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Treatment of patellar tendinopathy—a systematic review of randomized controlled trials

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Abstract

Purpose Patellar tendinopathy is a common, painful, overuse disorder. Although many different treatment methods have been described, there is no consensus regarding the optimal treatment for this condition. The purpose of this study was to systematically review, summarize, and compare treatments for patellar tendinopathy from published randomized controlled trials.

Methods Database searches were performed for randomized prospective controlled trials comparing treatment methods for patellar tendinopathy. The thirteen articles considered relevant were scrutinized according to quality assessment guidelines and levels of evidence.

Results Strong evidence was found for the use of eccentric training to treat patellar tendinopathy. Moderate evidence was found for conservative treatment (heavy slow resistance training) as an alternative to eccentric training. Moderate evidence suggests that low-intensity pulsed ultrasound treatment did not influence treatment outcomes. Limited evidence was found for surgery, sclerosing injections, and shockwave therapy.

Conclusion Physical training, and particularly eccentric training, appears to be the treatment of choice for patients suffering from patellar tendinopathy. However, type of exercise, frequency, load, and dosage must also be analyzed. Other treatment methods, such as surgical treatment, sclerosing injections, and shockwave therapy, must be investigated further before recommendations can be made regarding their use. Ultrasound can likely be excluded as a treatment for patellar tendinopathy. There is a persistent lack of well-designed studies with sufficiently long-term follow-up and number of patients to draw strong conclusions regarding therapy.

Level of evidence II.

Keywords Eccentric training · Evidence-based medicine · Jumper's knee

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Introduction

Patellar tendinopathy, also known as jumper's knee or patellar tendinitis, is currently the most common condition in which the patient complains of pain in the area just below the patella. Because biopsies have demonstrated that the disease is degenerative rather than inflammatory, the preferred term is "patellar tendinopathy" [13, 18]. The major cause is overuse in activities that involve rapid changes of direction, jumping, and running, such as volleyball, basketball, and soccer [6, 17]. Risk factors associated with patellar tendinopathy have recently been surveyed, and limited evidence was found for intrinsic factors [31].

The overall prevalence of patellar tendinopathy is reportedly 14.2%; however, its prevalence is higher in sports with strong demands on the patellar ligament [17]. Incidence as high as 40% has been described in elite volleyball players [6]. Diagnosis is clinical and is typically based on medical history and clinical findings. Imaging techniques such as color duplex sonography (CDS) and magnetic resonance imaging (MRI) are valuable tools to confirm the diagnosis and provide guidance for treatment [36].

Although there are many ways to treat patellar tendinopathy, evidence-based therapies are limited and there is no consensus regarding the best way to treat this condition. Techniques have been tried that have also been applied to Achilles tendinopathy, including eccentric training, extracorporeal shockwave (ECSW) therapy, ultrasound-guided sclerosing, open surgery, and arthroscopic surgery. Nonsteroidal anti-inflammatory drugs (NSAIDs), platelet-rich plasma injection [28], aprotinin, and autologous growth factors are other treatment options [1].

To our knowledge, no formal review has been published on patellar tendinopathy in which randomized controlled studies have been scrutinized according to a structured quality assessment guideline. This systematic review assesses randomized controlled studies addressing the comparison of patellar tendinopathy treatments.

Materials and methods

Randomized prospective controlled trials published in English and comparing methods for the treatment of patellar tendinopathy were considered for inclusion in this analysis. The MEDLINE database was searched from its inception to August 27, 2010, with the search strategy (*patella OR patellar*) *AND* (*tendonit* OR tendin**) *AND randomized* (30 hits) and *jumper's knee AND randomized* (10 hits). The titles and/or abstracts were screened according to the stated inclusion criteria. Thirteen articles were considered relevant; trials that focused on diagnostics were excluded. The reference lists from the 13 articles were searched for additional studies of interest. Additionally, the databases CINAHL and AMED were searched with the search strategies (*patella OR patellar*) and (*tendinopathy OR tendinitis OR tendonitis OR jumpers knee*), resulting in 99 and 45 hits, respectively; however, this search did not result in any new relevant articles. Thus, a total of thirteen articles involving 612 individuals (one study on prophylactic training had 244 individuals) were included in the present review. One study compared surgery with eccentric training [2]. Eccentric training was also compared with corticoid injections and heavy resistance training [16], concentric training [3, 12], different types/protocols of eccentric training [8, 40], and lack of treatment [7, 39]. Sclerosing treatment with polidocanol injection of neovessels was compared with injections of lidocaine/epinephrine in a single study [11]. One study investigated the clinical effect of low-intensity pulsed ultrasound (LIPUS) [37]. Another study compared extracorporeal shockwave therapy with conservative treatments such as NSAIDs, physical therapy, and use of a knee strap [35]. Hyperthermia was compared with conventional ultrasound in one study [9]. Ultrasound was also compared with exercise and transverse friction in one study [27].

