Co-interventions included applying cold compresses to the patellar tendon after exercise. Each session comprised three sets of 15 repetitions, conducted once daily. The exercises were integrated with specific volleyball training and took place in a sport-specific setting.

Jensen 1989 used a stretching exercise programme that involved participants performing quadriceps femoris and hamstring muscle stretches twice daily, seven days a week, targeting the involved side only, for eight weeks. These exercises were unsupervised and conducted at home, and compliance was monitored through written logs. The session duration and progression details were not provided.

Kongsgaard 2009 involved traditional strengthening exercises, including squat, leg press, and hack squat, performed three times a week for 12 weeks. Participants completed four sets of each exercise, with repetitions varying from 15 repetition maximum to 6 repetition maximum over the duration of the programme.

In Rieder 2022, the intervention involved heavy slow resistance training, consisting of three bilateral knee extension exercises (squats, leg press, and hack squats) performed over a range of 90° to 0°, with controlled eccentric and concentric phases. The programme spanned 12 weeks, with sessions including four sets of 15 repetitions in the first week, gradually progressing to fewer repetitions with increased weight. Supervision was provided weekly by an exercise therapist, and participants were allowed to engage in sporting activities if pain levels were manageable.

Stasinopoulos 2004 involved strengthening exercises and static stretching exercises for the quadriceps and hamstrings combined with eccentric exercises using a leg extension machine. Each session comprised three sets of 15 repetitions, focusing on eccentric loading of the quadriceps muscle and patellar tendon by gradually squatting with all bodyweight on the injured leg. The programme ran for four weeks with three treatments per week, supervised by a physiotherapist in a clinic setting.

In Visnes 2005, the strengthening exercise intervention involved eccentric quadriceps muscle contraction training on a 25° decline board. Participants performed the exercise twice daily, with three sets of 15 repetitions each session. The downward (eccentric) component was executed by the affected leg, while the upward component was performed by the asymptomatic leg. The load was adjusted based on pain levels, with increments in weight added to a backpack as pain decreased. Participants were instructed to increase weight if pain was rated below 3 or 4 on a scale of 0 to 10 and decrease weight if pain exceeded 6 to 7. The programme lasted for 12 weeks and was conducted at home without supervision.

Comparators

Bahr 2006 compared the effectiveness of exercise to surgery followed by 12 weeks of postsurgical rehabilitation. The patellar tendon was exposed during the surgical procedure, and any abnormal or damaged tissue was surgically excised and removed (Bahr 2006). Biernat 2014 compared exercise to no treatment and current participation in volleyball training. Jensen 1989 compared exercise to a combination of stretching and strengthening exercises. Kongsgaard 2009 compared exercises to glucocorticoid injections. Rieder 2022 compared exercises to a waiting-list control group maintaining usual routines. Stasinopoulos 2004 compared exercise to pulsed ultrasound and transverse friction interventions. Visnes 2005 compared exercise to a control group undergoing typical volleyball training.

Co-interventions

Bahr 2006, Jensen 1989, and Stasinopoulos 2004 did not provide specific details regarding co-interventions or additional treatments. After the exercise, Biernat 2014 applied cold compresses to the patellar tendon. Kongsgaard 2009 did not specify co-interventions. Rieder 2022 allowed participants to engage in sporting activities during intervention if they experienced moderate pain or less. Visnes 2005 permitted the use of prescribed pain medication, including non-steroidal anti-inflammatory drugs, alongside the intervention.

Outcomes

Major outcomes

Pain intensity

Three trials reported at least one measure of pain (Bahr 2006; Kongsgaard 2009; Rieder 2022). One trial recorded pain on a 0- to 10-point VAS during exercises (standing jump, counter-movement jump, and leg press) (Bahr 2006). Two studies recorded pain using a numerical scale of 0 to 100, where a lower score indicated lower pain intensity (Kongsgaard 2009; Rieder 2022). Athletes with patellar tendinopathy who reduced their pain level by more than 12% experienced a significant improvement in their clinical status (Challoumas 2023). One trial evaluated pain using an unknown validity scale: first category (worse, no change, slightly better) or second category (much better and no pain) (Stasinopoulos 2004).

Function

Five trials reported function using the VISA-P (Bahr 2006; Biernat 2014; Kongsgaard 2009; Rieder 2022; Visnes 2005). The VISA-P questionnaire evaluated the severity of symptoms, knee function, and ability to play sports in athletes with patellar tendinopathy. The VISA-P score ranges from 0 to 100, with higher scores indicating better knee function. Athletes with patellar tendinopathy who improved their VISA-P score by more than 13 points experienced an important positive change in their clinical status (Challoumas 2023).

Global assessment of treatment effect

One trial evaluated the global assessment of treatment success using a −5 to +5 scale (+5 is greater success) (Bahr 2006).

Quality of life

No included trials reported quality of life.

Return to sport

One trial reported participants returning to the sport at the same level after the end of treatment (Bahr 2006).

Proportion of participants with adverse events

No included trials reported adverse events.

Proportion of participant withdrawals, or overall dropouts

No included trials reported withdrawals or overall dropouts.

Minor outcomes

Muscle strength

One trial evaluated knee extensor muscle strength by assessing quadriceps femoris muscle strength using isokinetic resistance (Jensen 1989).

Excluded studies

Of the 26 excluded trials, 18 compared different types of strengthening exercises (Agergaard 2021; Breda 2021; Cannell 2001; Cunha 2012; Dimitrios 2012; Frohm 2007; Jonsson 2005; Kumar 2020; MacDonald 2019; Pearson 2020; Purdam 2004; Rio 2015; Rio 2017; Rosety-Rodríguez 2006; Sprague 2021; van Ark 2016; Young 2005; Zihao 2023), five used the same protocol of exercises for both groups (Dragoo 2014; Resteghini 2016; Scott 2019; Steunebrink 2013; Thijs 2017), two were conducted with healthy individuals with no history of patellar tendinopathy (Abián-Vicén 2022; Gual 2016), and one did not include an exercise intervention (Furia 2013).

Studies awaiting classification

No studies are awaiting classification.

Ongoing studies

We identified three ongoing studies (CTRI/2019/08/020643; NCT02597660; PACTR202304561563965).

Risk of bias in included studies

The risk of bias assessment for each trial is reported and summarized in Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

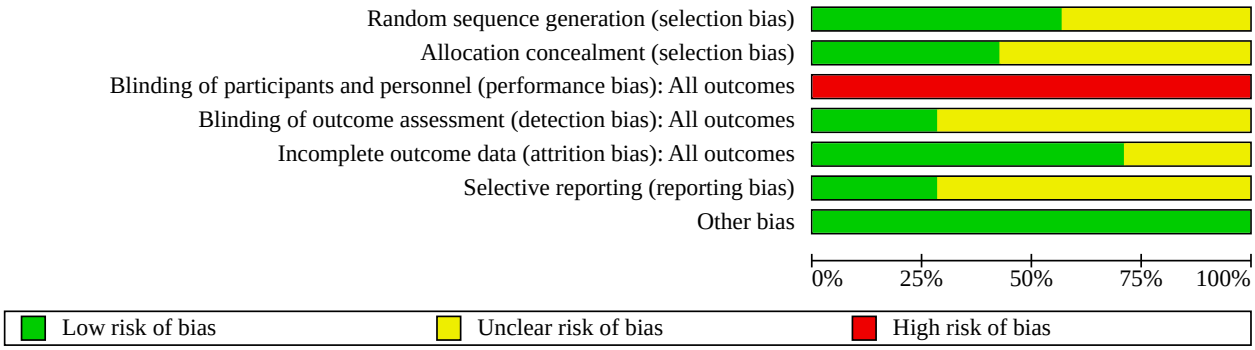
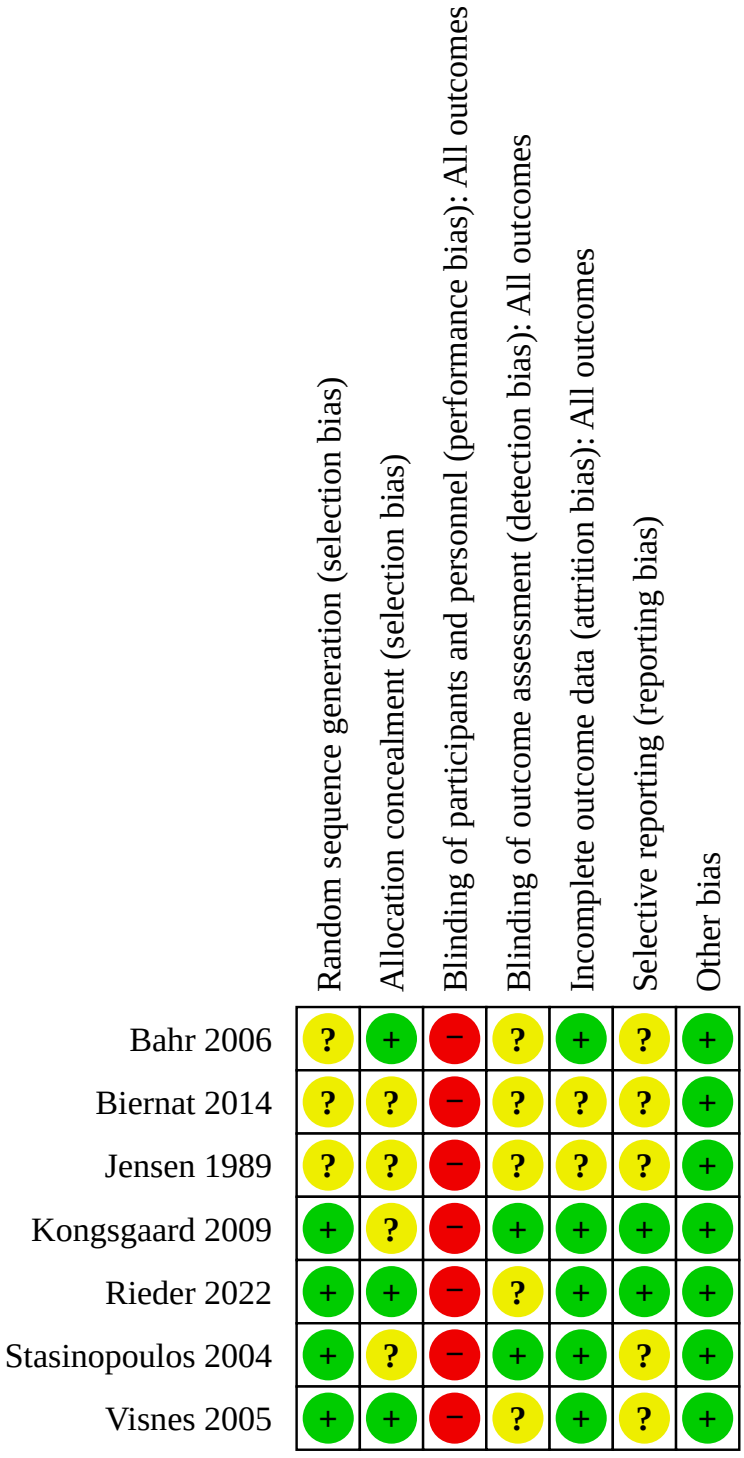


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Allocation

Four trials applied random sequence generation (Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005). Three trials concealed allocation of the participants using sealed and opaque envelopes (Bahr 2006; Rieder 2022; Visnes 2005). Therefore, we judged these trials at low risk of selection bias.

Three studies did not describe random sequence generation in sufficient detail (Bahr 2006; Biernat 2014; Jensen 1989), and four trials did not report the allocation process (Biernat 2014; Jensen 1989; Kongsgaard 2009; Stasinopoulos 2004). Therefore, we judged the risk of selection bias as unclear in these trials.

Blinding

Given the nature of the intervention, neither the participants nor the investigators were blinded concerning the group allocation in any trials (high risk of performance bias). Two trials performed blinding of outcome assessment and were at low risk of detection bias (Kongsgaard 2009; Stasinopoulos 2004). In five trials, the blinding of outcome assessment was not specified or unclear (unclear risk of detection bias) (Bahr 2006; Biernat 2014; Jensen 1989; Rieder 2022; Visnes 2005).

Incomplete outcome data

There were zero or less than 20% withdrawals in five trials, judged at low risk of attrition bias (Bahr 2006; Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005). The risk of attrition bias was unclear in the remaining two trials (Biernat 2014; Jensen 1989).

Selective reporting

Two trials published protocols and reported the outcomes mentioned in the protocols (Kongsgaard 2009; Rieder 2022). Five trials were at unclear risk for reporting bias due to the lack of information (Bahr 2006; Biernat 2014; Jensen 1989; Stasinopoulos 2004; Visnes 2005).

Other potential sources of bias

All trials were at low risk since there were no other sources of bias identified.

Effects of interventions

See: **Summary of findings 1** Strengthening exercise versus no treatment for patellar tendinopathy; **Summary of findings 2** Strengthening exercise versus glucocorticoid injection for patellar tendinopathy; **Summary of findings 3** Strengthening exercise versus surgery for patellar tendinopathy

Strengthening exercise versus placebo or sham intervention

We did not find any studies that compared exercise with placebo or sham intervention.

Strengthening exercise versus no treatment, usual care, or minimal intervention

Three trials investigated the effect of strengthening exercise compared to no treatment at the end of the treatment in athletes with chronic tendinopathy (Biernat 2014; Rieder 2022; Visnes 2005; Summary of findings 1). Rieder 2022 used a three-arm design to assess the effects of two types of exercise (heavy slow resistance training and whole-body vibration) compared with a waiting-list control. We reduced the control group numbers by half because we included the trial twice in the same meta-analysis.

Pain

We are very uncertain whether strengthening exercise reduces pain compared to no treatment at the end of treatment and six-month follow-up. Mean pain in the no-treatment group at the end of the treatment was 62.00 points on a 0 to 100 scale (0 was no pain) compared to 27.50 points in the exercise group (MD 34.94 points better, 95% CI 20.94 better to 48.94 better; 1 trial, 39 participants; very low-certainty evidence, Analysis 1.1). We downgraded the certainty of the evidence two levels for imprecision (a single trial with a small number of participants; 95% CIs did not rule in or rule out a clinically important change defined as 10 points on a 0- to 100-point VAS), and one level for serious risk of bias (selection, performance, detection, and reporting biases).

Function

Strengthening exercise may make little or no difference to function compared to no treatment at the end of treatment and six-month follow-up. The mean function in the no-treatment group at the end of treatment was 65.00 points on a 0 to 100 scale (100 = best function) compared to 72.04 points in the exercise group (MD 7.04 points better, 6.94 worse to 21.02 better; I^2 = 83%; 3 studies, 95 participants; low-certainty evidence; Analysis 1.2). We downgraded the certainty of the evidence one level for risk of bias (performance bias, selection bias, attrition bias, and reporting bias), and one level for imprecision (95% CIs did not rule in or rule out a clinically important change defined as 10 points on the 0- to 100-point VISA-P).

Other outcomes

No studies reported participant-reported global assessment of treatment success, quality of life, return to sport, proportion of participants with adverse events, proportion of participant withdrawals or overall dropouts, recurrence, or muscle strength.

Strengthening exercise versus other active intervention

Strengthening exercise versus glucocorticoid injection

One trial compared the effect of two types of strengthening exercises (eccentric decline squat training, and squat, leg press, and hack squat exercises combined) versus glucocorticoid injection in recreational male athletes with chronic tendinopathy at the end of the treatment (Kongsgaard 2009; Summary of findings 2).

Pain

Strengthening exercise may make little or no difference to pain compared to glucocorticoid injection. Mean pain in the glucocorticoid injection group was 18.00 points compared to 24.04 points in the exercise group (MD 6.04 points worse, 95% CI 8.19 better to 20.26 worse; 1 trial, 38 participants; low-certainty evidence; Analysis 2.1). We downgraded the certainty of the evidence two levels for imprecision (a single trial with a small number of participants; 95% CIs did not rule in or rule out a clinically important change defined as 10 points on a 0- to 100-point VAS scale).

Function or disability

Strengthening exercise may make little or no difference to function compared to glucocorticoid injection. Mean function in the no-treatment group at the end of treatment was 82.00 points on a 0 to 100 scale (100 was best function) compared to 76.25 points in the exercise group (MD 5.75 points worse, 95% CI 17.42 worse to 5.93 better; 1 trial, 38 participants; low-certainty evidence; Analysis 2.3). We downgraded the certainty of the evidence to two levels for imprecision (a single trial with a small number of participants; 95% CIs did not rule in or rule out a clinically important change, defined as 10 points on a 0- to 100-point VISA-P scale).

Other outcomes

No studies reported participant-reported global assessment of treatment success, quality of life, return to sport, proportion of participants with adverse events, proportion of participant withdrawals or overall dropouts, recurrence, or muscle strength.

Strengthening exercise versus surgery

One trial compared the effect of strengthening exercise versus surgery in athletes from different sports with chronic tendinopathy at 12 months' follow-up (Bahr 2006; Summary of findings 3).

Pain

We are very uncertain whether strengthening exercise reduces pain compared to surgery. Mean pain in the surgery group at 12-month follow-up was 13.00 points on a 0 to 100 scale (0 was no pain) compared to 17.00 points in the exercise group (MD 4.00 points worse, 95% CI 4.06 better to 12.06 worse; 1 trial, 40 participants; very low-certainty evidence; Analysis 3.1). We downgraded the certainty of the evidence two levels for imprecision (a single trial with a small number of participants; 95% CIs did not rule in or rule out a clinically important change defined as 10 points on a 0- to 100-point VAS), and one level for serious risk of bias (selection, performance, detection, and reporting biases).

Function

We are very uncertain whether strengthening exercise improves function compared to surgery. Mean function in the surgery group at the end of the treatment was 45.1 points compared to 52.4 points in the exercise group (MD 7.30 points better, 5.02 worse to 19.62 better; 1 trial, 35 participants (40 knees); very low-certainty evidence; Analysis 3.2). We downgraded the certainty of the evidence two levels for imprecision (a single trial with a small number of participants; 95% CIs did not rule in or rule out a clinically important change defined as 10 points on a 0- to 100-point VISA-P), and one level for serious risk of bias (selection, performance, detection, and reporting biases).

Participant-reported global assessment of treatment success

Strengthening exercise may make little or no difference to participant-reported global assessment of treatment success compared to surgery. The mean global assessment of treatment success in the surgery group at the end of treatment was 0.20 points on a −5 to +5 scale (+5 maximum improvement) compared to 1.76 points in the exercise group (MD 1.56 points better, 95% CI 0.52 worse to 3.64 better; 1 trial, 35 participants (40 knees); low-certainty evidence; Analysis 3.5). We downgraded the certainty of the evidence one level for imprecision (a single trial with a small number of participants) and one level for serious risk of bias (selection, performance, detection, and reporting biases).

Return to sport

One trial compared the number of participants who returned fully or partially to sports with or without pain for the strengthening exercise and surgery groups in athletes from different sports with chronic tendinopathy at the end of the treatment (Bahr 2006). Strengthening exercise may make little or no difference to the rate of participants who return to sport. The return to sport rate in the surgery group at 12-month follow-up was 86% compared to 85% in the exercise group (RR 1.02, 0.78 to 1.34; 1 trial, 35 participants (40 knees); low-certainty evidence; Analysis 3.8). We downgraded the certainty of the evidence one level for imprecision (a single trial with a small number of participants) and one level for serious risk of bias (selection, performance, detection, and reporting biases).

Other outcomes

The trial did not report quality of life, proportion of participants with adverse events, proportion of participant withdrawals or overall dropouts, recurrence, or muscle strength.

Strengthening exercise versus stretching exercise

One trial (15 recreational athletes) compared eccentric strengthening to stretching exercises (Jensen 1989). Both groups participated in a home muscle stretching exercise programme, but one group received additional strengthening eccentric training on an eccentric isokinetic dynamometer. The authors used an isokinetic dynamometer to measure quadriceps femoris muscle work. The strengthening eccentric exercise group was more efficient than the home muscle stretching exercise programme. This trial was not included in a quantitative synthesis analysis because the trial authors used two adapted and non-validated pain intensity scales (0 to 4 points, with 0 indicating no pain) instead of a conventional pain intensity scale.

Strengthening exercise versus pulsed ultrasound and transverse friction

One trial (30 recreational athletes) compared the effectiveness of strengthening and stretching exercises with pulsed ultrasound and transverse friction in reducing pain in people with chronic patellar tendinopathy (Stasinopoulos 2004). However, the authors only evaluated pain qualitatively (worse, no change, or slightly better). The results suggested that the exercise programme was a more effective treatment than ultrasound and transverse friction at the end of the treatment.

Addition of strengthening exercise over any other treatment versus other treatment alone

We did not find any studies that compared the addition of exercise to any other treatment.

DISCUSSION

Summary of main results

We found seven randomized trials, including 211 participants, that compared strengthening exercises with no treatment (3 trials, 93 participants), glucocorticoid injection (1 trial, 38 participants), surgery (1 trial, 40 participants), stretching exercise (1 trial, 15 participants), or pulsed ultrasound and transverse friction (1 trial,

30 participants) in individuals with chronic patellar tendinopathy (Bahr 2006; Biernat 2014; Jensen 1989; Kongsgaard 2009; Rieder 2022; Stasinopoulos 2004; Visnes 2005).

We found no trials comparing strengthening exercise to placebo or sham.

We are very uncertain whether strengthening exercise reduces pain compared to no treatment. Strengthening exercise may make little or no difference to function compared to no treatment for volleyball athletes with chronic patellar tendinopathy at the end of treatment and six-month follow-up.

Strengthening exercise may make little or no difference to pain or function compared to glucocorticoid injection in athletes with patellar tendinopathy at the end of treatment and six-month follow-up.

We are very uncertain whether strengthening exercise reduces pain compared to surgery for athletes with patellar tendinopathy at 12-month follow-up and improves function at the end of treatment and six- and 12-month follow-ups. Strengthening exercise may make little or no difference to the global assessment of treatment success at the end of treatment and six- and 12-month follow-ups and in the proportion of participants who fully or partially return to sport at 12-month follow-up compared to surgery.

No trials reported adverse events and quality of life.

Subgroup analyses could not be conducted due to insufficient studies in each comparison.

Overall completeness and applicability of evidence

All trials analyzed in this review included participants who were athletes at varying levels, ranging from competitive to recreational. The findings of this study can only be applied to athletes. However, we believe that these participants are representative of the broader population with patellar tendinopathy. The interventions utilized in the trials closely reflect clinical practice, which suggests that the results of this review can be generally applied to practical settings.

The trials investigated the effect of strengthening exercise compared to no treatment, glucocorticoid injection, surgery, stretching exercise, and pulsed ultrasound combined with transverse friction. For all trials, the duration of the strengthening exercise programme adopted was frequent and sufficiently long to show an effect on pain and function. Most trials included in this review partially described the intervention procedures; details of intervention providers; location of intervention delivery and key infrastructure; and details of intervention fidelity assessment, monitoring, and level achieved. The review included seven trials conducted in high-income countries, six in Europe, and one in the US. Another limitation of this review was the varying quality of the included studies.

Quality of the evidence

Evaluations of the certainty of evidence utilizing the GRADE approach revealed a substantial level of uncertainty, characterized by very low- to low-certainty evidence in the outcomes of this review. None of the included trials for any of the comparisons reported data on adverse events.

Strengthening exercise versus no treatment

The certainty of the evidence for the effect of strengthening exercise compared to no treatment was low for function and very low for pain. For pain, we downgraded the evidence from one study by two levels for imprecision (a single trial with a small number of participants; 95% CIs did not rule in or rule out a clinically important change defined as 10 points on a 0- to 100-point VAS), and one level for serious risk of bias (selection, performance, detection, and reporting biases). For function, we downgraded the evidence from three studies by one level due to a serious risk of bias (performance, selection, attrition, and reporting biases), and one level for imprecision (the 95% CIs do not rule in or rule out a clinically important change defined as 10 points on a 0- to 100-point VISA-P). None of the other outcomes were reported in this comparison.

Strengthening exercise versus glucocorticoid injection

The certainty of the evidence for the effect of strengthening exercise compared to glucocorticoid injection was low for both pain and function. We downgraded the evidence two levels for imprecision (a single trial with a small number of participants; the 95% CIs did not rule in or rule out a clinically important change). None of the other outcomes were reported in this comparison.

Strengthening exercise versus surgery

The certainty of the evidence for the effect of strengthening exercise compared to surgery was very low for both pain and function. We downgraded the evidence two levels for imprecision (a single trial with a small number of participants; the 95% CIs did not rule in or rule out a clinically important change), and one level for risk of bias (selection, performance, detection, and reporting biases). For participant-reported global assessment of treatment success and return to sport, the certainty of the evidence was low. We downgraded the evidence one level for imprecision (a single trial with a small number of participants) and one level for risk of bias (selection, performance, detection, and reporting biases).

Potential biases in the review process

We conducted a thorough search of major electronic databases and trial registries without any language restrictions to identify all relevant trials that met the review's eligibility criteria. To ensure accuracy, two review authors independently screened and selected studies, and assessed their risk of bias. It is important to note that none of the review authors were involved in the conduct of the included trials. Funnel plots could not be used to assess publication bias due to the limited number of included trials. We identified three ongoing trials that compare exercise with other interventions and believe these trials will be eligible when this review is updated. We conducted this review in accordance with our previously published protocol (Lopes 2018). None of the review authors had any potential conflicts of interest during the review process (Declarations of interest).

Agreements and disagreements with other studies or reviews

Since the mid-1990s, progressive eccentric muscle loading has become the dominant conservative intervention strategy for patellar tendinopathy (Abat 2014; Cook 2001; de Vos 2010; Dragoo 2014; Gaida 2011; Malliaras 2013; Mendonça 2020; Stanish 1986; Wasielewski 2007). Systematic reviews have been published

exploring the differences between various strengthening protocols of the extensor muscles of the knee (Challoumas 2021; Gaida 2011; Larsson 2012; Lim 2018; Malliaras 2013; Murtaugh 2013; Núñez-Martínez 2022; Rodriguez-Merchan 2013; Saithna 2012; Vang 2020). The authors of the majority of systematic reviews involving treatments for patellar tendinopathy concluded that there is evidence in favour of eccentric strengthening exercise training to treat patellar tendinopathy. However, the primary studies in these reviews compared different strengthening exercise protocols and did not compare exercises versus placebo, sham intervention, no treatment, usual care, or other treatments. It is generally assumed that these exercises are effective for patellar tendinopathy, and the main focus of these studies is to determine the best exercises to use when treating this condition.

One systematic review comparing different treatment methods for patellar tendinopathy concluded that there was strong evidence in favour of eccentric training for treating patellar tendinopathy (Larsson 2012). Our review included the two studies used to support the authors' conclusion (Bahr 2006; Stasinopoulos 2004). One trial compared exercise with surgery, which reported no difference (Bahr 2006). The second study compared stretching and strengthening exercises with pulsed ultrasound plus transverse friction, but the trial authors only evaluated pain using binary answers (worse or better) for 10 participants in each group (Stasinopoulos 2004). We found low to very low certainty evidence that exercise may make little to no difference in the treatment of patellar tendinopathy compared to other treatments.

AUTHORS' CONCLUSIONS

Implications for practice

Due to the low- to very low-certainty evidence available for strengthening exercise for patellar tendinopathy, we could not draw conclusions about the effects of strengthening exercise for patellar tendinopathy. The currently available evidence for strengthening exercise for patellar tendinopathy relies only on seven studies. In athletes with patellar tendinopathy, we are uncertain whether strengthening exercise reduces pain compared to no treatment. Strengthening exercise may make little or no difference in function compared to no treatment, and may make little or no difference in function or pain compared to glucocorticoid injections. We are uncertain whether strengthening exercise reduces pain or improves function at the end of treatment compared to surgery. Participant-reported global assessment of treatment success and the proportion of participants who fully or partially returned to sport showed little or no difference between groups when comparing strengthening exercise to surgery. All trials analyzed in this review included participants who were athletes and, therefore, results can only be applied to athletes.

Implications for research

We recommend further trials comparing the effects of strengthening exercises versus placebo/sham treatment. Arguably, we need good-quality trials comparing eccentric exercise to sham exercise to establish efficacy before we advocate for trials compared to other active interventions. We suggest that future studies include females, as our review identified that approximately 88% of participants were male. Additionally, we suggest exploring patellar tendinopathy within the non-athletic population. The age range of participants could also be expanded in future studies. Although patellar tendinopathy most commonly affects jumping athletes from adolescence through to the fourth decade of life, the age range identified in this review was approximately between 20 and 30 years, so more trials, including participants aged 12 to 20 years, would be helpful. Most of the trials failed to provide adequate information on the exercise intervention, making it difficult to replicate. A more complete description of the interventions will help clinicians (when using the exercises) and researchers (when comparing trial results).

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Bahr 2006

Study characteristics	
Methods	**Study design:** randomized, controlled, parallel design **Sample size:** 35 participants (40 knees) (20 knees in the exercise group and 20 knees in the surgery group) **Description of the sample:** athletes at national team level and broad range of athletes **Recruitment:** physicians and physiotherapists were asked to refer people who fulfilled the inclusion criteria to the Health Department at the Olympic Training Center. **Country:** Norway **Funding:** ≥ 1 authors received grants or outside funding from Norwegian Eastern Health Corporate, Royal Norwegian Ministry of Culture, Norwegian Olympic Committee and Confederation of Sport, Norsk Tipping AS, and Pfizer AS.
Participants	**Gender:** 5 women (3 in the exercise group and 2 in the surgery group); 30 men (12 in the exercise group and 18 in the surgery group) **Mean age:** 30.5 years (31 years in the exercise group and 30 years in the surgery group) **Mean duration of symptoms:** 34 months (33 months in the exercise group and 35 months in the surgery group) **Mean pain at baseline:** not reported **Mean function at baseline:** 30 (0–100 VISA-P, 100 is optimal function), 29 in the exercise group and 31 in the surgical group. **Inclusion criteria:** history of exercise-related pain in the patellar tendon during and after activity and had to be unable to participate in sports at the same level as before the onset of pain; tenderness to palpation and thickening; increased signal intensity changes corresponding to the painful area as seen on the magnetic resonance imaging scan **Exclusion criteria:** history of knee or patellar tendon surgery or had an inflammatory or degenerative joint condition
Interventions	**Strengthening exercise** 1. **Description of the exercise:** eccentric exercise performed on a 25° decline board at home without any previous warming up. The downward component was performed with the affected leg, and the upward component was performed with the asymptomatic leg. Knee was flexed to ≥ 60° despite pain (stop exercise only if the pain became disabling or > 5 points on a 0–10 scale). Progression: if pain < 3, participants added 5 kg load. If pain increased to > 5, participants performed the exercise with less weight. After 4 weeks, they were allowed to cycle or jog if these activities could be done without pain. After 8 weeks, they were allowed to gradually return to their sport if there was no or minimal pain. 2. **Duration of each session:** 3 sets of 15 repetitions, twice daily at home 3. **Length of the programme:** 12 weeks

Bahr 2006 *(Continued)*

4. **Supervision:** at home, with supervision weekly by a physiotherapist
5. **Setting:** at home and physiotherapy visit weekly
6. **Co-interventions:** not reported

Surgery plus 12 weeks of postsurgical rehabilitation

1. All abnormal tissue was removed. No osseous procedures were performed, and no sutures were placed in the tendon. During physiotherapy, participants performed isometric quadriceps exercises, gradual reduction of the use of crutches, cycle ergometry, squats, step-ups, step-downs, no or minimal pain during eccentric exercises, and a gradual increase in the number of training sessions.

Outcomes	Outcomes were measured at the end of treatment at 12 weeks, at 6 months' follow-up, and 12 months' follow-up. **Primary outcome** 1. Function using VISA-P score (range 0 to 100, 0 was optimal function). **Secondary outcomes** 1. Global evaluation score: 11-point Visual Numerical Scale, with +5 representing maximum improvement (no symptoms), 0 representing no change, and –5 representing maximum worsening (severe symptoms) 2. Treatment satisfaction: 4-grade scale as "no symptoms," "improved, but still symptomatic," "no change," or "worse" 3. Functional tests (jumping performance): standing jumps, counter-movement jumps, and leg extension strength 4. Strength: recorded as the 1 repetition maximum load (in kilograms) that the participant could lift in a closed-chain exercise with use of a leg-press machine 5. Return to sport: (yes/no)
Notes	**Funding:** ≥ 1 of the authors received grants or outside funding from Norwegian Eastern Health Corporate, Royal Norwegian Ministry of Culture, Norwegian Olympic Committee and Confederation of Sport, Norsk Tipping AS, and Pfizer AS.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "A randomization sequence to surgical treatment or eccentric training (in blocks of four) was created by our statistician prior to the start of the study." No information about the method that the statistician used.
Allocation concealment (selection bias)	Low risk	Quote: "Numbered, sealed envelopes were used to conceal the group allocation to the investigator and the patient after inclusion in the study."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "Neither the patients nor the investigators were blinded with regard to the group allocation." No more information about assessors.

Bahr 2006 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "An intention-to-treat analysis was used, which means that for patients in the eccentric training group who opted for secondary surgery, the final score before surgery was carried forward to the twelve-month follow-up."
Selective reporting (reporting bias)	Unclear risk	This trial was not prospectively registered. Study published in August 2006.
Other bias	Low risk	No other concerns

Biernat 2014

Study characteristics	
Methods	**Study design:** randomized, controlled, parallel design **Sample size:** 28 participants (15 in the exercise group and 13 in the no-treatment group) **Description of the sample:** volleyball players participating in systematic training and volleyball matches with patellar tendinopathy **Recruitment:** not reported **Country:** Poland **Funding:** not reported
Participants	**Gender:** not reported **Mean age:** 17.1 years (17.7 years in the exercise group and 16.5 years in the no-treatment group) **Mean duration of symptoms:** not reported **Mean pain at baseline:** not reported **Mean function at baseline:** 88.45 (0–100 VISA-P, 100 is optimal function), 84.6 in the exercise group and 92.3 in the no-treatment group **Inclusion criteria:** aged 16–19 years, systematic training and participation in volleyball matches, volleyball players with patellar tendinopathy **Exclusion criteria:** not reported
Interventions	**Strengthening exercise** 1. **Description of the exercise:** eccentric squat on decline board with inclination angle of 25° unilaterally, knee flexed to the angle 60°, the concentric phase was done bilaterally to erect position. Exercise was performed with the level of pain < 4 points on a 0–10 VAS scale. Progression: in the fourth week of the programme an unstable surface was incremented. In case of pain exaggeration, the exercise was not carried out, the load had to be lowered or the number of repetitions limited. 2. **Co-interventions:** cold compresses were applied on patellar tendon after exercise. 3. **Duration of each session:** 3 series of 15 repetitions once a day 4. **Length of the programme:** 24 weeks 5. **Supervision:** exercises were combined with specific volleyball training. 6. **Setting:** sport-specific setting. **Comparison group** 1. No treatment, current participation on volleyball training

Biernat 2014 *(Continued)*

Outcomes	Outcomes were measured during treatment (12 weeks), and at the end of the treatment (24 weeks follow-up). **Primary outcomes** 1. VAS scale (0–10 points) 2. VISA-P questionnaire (0–100 VISA-P, 0 is optimal function) 3. Muscle strength peak torque measurements of knee flexors and extensors under static and dynamic conditions (concentric activity under isokinetic conditions) 4. Jumping ability and power of lower limbs during bilateral counter-movement jump akimbo (CMJ akimbo) 5. Ultrasound imagining with colour Doppler function
Notes	**Funding:** not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The participants were familiar with those training methods used in experiment, matched and randomized to 2 training groups, so that we could be sure that the changes were because of the different program and not because the subjects had a preference for that type of training." Comment: not described in sufficient detail to allow a definite judgement.
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "A total of 32 male volleyball players were divided into two groups and authors analysed 28 participants." Comment: there was no information on missing data.
Selective reporting (reporting bias)	Unclear risk	Trial was not prospectively registered. Study published in January 2014. However, all measures reported in the methods were reported in the results.
Other bias	Low risk	No concerns.

Jensen 1989

Study characteristics

Methods	**Study design:** randomized, controlled, parallel design **Sample size:** 15 participants (7 in the stretching exercise group and 8 in the eccentric exercise group) **Description of the sample:** recreational athletes

Jensen 1989 *(Continued)*

	Recruitment: referred to the study by orthopaedic surgeons at the University of Wisconsin Hospital and Clinics Sports Medicine Center **Country:** US **Funding:** not reported
Participants	**Gender:** 3 women (2 in the stretching exercise and 1 in the eccentric exercise); 12 men (5 participants in the stretching exercise group and 7 participants in the eccentric exercise group) **Mean age:** 24 years (23 years in the stretching exercise group and 25 years in the eccentric exercise group) **Mean duration of symptoms:** 19 months **Mean pain at baseline:** not reported **Mean function at baseline:** not reported **Inclusion criteria:** tenderness with palpation of the inferior pole of the patella; no history of trauma to the knee; onset of symptoms a minimum of 6 weeks prior to participating in the study; no anti-inflammatory oral medication or injection for ≥ 2 weeks prior to starting the study; no other current knee or lower extremity problems including chondromalacia, muscle strains, and hip or ankle injuries **Exclusion criteria:** not reported
Interventions	**Stretching exercise** 1. **Description of the exercise:** quadriceps femoris and 2 hamstring muscle stretching exercises; 2 times per day, 7 days per week, on the involved side only 2. **Duration of each session:** not reported 3. **Progression:** not reported 4. **Length of the programme:** 8 weeks 5. **Supervision:** no supervision (home exercises). Compliance was confirmed through a written log completed by each participant. 6. **Setting:** home 7. **Co-interventions:** not reported **Stretching exercise plus strengthening exercise** 1. **Description of the exercise:** quadriceps femoris and hamstring muscle stretching exercises (2 times per day, 7 days per week, on the involved side only) plus eccentric quadriceps femoris muscle strengthening exercise; 3 times a week 2. **Duration of each session:** not reported 3. **Progression:** initially at a speed of 30°/second, and then 70°/second 4. **Length of the programme:** 8 weeks 5. **Supervision:** not reported 6. **Setting:** physiotherapy clinic 7. **Co-interventions:** not reported
Outcomes	Outcomes were measured at the end of treatment (8 weeks). **Primary outcomes** 1. Pain intensity scales (0–4, 0 no pain). The scales were adapted, but they were not validated. 2. Strength (isokinetic dynamometer)
Notes	**Funding:** none
Risk of bias	

Jensen 1989 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The subjects were randomly divided into one of four groups." Comment: not described in sufficient detail to allow a definite judgement.
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	All subjects were analysed. There was no information on missing data.
Selective reporting (reporting bias)	Unclear risk	This trial was not prospectively registered. Study published before 2005 (March 1989). All measures reported in the methods were reported in the results.
Other bias	Low risk	No concerns.

Kongsgaard 2009

Study characteristics	
Methods	**Study design:** randomized, controlled, parallel 3-arm design **Sample size:** 39 participants (13 in the corticosteroid injection group, 13 in the isotonic exercise group, 13 in the eccentric exercise group) **Description of the sample:** recreational male athletes **Recruitment:** self-selection following advertisement **Country:** Denmark **Funding:** work funded by Team Denmark's Research Foundation, The Danish Ministry of Culture, and the Danish Arthritis Foundation.
Participants	**Gender:** men **Mean age:** 32.4 years (34.4 years in the corticosteroid injection group, 31.7 years in the isotonic exercise group, 31.3 years in eccentric exercise group) **Mean duration of symptoms:** 18.6 months **Median pain at baseline:** not reported **Median function at baseline:** 57.6 (0–100 VISA-P, 100 is optimal function)

Kongsgaard 2009 *(Continued)*

	Inclusion criteria: chronic condition (> 3 months with pain), ultrasonography with local anterior–posterior thickening of the tendon of ≥ 1 mm compared with the mid-tendon level, and a hypo-echoic area and presence of a colour Doppler signal within the hypo-echoic area **Exclusion criteria:** corticosteroid injections within 12 months, previous knee surgery, arthritis, diabetes, or any confounding diagnosis to the knee joint
Interventions	**Strengthening exercises (squat, leg press, and hack squat)** 1. **Description of the exercise:** each session consisted of 3 bilateral exercises (squat, leg press, and hack squat); 4 sets of each exercise with a 2- to 3-minute rest between sets; 3 weekly sessions. All exercises were performed from complete extension to 90° of knee flexion and back again. Participants were instructed to spend 3 seconds completing each of the eccentric and concentric phases, respectively (i.e. 6 seconds/repetition). Pain during exercises was acceptable but pain and discomfort were not to increase following cessation of training. 2. **Duration of each session:** 15 repetition maximum week 1, 12 repetition maximum weeks 2–3, 10 repetition maximum weeks 4–5, 8 repetition maximum weeks 6–8 and 6 repetition maximum weeks 9–12; 4 sets in each exercise with a 2- to 3-minute rest between sets. 3. **Length of the programme:** 12 weeks 4. **Supervision:** 1 supervised session per week 5. **Setting:** not reported 6. **Co-interventions:** not reported **Strengthening exercises (eccentric squats on a 25° decline board)** 1. **Description of the exercise:** slow repetitions of eccentric unilateral squats on a 25° decline board twice daily (morning and evening). Participants were instructed to spend approximately 3 seconds completing each repetition and to have a 2-minute rest period between sets. Participants with a bilateral condition used the arms and both legs during the concentric phase. Pain during exercises was acceptable, but pain and discomfort were not to increase following cessation of training. 2. **Duration of each session:** 15 repetitions twice daily (morning and evening) 3. **Length of the programme:** 12 weeks 4. **Supervision:** 1 supervised session per week 5. **Setting:** not reported 6. **Co-interventions:** not reported **Glucocorticoid injection** 1. **Description of the intervention:** ultrasound-guided (grey scale) injections of 1 mL of a solution that contains methylprednisolone at a concentration of 40 mg/mL mixed into 0.5 mL of lidocaine 1% solution into the peritendinous tissue posterior to the hypoechoic area of the patellar tendon. Injections were administered from the medial side of the knee. A second injection was administered 4 weeks later. The same physician administered all the injections. Participants were instructed to refrain from training and sporting activities for the first week after the injections. 2. **Co-interventions:** not reported
Outcomes	Outcomes were measured at the end of treatment at 12 weeks and at 6 months' follow-up. **Primary outcome** 1. Function using VISA-P score (range 0–100, 0 was optimal function) **Secondary outcomes** 1. Maximal tendon pain during preferred sporting activity was indicated on a 100-mm VAS 2. Treatment satisfaction ("satisfied" or "not satisfied")
Notes	**Funding:** not reported

Kongsgaard 2009 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Thirty-nine subjects fulfilled the inclusion criteria and 13 subjects were randomly allocated to each group using a computer-generated minimization randomization procedure."
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Analyses of ultrasonography measures were conducted in an investigator-blinded fashion. All biopsy samples were analyzed in an investigator-blinded fashion. The MRI [magnetic resonance imaging] investigator was blinded with regard to subject treatment."
Incomplete outcome data (attrition bias) All outcomes	Low risk	39 were randomized in 3 arms, 1 was withdrawn in 2 arms (completed trial and the follow-up 12 weeks).
Selective reporting (reporting bias)	Low risk	All outcomes were reported. Trial registration number: NCT00404469.
Other bias	Low risk	No concerns.

Rieder 2022

Study characteristics

Methods	**Study design:** randomized, controlled, parallel 3-arm design **Sample size:** 35 participants (8 in heavy slow resistance training group, 12 in the whole-body vibration group, 15 waiting-list control group) **Description of the sample:** people playing recreational or athletic activities **Recruitment:** via local newspaper advertisements, social media, calls, and visits to local sports clubs **Country:** Austria
Participants	**Gender:** 8 women (2 in the heavy slow resistance training group, 2 in the whole-body vibration group, and 4 in the waiting-list control group); 27 men (6 in the heavy slow resistance training group, 10 in the whole-body vibration group, and 11 in the waiting-list control group) **Mean age:** 29 (SD 6) years in the heavy slow resistance training group, 25.5 (SD 6) years in the whole-body vibration group, and 27 (SD 6) years in the waiting-list control group **Mean duration of symptoms:** 58 (SD 77) months in the heavy slow resistance training group, 22 (SD 13) months in the whole-body vibration group, and 45 (SD 48) months for the waiting-list control group **Mean pain at baseline:** 6.4 (SD 1.9) in the heavy slow resistance training group, 7 (SD 1.5) in the whole-body vibration group, and 7.1 (SD 1.6) for the waiting-list control group

Rieder 2022 *(Continued)*

Mean function at baseline: 62.4 (SD 10.9) in the heavy slow resistance training group, 65.7 (SD 14.5) in the whole-body vibration group, and 58.3 (SD 16.4) in the waiting-list control group

Inclusion criteria: clinical diagnosis of patellar tendinopathy conducted by 2 experienced physicians, tenderness on palpation, and a VISA-P score < 87. After initial screening, ultrasonographic or magnetic resonance imaging was performed. Participants with bilateral symptoms received the same treatment on both sides, and the most symptomatic knee (lowest VISA-P score) was selected for measurements.

Exclusion criteria: cardiovascular diseases, orthopaedic disorders of the affected leg, any injuries or degenerations of the knee joint not related to tendinopathy, inflammatory conditions of the musculoskeletal system, epilepsy, diabetes, pregnancy, tumours, any implant held in place by a magnet, eye lenses, claustrophobia, injections in the patellar tendon in the preceding 3 months, corticosteroid injections within 12 months, current use of anticoagulants. Concomitant knee joint injuries were excluded using comprehensive manual clinical examinations.

Interventions

Heavy slow resistance training

Description of the exercise: the exercise consisted of 3 bilateral knee extension exercises (squats, leg press, and hack squats). The knee extension was performed over a range of 90° to 0° (with 0° corresponding to full extension) for all exercises and lasted 3 seconds for the eccentric and 3 seconds for the concentric phase.

1. **Duration of each session:** each task was performed in 4 sets of 15 repetitions in the first week. Progressive overload was ensured by increasing the weight with a concurrent reduction of repetitions: 12 repetition maximum in weeks 2 and 3, 10 repetition maximum in weeks 4 and 5; 8 repetition maximum in weeks 6–8; 6 repetition maximum in weeks 9–12 RM.
2. **Length of the programme:** 12 weeks
3. **Supervision:** weekly by an exercise therapist
4. **Setting:** clinic, Paracelsus Medical University
5. **Co-interventions:** participants were allowed to continue to take part in sporting activities during the intervention period if they did not experience more than moderate pain (VAS ≤ 50 points, maximum 100 points).

Whole body vibration

Description of the exercise: each session involved 10 sets of 60 seconds of static standing in a slightly squatted position on an oscillating platform with 60 seconds of rest between sets. The knee joint angle was standardized at 50° (0° full extension), and vibration parameters were set at a frequency of 30 Hz, amplitude of 2 mm, and acceleration of 2 g.

1. **Duration of each session:** 10 sets of 60 seconds of static standing in a slightly squatted position on an oscillating platform with 60 seconds of rest between sets.
2. **Length of the programme:** 12 weeks
3. **Supervision:** weekly by an exercise therapist
4. **Setting:** clinic, Paracelsus Medical University
5. **Co-interventions:** participants were allowed to continue to take part in sporting activities during the intervention period if they did not experience more than moderate pain (VAS ≤ 50 points, maximum 100 points).

Waiting-list control

Participants were encouraged to retain their habitual daily routines and performed the same measurements as the intervention group but did not receive any treatment within
this first 12 weeks.

1. **Duration of each session:** not applicable
2. **Length of the programme:** 12 weeks
3. **Supervision:** not applicable
4. **Setting:** not applicable

Rieder 2022 *(Continued)*

	5. **Co-interventions:** participants were allowed to continue to take part in sporting activities during the intervention period if they did not experience more than moderate pain (VAS ≤ 50 points, maximum 100 points).
Outcomes	Outcomes were measured at the end of treatment at 12 weeks and at 6-month follow-up. **Primary outcomes** 1. Function using VISA-P score (range 0–100, 0 was optimal function) 2. Pain using VAS score (range 0–10, 10 was maximum pain) **Secondary outcomes** 1. Tendon morphology 2. Neovascularization 3. Isometric knee extension strength 4. Tendon mechanical and material properties
Notes	**Funding:** Austrian Science Fund (FWF; KLI585B30). Furthermore, 2 trial authors were financially supported by this non-industrial Austria's central funding organization.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomization was conducted after clinical assessment of the eligibility criteria. All participants were drawn from 60 sealed opaque envelopes of a 2:1:1 ratio of waiting-list control, heavy slow resistance training, and whole-body vibration group. All envelopes were prepared off-site.
Allocation concealment (selection bias)	Low risk	All examiners remained blinded to the participants allocations.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Sports scientists were blinded for the baseline assessments and data analysis but became unblinded for some participants after testing.
Incomplete outcome data (attrition bias) All outcomes	Low risk	29 were randomized in 3 arms. Heavy slow resistance training: 8/11 (72.7%); whole-body vibration: 12/13 (92%); and waiting-list control: 15/15 (100%) analyzed in 6 weeks.
Selective reporting (reporting bias)	Low risk	All outcomes were reported. Trial registration number: DRKS00011338.
Other bias	Low risk	No concerns.

Stasinopoulos 2004

Study characteristics

Methods	**Study design:** randomized, controlled, parallel 3-arm design

Stasinopoulos 2004 *(Continued)*

Sample size: 30 participants (10 in the exercise programme group, 10 in the pulsed ultrasound group, 10 in the transverse friction group)

Description of the sample: recreational athletes

Recruitment: selected from people referred to the Rehabilitation and Rheumatology Centre during the season 2001–2002

Country: Greece

Funding: not reported

Participants	**Gender:** exercise programme group: 7 men, 3 women; pulsed ultrasound group: 6 men, 4 women; transverse friction group: 5 men, 5 women **Mean age:** 28.12 years in exercise programme group, 29.17 years in pulsed ultrasound group, 26.24 years in transverse friction group **Mean duration of symptoms:** not reported **Mean pain at baseline:** not reported **Mean function at baseline:** not reported **Inclusion criteria:** tenderness with palpation over the inferior pole of the patella; no history of trauma to the knee; minimum duration of symptoms 3 months; unsuccessful conservative treatment before entering study; no other current knee or lower extremity problems including anterior knee pain, muscle strains, and hip or ankle injuries; and positive decline squat test **Exclusion criteria:** not reported
Interventions	**Strengthening exercise** 1. **Description of the exercise:** static stretching exercises of quadriceps and hamstring, and eccentric exercises using leg extension machine 2. **Duration of each session:** 3 sets of 15 repetitions. The squat was performed at a slow speed at every treatment session. At the beginning, the load consisted of the bodyweight and participants were standing with all their bodyweight on the injured leg. As they moved from the standing to the squat position, the quadriceps muscle and patellar tendon by inference were loaded eccentrically; no following concentric loading was done, as the non-injured leg was used to get back to the start position. 3. **Length of the programme:** 4 weeks, 3 treatments per week 4. **Supervision:** physiotherapist 5. **Setting:** clinic 6. **Co-interventions:** none **Pulsed ultrasound** 1. **Description of the intervention:** local pulsed ultrasound of 0.4–0.8 W/cm^2 from an RT-20 ultrasonic machine. The pulse ratio was 1:4, duration of pulse 2 ms, and frequency 1 MHz. The ultrasound head was applied to the participant's skin, using an ultrasonic coupling medium. The radiated area was over the inferior pole of the patella. Treatment time was 10 minutes. **Transverse friction** 1. **Description of the intervention:** transverse friction was applied to the patellar tendon as described by Cyriax continuously for 10 minutes.
Outcomes	Outcome was measured at the end of treatments (week 4), 1 month after the end of the treatment (week 8), and 3 months after the end of the course of treatments (week 16). **Primary outcome**

Stasinopoulos 2004 *(Continued)*

1. Pain: participants described the status of their pain from the following alternatives: worse, no change, somewhat better, much better, and no pain during the follow-ups.

Notes	**Funding:** not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomly allocated to 3 groups by drawing lots.
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Evaluations were measured independently by the manager of the centre (IS) who was blind to the participants' therapy groups and who did not treat participants.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Number of participants randomized and analysed was the same for the primary outcome.
Selective reporting (reporting bias)	Unclear risk	This trial was not registered. Study published before 2005 (January 2004).
Other bias	Low risk	No concerns.

Visnes 2005

Study characteristics

Methods	**Study design:** randomized, controlled, parallel 2-arm design **Sample size:** 29 participants (13 in the training group, 16 in the control group) **Description of the sample:** elite volleyball athletes **Recruitment:** from the clubs in the elite and 1st divisions for men and women in Norway **Country:** Norway **Funding:** not reported
Participants	**Gender:** 10 women (5 training in the group, 5 in the control group); 19 men (8 in the training group, 11 in the control group) **Mean age:** 26.8 (SD 4.6) years in the training group, 26.4 (SD 3.4) years in the control group **Mean duration of symptoms:** 67 (SD 44) months in the training group, 79 (SD 75) months in the control group **Mean pain at baseline:** not reported

Visnes 2005 *(Continued)*

	Mean function at baseline: 30 (0–100 VISA-P, 100 was optimal function), 29 in the training group, 31 in the control group **Inclusion criteria:** history of pain in the quadriceps or patellar tendons or their patellar or tibial insertions (localized on a knee map) in connection with training or competition, and tenderness to palpation corresponding to the painful area; patellar tendinopathy symptoms present for a minimum of 3 months; VISA-P score < 80 points **Exclusion criteria:** history of knee problems caused by patellofemoral pain syndrome, inflammatory joint conditions, or degenerative conditions
Interventions	**Strengthening exercise** 1. **Description of the exercise:** eccentric quadriceps muscle contraction training programme on a 25° decline board 2. **Duration of each session:** twice daily with 3 sets of 15 repetitions each session. The downward component (eccentric component) was on the affected leg, and the upward component was on the asymptomatic leg. Load was increased as pain decreased, and they added load to a backpack in 5-kg increments. Participants with pain < 3–4 (0–10 scale) were recommended to increase the weight. Players with pain > 6–7 (0–10 scale) during the exercises were recommended to do the exercise with less weight. 3. **Length of the programme:** 12 weeks 4. **Supervision:** not performed 5. **Setting:** at home 6. **Co-interventions:** participants were allowed to take prescribed pain medication, including non-steroidal anti-inflammatory drugs **Control group (usual training)** 1. **Description of the intervention:** volleyball training for 12 weeks
Outcomes	Outcomes were measured at the end of treatment at 6 weeks and at 6 months follow-up. **Primary outcome** 1. Function using the VISA-P score (range 0–100, 0 was optimal function) **Secondary outcomes** 1. Global evaluation score (pain and function), 11-point Visual Numerical Scale, where +5 represented maximal improvement (no symptoms), 0 was no change, and −5 maximal worsening (serious symptoms) 2. Jumping performance (standing jump and a counter-movement jump) 3. Pain intensity during training (0–10 VAS)
Notes	**Funding:** not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "After inclusion, the subjects were randomized into treatment or control groups by a statistician who was blinded to player identity. Players from the same teams were randomized in blocks to different groups."
Allocation concealment (selection bias)	Low risk	After our contact, the authors sent an email stating that randomization was performed using a closed-envelope procedure by a statistician.

Visnes 2005 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	High risk	Given the nature of the intervention, neither participants nor investigators were blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Exercise group: 13/15 analysed in 6 weeks; 12/15 analysed in 6 months.
Selective reporting (reporting bias)	Unclear risk	This trial was not prospectively registered. Study published in March 2005.
Other bias	Low risk	No concerns.

SD: standard deviation; VAS: Visual Analogue Scale; VISA-P: Victorian Institute of Sport Assessment – Patella.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Abián-Vicén 2021	Study population did not have patellar tendinopathy.
Agergaard 2021	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Breda 2021	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Cannell 2001	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Cunha 2012	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Dimitrios 2012	Solely focused on comparing strengthening exercises, without comparing to other interventions. The same protocol of strengthening exercises was used for both groups.
Dragoo 2014	The same protocol of strengthening exercises was used for both groups.
Frohm 2007	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Furia 2013	The interventions did not include exercise.
Gual 2016	Study population did not have patellar tendinopathy.
Jonsson 2005	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Kumar 2020	Solely focused on comparing strengthening exercises, without comparing to other interventions.
MacDonald 2019	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Pearson 2020	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Purdam 2004	Solely focused on comparing strengthening exercises, without comparing to other interventions.

Study	Reason for exclusion
Resteghini 2016	The same protocol of strengthening exercises was used for both groups.
Rio 2015	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Rio 2017	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Rosety-Rodríguez 2006	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Scott 2019	The same protocol of strengthening exercises was used for both groups.
Sprague 2021	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Steunebrink 2013	The same protocol of strengthening exercises was used for both groups.
Thijs 2017	The same protocol of strengthening exercises was used for both groups.
van Ark 2016	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Young 2005	Solely focused on comparing strengthening exercises, without comparing to other interventions.
Zihao 2023	Solely focused on comparing strengthening exercises, without comparing to other interventions.

Characteristics of ongoing studies *[ordered by study ID]*

CTRI/2019/08/020643

Study name	Differences between fascial manipulation and eccentric training in patellar tendinopathy patients
Methods	**Study design:** prospective 2-arm randomized controlled trial **Setting:** Srinivas College of Physiotherapy, India **Trial time period:** not reported **Interventions:** fascial manipulation versus eccentric training and stretching **Sample size calculations:** 86 **Analysis:** not reported
Participants	**Inclusion criteria:** aged 18–35 years; professional volleyball and basketball, soccer players, runners playing at regional, state, and national level, collegiate players, recreational players; history of insidious onset of activity-related anterior knee pain, pain at inferior poll of patella; Victorian Institute of Sport Assessment – Patella score < 80 **Exclusion criteria:** any acute lower limb injuries; previous pelvis or lower limb fracture; history of lower extremity surgery; bursitis; patellofemoral pain syndrome; fat pad syndrome; Osgood-Slater disease; Sinding-Larsen-Johansson disease; quadriceps tendinopathy
Interventions	**Fascial manipulation** 1. 4 sessions in 1 week, total intervention period 4 weeks **Exercises**

CTRI/2019/08/020643 *(Continued)*

	1. Eccentric training and stretching exercises for 5 sessions in 1 week, total intervention period 4 weeks
Outcomes	Outcomes will be measured at 4 weeks, and 3-, 6-, and 12-month follow-up **Primary outcome** 1. Victorian Institute of Sport Assessment – Patella questionnaire **Secondary outcomes** 1. Numeric Pain Rating Scale 2. Colour Doppler ultrasound 3. Patient Satisfaction Scale
Starting date	23 August 2019
Contact information	S Rajasekar, Musculoskeletal OPD, Physiotherapy Department, Srinivas College of Physiotherapy, Srinivas University, Mukka, Mangaluru, Karnataka
Notes	**Trial status:** completed **Trial register number:** CTRI/2019/08/020643 **Expected completion date:** December 2020. No results are available.

NCT02597660

Study name	Use of human growth hormone (hGH) in the treatment of patellar tendinopathy
Methods	**Study design:** prospective 3-arm randomized controlled trial **Setting:** Hospital for Special Surgery, New York, US **Trial time period:** May 2020 to December 2020 **Interventions:** human growth hormone versus strengthening exercise versus placebo **Sample size calculations:** 50 **Analysis:** not reported
Participants	**Inclusion criteria:** men and women ages 18–50 years; > 3-month history of anterior knee pain; confirmed diagnosis of patellar tendinopathy (confirmation by ultrasonography demonstrating local anterior-posterior thickening of the tendon of ≥ 1 mm compared with the mid-tendon level, and a hypo-echoic area) **Exclusion criteria:** received corticosteroid injections within 12 months; have full-width disruptions of the patellar tendon; have undergone previous knee surgery or intraarticular injury; have had arthritis (Kellgren and Lawrence grade 2 or higher), open growth plates, diabetes, cardiovascular disease, history of cancer, any major medical illnesses, or endocrine disorders; body mass index > 35; pregnant or planning to become pregnant; current collegiate, professional, or elite athletes, or are participating in sports organizations that currently ban the use of somatropin
Interventions	**Drug: somatropin** 1. Active drug (growth hormone, human growth hormone) **Drug: bacteriostatic saline**

NCT02597660 *(Continued)*

	1. Placebo, the diluent used to reconstitute somatropin **Progressive exercise programme** 1. Eccentric exercise training regimen 2. 12-week period 3. Each session consists of 3 bilateral exercises: leg press, back squat, and hack squat 4. Will complete 4 sets in each exercise with a 2- to 3-minute rest between sets 5. Repetitions/loads are 15 repetition maximum week 1, 12 repetition maximum weeks 2–3, 10 repetition maximum weeks 4–5, 8 repetition maximum weeks 6–8, and 6 repetition maximum weeks 9–12 6. All exercises are performed from complete 0° to 90° of knee flexion and back again 7. Each of the eccentric and concentric phases will occur over a period of 3 seconds, for a total of 6 seconds per contraction
Outcomes	Outcomes will be measured at 1, 2, 3, 4, 9, 14, and 26 weeks' follow-up **Primary outcome** 1. Function using change in Victorian Institute of Sport Assessment – Patellar outcome score from enrolment **Secondary outcomes** 1. Change in patient completed Visual Analogue Scale knee pain levels 2. Change in patient completed Victorian Institute of Sport Assessment – Patellar outcome score 3. Change in patient completed Patient Reported Outcomes Measurement Instrument System (PROMIS) Physical Function Computer Adaptive Test 4. Change in patient completed Patient Reported Outcomes Measurement Instrument System (PROMIS) Short Form Global Health Scale 5. Ultrasound assessment of patellar tendon quality at weeks 1, 14, and 26 6. 5-point assessment scale of tendon quality (0 normal, normal tendon structure; 1 mild, ill-defined abnormal hypoechogenicity; 2 moderate, well-defined abnormal hypoechogenicity; 3 severe, well-defined abnormal hypoechogenicity and anechoic clefts; 4 complete, full-width tendon disruption or tear) 7. Electron micrographs of patellar tendon biopsy sample at week 26 8. Bilateral biopsies will be taken, and the size (measured in nanometres squared) will be measured 9. Gene expression of patellar tendon biopsy sample at week 26 10. Bilateral biopsies will be taken, and the expression of genes will be measured with microarrays or ribonucleic acid sequencing
Starting date	1 May 2020
Contact information	Christopher L Mendias, Hospital for Special Surgery, New York, US
Notes	**Trial status:** withdrawn (principal investigator decided not to enrol) **Trial registration number:** NCT02597660 **Expected completion date:** December 2020

PACTR202304561563965

Study name	The effect of eccentric training on postural balance in athletes with patellar tendinopathy
Methods	**Study design:** prospective 2-arm randomized controlled trial

PACTR202304561563965 *(Continued)*	**Setting:** medical sports centre **Trial time period:** 4 January 2020 **Interventions:** eccentric training group versus no intervention **Sample size calculations:** 40 **Analysis:** not reported
Participants	**Inclusion criteria:** athletes aged 18–35 years; clinical diagnosis of unilateral patellar tendinopathy conducted by an experienced sports physician; diagnosis based mainly on clinical assessment; had activity-related patellar tendon pain for ≥ 3 months **Exclusion criteria:** prior knee surgery; corticosteroid injections for patellar tendinopathy in the last 12 months; history of lower limb fracture; any other coexisting knee pathology; recovering from another lower-extremity injury; concussion; visual, vestibular, or neurological disorders; any other disease that may influence balance control
Interventions	**Eccentric training group** 1. Exercise programme consisting of standing on the injured leg on a 25° decline board and slowly squatting down for 12 weeks 2. Daily, with 3 sets of 15 repetitions for 12 weeks, 3 months **Control group** 1. No intervention
Outcomes	Outcomes were measured at 12-week follow-up. **Primary outcome** 1. Postural balance **Secondary outcomes** 1. Strength 2. Pain
Starting date	4 January 2020
Contact information	Fendr T, Laboratory EM2S, Tunisia; +21671783828; thouraya.fendri.1@gmail.com
Notes	**Trial status:** completed **Trial register number:** CTRI/2019/08/020643 **Expected completion date:** December 2020. No results are available.

DATA AND ANALYSES

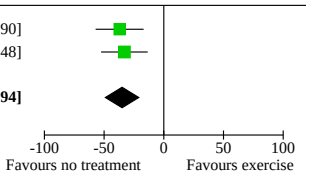
Comparison 1. Strengthening exercise versus no treatment

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.1 Pain intensity at the end of the treatment (6 months)	1	36	Mean Difference (IV, Fixed, 95% CI)	-34.94 [-48.94, -20.94]
1.2 Function at the end of treatment	3	95	Mean Difference (IV, Random, 95% CI)	7.04 [-6.94, 21.02]
1.3 Function at 6 months' follow-up	1	31	Mean Difference (IV, Fixed, 95% CI)	0.80 [-25.28, 26.88]

Analysis 1.1. Comparison 1: Strengthening exercise versus no treatment, Outcome 1: Pain intensity at the end of the treatment (6 months)

Study or Subgroup	Strengthening exercise Mean [0-100]	SD [0-100]	Total	No treatment Mean [0-100]	SD [0-100]	Total	Weight	Mean Difference IV, Fixed, 95% CI [0-100]
Rieder 2022	25	20	8	62	21	8	48.6%	-37.00 [-57.10 , -16.90]
Rieder 2022	29	23	12	62	21	8	51.4%	-33.00 [-52.52 , -13.48]
Total			**20**			**16**	**100.0%**	**-34.94 [-48.94 , -20.94]**

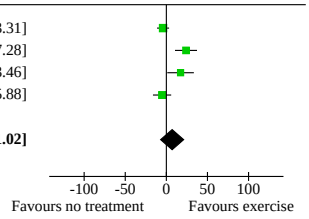
Test for overall effect: Z = 4.89 (P < 0.00001)
Test for subgroup differences: Not applicable
Heterogeneity: Chi² = 0.08, df = 1 (P = 0.78); I² = 0%



Analysis 1.2. Comparison 1: Strengthening exercise versus no treatment, Outcome 2: Function at the end of treatment

Study or Subgroup	Strengthening exercise Mean [0-100]	SD [0-100]	Total	No treatment Mean [0-100]	SD [0-100]	Total	Weight	Mean Difference IV, Random, 95% CI [0-100]
Biernat 2014	90.3	12.2	15	94.3	7.2	13	28.4%	-4.00 [-11.31 , 3.31]
Rieder 2022	86	7.7	8	62.1	17.7	8	24.0%	23.90 [10.52 , 37.28]
Rieder 2022	79.4	17.8	11	62.1	17.7	8	21.8%	17.30 [1.14 , 33.46]
Visnes 2005	70	15.14	16	75.2	16.8	16	25.8%	-5.20 [-16.28 , 5.88]
Total (Wald[a])			**50**			**45**	**100.0%**	**7.04 [-6.94 , 21.02]**

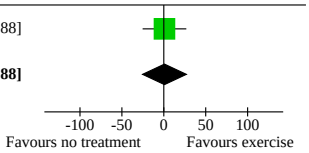
Test for overall effect: Z = 0.99 (P = 0.32)
Test for subgroup differences: Not applicable
Heterogeneity: Tau² (DL[b]) = 165.30; Chi² = 17.94, df = 3 (P = 0.0005); I² = 83%



Footnotes
[a]CI calculated by Wald-type method.
[b]Tau² calculated by DerSimonian and Laird method.

Analysis 1.3. Comparison 1: Strengthening exercise versus no treatment, Outcome 3: Function at 6 months' follow-up

Study or Subgroup	Strengthening exercise Mean [0-100]	SD [0-100]	Total	No treatment Mean [0-100]	SD [0-100]	Total	Weight	Mean Difference IV, Fixed, 95% CI [0-100]
Visnes 2005	82.5	38.3	15	81.7	35.6	16	100.0%	0.80 [-25.28 , 26.88]
Total			**15**			**16**	**100.0%**	**0.80 [-25.28 , 26.88]**



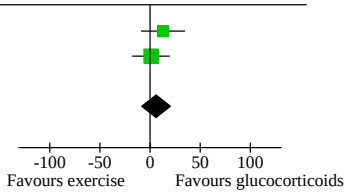
Test for overall effect: Z = 0.06 (P = 0.95)
Test for subgroup differences: Not applicable
Heterogeneity: Not applicable

Comparison 2. Strengthening exercise versus glucocorticoid injection

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.1 Pain intensity at the end of treatment	1	38	Mean Difference (IV, Random, 95% CI)	6.04 [-8.19, 20.26]
2.2 Pain intensity at 6 months	1	38	Mean Difference (IV, Random, 95% CI)	-6.46 [-21.54, 8.62]
2.3 Function at the end of treatment	1	38	Mean Difference (IV, Random, 95% CI)	-5.75 [-17.42, 5.93]
2.4 Function at 6 months' follow-up	1	37	Mean Difference (IV, Random, 95% CI)	-0.66 [-12.75, 11.42]

Analysis 2.1. Comparison 2: Strengthening exercise versus glucocorticoid injection, Outcome 1: Pain intensity at the end of treatment

Study or Subgroup	Strengthening exercise Mean	SD	Total	Glucocorticoid injection Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Kongsgaard 2009[a]	31	26	13	18	21	6	42.0%	13.00 [-8.96 , 34.96]
Kongsgaard 2009[b]	19	15	13	18	21	6	58.0%	1.00 [-17.68 , 19.68]
Total (Wald[c])			**26**			**12**	**100.0%**	**6.04 [-8.19 , 20.26]**

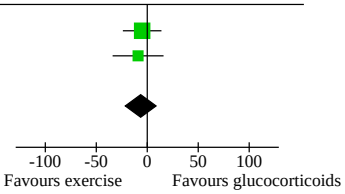


Test for overall effect: Z = 0.83 (P = 0.41)
Test for subgroup differences: Not applicable
Heterogeneity: Tau² (DL[d]) = 0.00; Chi² = 0.67, df = 1 (P = 0.41); I² = 0%

Footnotes
[a]Intervention arm was eccentric exercise compared to the control group.
[b]Intervention arm was isotonic (concentric with eccentric) exercise compared to the control group.
[c]CI calculated by Wald-type method.
[d]Tau² calculated by DerSimonian and Laird method.

Analysis 2.2. Comparison 2: Strengthening exercise versus glucocorticoid injection, Outcome 2: Pain intensity at 6 months

Study or Subgroup	Strengthening exercise Mean	SD	Total	Glucocorticoid injection Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Kongsgaard 2009[a]	13	16	13	18	21	6	63.5%	-5.00 [-23.92 , 13.92]
Kongsgaard 2009[b]	22	17	13	31	29	6	36.5%	-9.00 [-33.98 , 15.98]
Total (Wald[c])			**26**			**12**	**100.0%**	**-6.46 [-21.54 , 8.62]**

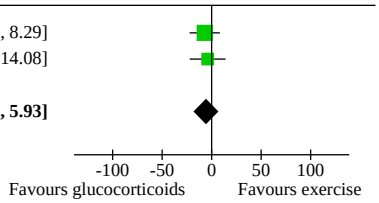


Test for overall effect: Z = 0.84 (P = 0.40)
Test for subgroup differences: Not applicable
Heterogeneity: Tau² (DL[d]) = 0.00; Chi² = 0.06, df = 1 (P = 0.80); I² = 0%

Footnotes
[a]Intervention arm was isotonic (concentric with eccentric) exercise compared to the control group at end of treatment programme.
[b]Intervention arm was eccentric exercise compared to the control group at end of treatment programme.
[c]CI calculated by Wald-type method.
[d]Tau² calculated by DerSimonian and Laird method.

Analysis 2.3. Comparison 2: Strengthening exercise versus glucocorticoid injection, Outcome 3: Function at the end of treatment

Study or Subgroup	Strengthening exercise Mean	SD	Total	Glucocorticoid injection Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Kongsgaard 2009[a]	75	3	13	82	19	6	58.3%	-7.00 [-22.29 , 8.29]
Kongsgaard 2009[b]	78	18	13	82	19	6	41.7%	-4.00 [-22.08 , 14.08]
Total (Wald[c])			**26**			**12**	**100.0%**	**-5.75 [-17.42 , 5.93]**

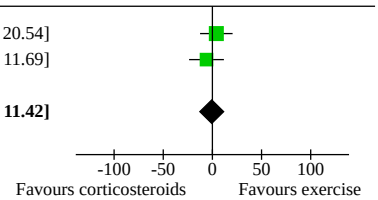


Test for overall effect: Z = 0.97 (P = 0.33)
Test for subgroup differences: Not applicable
Heterogeneity: Tau² (DL[d]) = 0.00; Chi² = 0.06, df = 1 (P = 0.80); I² = 0%

Footnotes
[a]Intervention arm was eccentric exercise compared to the control group at end of treatment programme.
[b]Intervention arm was isotonic (concentric with eccentric) exercise compared to the control group at end of treatment programme.
[c]CI calculated by Wald-type method.
[d]Tau² calculated by DerSimonian and Laird method.

Analysis 2.4. Comparison 2: Strengthening exercise versus glucocorticoid injection, Outcome 4: Function at 6 months' follow-up

Study or Subgroup	Strengthening exercise Mean	SD	Total	Glucocorticoid injection Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Kongsgaard 2009[a]	86	12	13	82	19	6	53.4%	4.00 [-12.54 , 20.54]
Kongsgaard 2009[b]	76	16	12	82	19	6	46.6%	-6.00 [-23.69 , 11.69]
Total (Wald[c])			**25**			**12**	**100.0%**	**-0.66 [-12.75 , 11.42]**



Test for overall effect: Z = 0.11 (P = 0.91)
Test for subgroup differences: Not applicable
Heterogeneity: Tau² (DL[d]) = 0.00; Chi² = 0.65, df = 1 (P = 0.42); I² = 0%

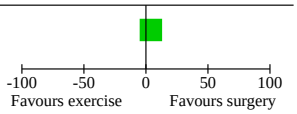
Footnotes
[a]Intervention arm was isotonic (concentric with eccentric) exercise compared to the control group at end of treatment programme.
[b]Intervention arm was eccentric exercise compared to the control group at end of treatment programme.
[c]CI calculated by Wald-type method.
[d]Tau² calculated by DerSimonian and Laird method.

Comparison 3. Strengthening exercise versus surgery

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.1 Pain intensity at 12 months' follow-up	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
3.2 Function at end of treatment	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
3.3 Function at 6 months' follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.4 Function at 12 months' follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.5 Global assessment treatment success at the end of treatment	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.6 Global assessment treatment success at 6 months' follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.7 Global assessment treatment success at 12 months' follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.8 Return to sport at 12 months' follow-up	1		Risk Ratio (M-H, Random, 95% CI)	Subtotals only

Analysis 3.1. Comparison 3: Strengthening exercise versus surgery, Outcome 1: Pain intensity at 12 months' follow-up

	Strengthening exercise			Surgery			Mean Difference	Mean Difference
Study or Subgroup	Mean [0-100]	SD [0-100]	Total	Mean [0-100]	SD [0-100]	Total	IV, Random, 95% CI [0-100]	IV, Random, 95% CI [0-100]
Bahr 2006[a]	17	17	20	13	7	20	4.00 [-4.06 , 12.06]	

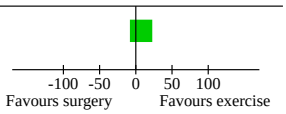


Footnotes

[a]Pain during standing jump test.

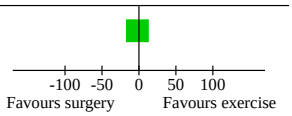
Analysis 3.2. Comparison 3: Strengthening exercise versus surgery, Outcome 2: Function at end of treatment

	Strengthening exercise			Surgery			Mean Difference	Mean Difference
Study or Subgroup	Mean [0-100]	SD [0-100]	Total	Mean [0-100]	SD [0-100]	Total	IV, Random, 95% CI [0-100]	IV, Random, 95% CI [0-100]
Bahr 2006	52.4	22.4	20	45.1	17	20	7.30 [-5.02 , 19.62]	



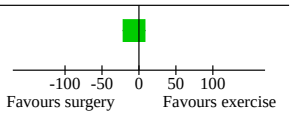
Analysis 3.3. Comparison 3: Strengthening exercise versus surgery, Outcome 3: Function at 6 months' follow-up

Study or Subgroup	Strengthening exercise Mean [0-100]	SD [0-100]	Total	Surgery Mean [0-100]	SD [0-100]	Total	Mean Difference IV, Fixed, 95% CI [0-100]	Mean Difference IV, Fixed, 95% CI [0-100]
Bahr 2006	57.1	20.2	20	59.2	23.7	20	-2.10 [-15.75 , 11.55]	



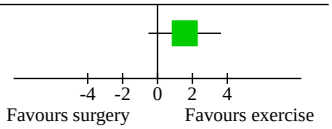
Analysis 3.4. Comparison 3: Strengthening exercise versus surgery, Outcome 4: Function at 12 months' follow-up

Study or Subgroup	Strengthening exercise Mean [0-100]	SD [0-100]	Total	Surgery Mean [0-100]	SD [0-100]	Total	Mean Difference IV, Fixed, 95% CI [0-100]	Mean Difference IV, Fixed, 95% CI [0-100]
Bahr 2006	66.1	20.2	20	72.7	28.8	20	-6.60 [-22.02 , 8.82]	



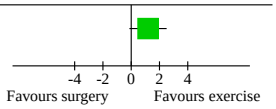
Analysis 3.5. Comparison 3: Strengthening exercise versus surgery, Outcome 5: Global assessment treatment success at the end of treatment

Study or Subgroup	Strengthening exercise Mean [4]	SD [4]	Total	Surgery Mean [4]	SD [4]	Total	Mean Difference IV, Fixed, 95% CI [4]	Mean Difference IV, Fixed, 95% CI [4]
Bahr 2006	1.76	4.15	20	0.2	2.3	20	1.56 [-0.52 , 3.64]	



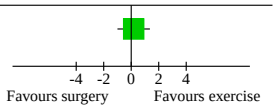
Analysis 3.6. Comparison 3: Strengthening exercise versus surgery, Outcome 6: Global assessment treatment success at 6 months' follow-up

Study or Subgroup	Strengthening exercise Mean [-5 to +5]	SD [-5 to +5]	Total	Surgery Mean [-5 to +5]	SD [-5 to +5]	Total	Mean Difference IV, Fixed, 95% CI [-5 to +5]	Mean Difference IV, Fixed, 95% CI [-5 to +5]
Bahr 2006	2.09	1.5	20	0.9	2.6	20	1.19 [-0.13 , 2.51]	



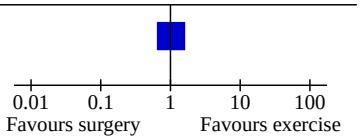
Analysis 3.7. Comparison 3: Strengthening exercise versus surgery, Outcome 7: Global assessment treatment success at 12 months' follow-up

Study or Subgroup	Strengthening exercise Mean [-5 to +5]	SD [-5 to +5]	Total	Surgery Mean [-5 to +5]	SD [-5 to +5]	Total	Mean Difference IV, Fixed, 95% CI [-5 to +5]	Mean Difference IV, Fixed, 95% CI [-5 to +5]
Bahr 2006	3.08	1.8	20	2.9	2	20	0.18 [-1.00 , 1.36]	



Analysis 3.8. Comparison 3: Strengthening exercise versus surgery, Outcome 8: Return to sport at 12 months' follow-up

Study or Subgroup	Strengthening exercise Events	Total	Surgery Events	Total	Risk Ratio M-H, Random, 95% CI	Risk Ratio M-H, Random, 95% CI
Bahr 2006[a]	13	15	17	20	1.02 [0.78 , 1.34]	



Footnotes

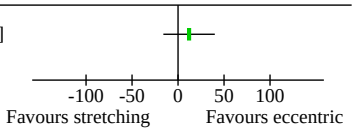
[a]Number of participants who returned fully or partially to sport with or without pain

Comparison 4. Strengthening exercise versus stretching exercise

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
4.1 Muscle strength at the end of treatment	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 4.1. Comparison 4: Strengthening exercise versus stretching exercise, Outcome 1: Muscle strength at the end of treatment

Study or Subgroup	Strengthening exercise Mean	SD	Total	Stretching exercise Mean	SD	Total	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Jensen 1989[a]	106	32	8	94	23	7	12.00 [-15.96 , 39.96]	



Footnotes

[a]Eccentric quadriceps femoris muscle work ratio (involved limb/uninvolved limb)

APPENDICES

Appendix 1. Cochrane Central Register of Controlled Trials search strategy

1. Tendinopathy/ 749

2. tendinopath*.tw. 1140

3. Tendinitis.tw. 480

4. Tendoniti*.tw. 187

5. Tendinosis.tw. 138

6. tendinos*.tw. 148

7. Tendon Injuries/ 347

8. (Tendon adj5 Injur$).tw. 371

9. or/1-8 2491

10. Patellar Ligament/ 213

11. Patella$.mp. 2684

12. patella/ 406

13. or/10-12 2684

14. 9 and 13 286

15. exp Exercise/ 38180

16. fitness.mp. 14840

17. exp Exercise Test/ 10408

18. exp Exercise Tolerance/ 3278

19. Sport/ 215

20. exp Pliability/ 253

21. (physical activity, capacity and performance).mp. 40

22. exertion$.tw. 5827

23. exercis$.tw. 116587

24. sport$.tw. 10727

25. ((physical or motion) adj5 (fitness or therap$)).tw. 16305

26. (physical$ adj2 endur$).tw. 262

27. ((strength$ or endurance or weight$) adj5 (exercis$ or train$)).tw. 22224

28. (skate$ or skating).tw,kf. 140

29. run$.tw,kf. 25978

30. jog$.tw,kf. 713

31. treadmill$.tw,kf. 9603

32. swim$.tw,kf. 1498

33. bicycl$.tw,kf. 3464

34. (cycle$ or cycling).tw,kf. 66209

35. walk$.tw,kf. 38196

36. (row or rows or rowing).tw,kf. 1989

37. muscle strength$.tw. 14059

38. or/15-37 244858

39. 14 and 38 301

Appendix 2. MEDLINE (Ovid) search strategy

1. Tendinopathy/ 7056

2. tendinopath*.tw. 4324

3. Tendinitis.tw. 2290

4. Tendoniti*.tw. 880

5. Tendinosis.tw. 840

6. tendinos*.tw. 946

7. Tendon Injuries/ 14880

8. (Tendon adj5 Injur$).tw. 5175

9. or/1-8 25744

10. Patellar Ligament/ 2977

11. Patella$.mp. 23447

12. patella/ 10977

13. or/10-12 23447

14. 9 and 13 1889

15. exp Exercise/ 247874

16. fitness.mp. 98202

17. exp Exercise Test/ 71130

18. exp Exercise Tolerance/ 14954

19. Sport/ 34995

20. exp Pliability/ 4619

21. (physical activity, capacity and performance).mp. 6

22. exertion$.tw. 23422

23. exercis$.tw. 306642

24. sport$.tw. 79012

25. ((physical or motion) adj5 (fitness or therap$)).tw. 42941

26. (physical$ adj2 endur$).tw. 771

27. ((strength$ or endurance or weight$) adj5 (exercis$ or train$)).tw. 39452

28. (skate$ or skating).tw,kf. 2556

29. run$.tw,kf. 193797

30. jog$.tw,kf. 2367

31. treadmill$.tw,kf. 33438

32. swim$.tw,kf. 41717

33. bicycl$.tw,kf. 22455

34. (cycle$ or cycling).tw,kf. 636687

35. walk$.tw,kf. 123888

36. (row or rows or rowing).tw,kf. 20337

37. muscle strength$.tw. 25203

38. or/15-37 1524773

39. 14 and 38 683

40. randomized controlled trial.pt. 598806

41. controlled clinical trial.pt. 95395

42. randomized.ab. 535262

43. placebo.ab. 219924

44. drug therapy.fs. 2619401

45. randomly.ab. 350108

46. trial.ab. 575677

47. groups.ab. 2175185

48. or/40-47 5230244

49. exp animals/ not humans.sh. 5151139

50. 48 not 49 4501686

51. 14 and 39 and 50 309

Appendix 3. Embase Classic + Embase search strategy

1. Tendinopathy/ 7824

2. tendinopath*.tw. 6952

3. Tendinitis.tw. 3667

4. Tendoniti*.tw. 1580

5. Tendinosis.tw. 1334

6. tendinos*.tw. 1502

7. Tendon Injuries/ 8049

8. (Tendon adj5 Injur$).tw. 7431

9. or/1-8 27412

10. Patellar Ligament/ 2978

11. Patella$.mp. 37598

12. patella/ 12658

13. or/10-12 37598

14. 9 and 13 2481

15. exp Exercise/ 459771

16. fitness.mp. 132592

17. exp Exercise Test/ 119693

18. exp Exercise Tolerance/ 20734

19. Sport/ 62792

20. exp Pliability/ 3395

21. (physical activity, capacity and performance).mp. 369

22. exertion$.tw. 42920

23. exercis$.tw. 498292

24. sport$.tw. 132976

25. ((physical or motion) adj5 (fitness or therap$)).tw. 78682

26. (physical$ adj2 endur$).tw. 1263

27. ((strength$ or endurance or weight$) adj5 (exercis$ or train$)).tw. 62747

28. (skate$ or skating).tw,kf. 3411

29. run$.tw,kf. 334273

30. jog$.tw,kf. 3607

31. treadmill$.tw,kf. 49993

32. swim$.tw,kf. 60174

33. bicycl$.tw,kf. 38642

34. (cycle$ or cycling).tw,kf. 1032419

35. walk$.tw,kf. 216852

36. (row or rows or rowing).tw,kf. 34539

37. muscle strength$.tw. 43553

38. or/15-37 2500996

39. 14 and 38 1107

40. exp randomized controlled trial/ 785421

41. controlled clinical trial/ 471213

42. random$.ti,ab. 1981754

43. exp randomization/ 98891

44. intermethod comparison/ 300203

45. placebo.ti,ab. 369619

46. (compare or compared or comparison).ti. 635266

47. ((evaluated or evaluate or evaluating or assessed or assess) and (compare or compared or comparing or comparison)).ab. 2777792

48. (open adj label).ti,ab. 108447

49. ((double or single or doubly or singly) adj (blind or blinded or blindly)).ti,ab. 278956

50. double blind procedure/ 212780

51. parallel group$1.ti,ab. 32096

52. (crossover or cross over).ti,ab. 125806

53. ((assign$ or match or matched or allocation) adj5 (alternate or group$1 or intervention$1 or patient$1 or subject$1 or participant $1)).ti,ab. 416515

54. (assigned or allocated).ti,ab. 492327

55. (controlled adj7 (study or design or trial)).ti,ab. 452970

56. (volunteer or volunteers).ti,ab. 288327

57. human experiment/ 640813

58. trial.ti. 408472

59. or/40-58 6388465

60. 39 and 59 498

Appendix 4. ClinicalTrials.gov search strategy

Condition/disease field: Tendinopathy, Tendon Injuries, Tendinosis

Intervention/treatment: Exercise, Exercise Training, Exercise Intervention, Exercise Program, Exercises

Appendix 5. ICTRP search strategy

Tendinopathy OR Tendon Injuries OR Tendinosis AND Exercise OR Exercise Training OR Exercise Intervention OR Exercise Program OR Exercises

Appendix 6. Results of application of the Consensus on Exercise Reporting Template (CERT) to each included trial[a]

Component	Bahr 2006	Biernat 2014	Jensen 1989	Kongsgaard 2009	Rieder 2022	Stasinopoulos 2004	Visnes 2005
1 Detailed description of the type of exercise equipment.	1	1	1	1	1	1	1
2 Detailed description of the qualifications, supervising expertise, training undertaken by the exercise instructor, or combinations of these.	0	0	0	0	0	0	0
3 Describe whether exercises were performed individually or in a group.	1	0	1	0	0	0	0
4 Describe whether exercises were supervised or unsupervised and how they were delivered.	1	0	0	1	0	1	0
5 Detailed description of how adherence to exercise was measured and reported.	0	0	0	0	0	0	0
6 Detailed description of motivation strategies.	0	0	0	0	0	0	0
7a Detailed description of the decision rule(s) for determining exercise progression.	1	1	0	1	1	0	1
7b Detailed description of how the exercise programme was progressed.	0	0	0	0	0	0	0
8 Detailed description of each exercise to enable replication.	0	1	0	1	1	0	0
9 Detailed description of any home programme component.	0	NA	0	NA	NA	NA	0
10 Describe whether there were any non-exercise components.	0	0	NA	1	0	1	0
11 Describe the type and number of adverse events that occurred during exercise.	0	0	0	0	0	0	0
12 Describe the setting in which the exercises were	1	1	1	0	0	1	1

(Continued)

performed.							
13 Detailed description of the exercise intervention.	1	1	0	1	0	1	0
14a Describe whether the exercises were generic or tailored.	0	0	0	0	0	0	0
14b Detailed description of how exercises were tailored to the individual	0	0	0	0	0	0	0
15 Describe the decision rule for determining the starting level at which people started an exercise programme.	0	0	0	0	0	0	0
16a Describe how adherence or fidelity to the exercise intervention was assessed/measured.	0	0	0	0	0	0	0
16b Describe the extent to which the intervention was delivered as planned.	0	0	0	0	0	0	0

0: no; 1: yes.

[a]Slade 2016.

Appendix 7. Exercise table – Consensus on Exercise Reporting Template (CERT)

Trial	Types	Prescriber (number and qualifications)	Equipment type	Starting levels, tailoring, progression strategies, or combinations of these	Adherence strategies	Dosage	Number of sessions per day	Number of weeks of treatment	Number of therapist visits
Exercise versus no treatment, usual care, or minimal intervention (3 trials)									
Biernat 2014	Squat strengthening exercises on decline board	Not reported	Decline board (angle of 25°)	Exercise was performed with pain < 4 points (0–10 VAS). Progression in the fourth week, and an unstable surface was incremented. In case of pain exaggeration, the exercise was not carried out, the load had to be lowered, or the number of repetitions was limited	Not reported	3 sets, 15 repetitions	1	24	Not reported
	No treatment			Participation in volleyball training					
Rieder 2022	Squat strengthening exercises	Not reported	Barbell and hack squat (squats, leg press, and hack squats)	Progressive overload was ensured by increasing the weight with a concurrent reduction of repetitions: 12 repetition maximum in weeks 2 and 3, 10 repetition maximum in weeks 4 and 5; 8 repetition maximum in weeks 6–8; 6 repetition maximum in weeks 9–12	Not reported	4 sets, 15 repetitions	1	12	Weekly supervision
	Whole-body vibration		Oscillating platform	Not reported		10 sets, 60 seconds static standing in a slightly squatted position on an oscillating platform with 60 seconds rest between sets			Weekly supervision
	Waiting-list control		—	—		—			—

(Continued)

Visnes 2005	Squat strengthening exercises on decline board	Not reported	Decline board (angle of 25°)	Load was increased as pain decreased, and they added load in a backpack in 5-kg increments. Those with less pain than 3–4 (0–10 scale), were recommended to increase the weight. Players with more pain than 6–7 (0–10 scale) during the exercises were recommended to do the exercise with less weight	Not reported	3 sets, 15 repetitions	1	12	Not reported
	Control group (volleyball training)			Usual volleyball training					
Exercise compared to glucocorticoid injection (1 trial)									
Kongsgaard 2009	Squat strengthening exercises	Not reported	Squat, leg press, and hack squat	15 repetition maximum week 1, 12 repetition maximum weeks 2–3, 10 repetition maximum weeks 4–5, 8 repetition maximum weeks 6–8 and 6 repetition maximum weeks 9–12	Not reported	4 sets in each exercise, repetitions varied during treatment	Single session, but for 3 days a week	12	Weekly supervision
	Squat strengthening exercises on decline board		Decline board (angle of 25°)	Load was increased using an incrementally loaded backpack as pain diminished.		3 sets, 15 reps	2		
	Glucocorticoid injection		—	—		—	—		
Exercise compared to surgery (1 trial)									
Bahr 2006	Squat strengthening exercises on decline board	Physiotherapist	Decline board (angle of 25°)	If pain < 3, added 5-kg load, > 5 exercise with less weight. After 4 weeks, allowed to cycle, to jog if these activities could be performed without pain. After 8 weeks, gradually return to their sport if there was no or minimal pain	Not reported	3 sets, 15 repetitions	2	12	Weekly supervision
	Surgery								
Exercise compared to stretching exercise (1 trial)									
Jensen 1989	Stretching exercise	Not reported	No equipment	Not reported	Not reported	Not reported	2	8	Not reported

(Continued)

	Stretching exercise plus strengthening exercise		Isokinetic dynamometer	Increase of angular velocities during the weeks		Week 1: 6 sets of 5 repetitions; weeks 2–8: 4 sets of 5 repetitions per angular velocity	—		
Exercises compared to pulsed ultrasound and transverse friction (1 trial)									
Stasinopoulos 2004	Stretching exercise plus squat strengthening exercises	Physiotherapist	No equipment	Load consisted of the bodyweight and participants were standing with all their bodyweight on the injured leg. As they moved from the standing to the squat position	Not reported	3 sets, 15 repetitions	Single session, but for 3 days a week	4	Not reported
	Transverse friction								
	Pulsed ultrasound								

VAS: Visual Analogue Scale.

HISTORY

Protocol first published: Issue 7, 2018

CONTRIBUTIONS OF AUTHORS

Conception, design, drafting, critical revision: ADL, RRR, LCH, LOC, and SJK.

Final approval: all review authors.

DECLARATIONS OF INTEREST

ADL: none.

RRR: none.

LCH: none.

LOC: none.

SJK: none.

SOURCES OF SUPPORT

Internal sources

- Northeastern University, USA

  In-kind support by providing office, computer, and library access.
- Universidade Cidade de São Paulo, Brazil

  In-kind support by providing office, computer, and library access.

External sources

- No external source of support, Other

  none

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

There were no differences between protocol and review (Lopes 2018).

INDEX TERMS

Medical Subject Headings (MeSH)

Bias; *Exercise Therapy [adverse effects] [methods]; *Patellar Ligament [injuries]; Quality of Life; Randomized Controlled Trials as Topic; Resistance Training [methods]; *Tendinopathy [therapy]

MeSH check words

Adult; Female; Humans; Male