The quality of the relevant 13 articles was scrutinized according to guidelines established by Van Tulder et al. [34]. This scoring system shows great similarity to the Methodological Quality Scores used by Khan et al. [14], and also includes cutoff scores for high and low quality, making it possible to draw conclusions regarding the level of evidence in a given study. Each criterion was assessed with the alternatives "Yes," "No," or "Don't know" (Table 1), as also recommended in the Cochrane Handbook for Systematic Reviews of Intervention [10]. The assessment "Don't know" was used when the information in the article was insufficient to provide a "Yes" or "No" assessment. The total number of "Yes" responses was determined, from which the quality of the article was assessed (Table 2). Articles fulfilling at least 6/11 possible criteria were considered to be of "high quality," while studies with less than six positive criteria were considered to be of "low quality." The assessment was based solely on the information gathered from the articles. Quality of the methodology was independently assessed by MEHL, IK, and KNH; differences were resolved by discussion. Pooled statistical evaluation of the included trials could not be performed because of the differences in study design, treatment methods, and heterogeneous outcome variables.

Results

After the quality assessment (see Table 2), nine articles were considered to possess high methodological quality (see Table 3). Seven of the high-quality articles investigated eccentric training [2, 3, 8, 16, 27, 39, 40]; five of these [2, 3, 8, 16, 40] reported significant improvement among the participants compared with baseline. Five of the high-quality articles [2, 3, 8, 39, 40] uncovered no significant differences between the intervention group and the control group. However, two articles [16, 27] demonstrated a significant difference between the groups that performed eccentric training and groups experiencing pulsed ultrasound and transverse friction [27] and corticosteroid

Table 1 Criteria for quality assessment, with motivations

Study	Criteria										
	A	B	C	D	E	F	G	H	I	J	K
Kongsgaard et al. [16]	Yes, a computer-generated minimization randomization procedure	Don't know? Not explicitly expressed whether the person responsible for eligibility was different from the person who allocated the patients	Yes	Don't know	Don't know whether there were different care providers for different interventions or whether they knew about the other interventions	Yes	Yes	Yes	Yes	Yes	No
Warden et al. [37]	Yes, simple randomization in blocks of 10	Yes	Yes	Yes	Yes	Yes	Yes, similar 1/3 resp	Yes	No, exceeds 20%	Yes	Yes
Fredberg et al. [7]	Don't know, randomized but no description of how the randomization took place	Don't know, no description of how the randomization took place	Yes, on ultrasound	Don't know whether the teams were informed of what the other teams did	No, care provider not blinded to intervention	Don't know, ultrasonography procedure was well described, but a description of blinding was not provided	Yes, were instructed not to perform eccentric training	Don't know, described how to maximize compliance but no report on actual compliance	Don't know, relevance?	Yes	No, one group changed after randomization
Wang et al. [35]	No, used odd and even numbers on medical records	Don't know	Yes	Don't know, not expressed in paper	Don't know, not clearly expressed in paper	Yes	Don't know for the control group	Don't know, co-interventions in study group?	Yes	Yes	No, 4 knees lost to follow-up and excluded
Frohm et al. [8]	Yes, by draw of sealed opaque envelopes	Don't know	Yes	Don't know	Don't know	No, all patients examined were trained and tested by the principal investigator	Don't know	Yes? 20 completed the program which was well described; however, compliance was not specified	Yes	Yes after 12 weeks	Yes
Bahr et al. [2]	Yes	Yes	Yes	No	No	No, neither patient nor investigator were blinded (can't see who was assessor)	Yes, both could take pain medication	Yes? 66% vs. 72%	Yes	Yes	Yes? Says there was ITT with LOCF but $n = 15$?

Table 1 continued

Study	Criteria										
	A	B	C	D	E	F	G	H	I	J	K
Hoksrud et al. [11]	Yes? statistician but how?	Yes	Yes	Yes	Yes	Yes	Yes, but only for medication	Yes?	Yes	No? same follow-up occasions but differed in active treatment time (placebo group was treated from 4 months)	Yes
Jonsson and Alfredson [12]	Don’t know, no description of how randomization was performed	Don’t know, were the included all eligible for the study? On a specific time limit? Was assignment made by an independent person with no influence on decision of eligibility?	Yes	Don’t know, not reported	No PJ gave instructions to both groups	Don’t know. Self-assessment, but was the investigator blinded to group during analysis?	Don’t know. No reporting of whether it was avoided or similar	No, dropout was high in the concentric group, which did not comply with treatment after 6 weeks	No, described but not acceptable. Many dropouts due to painful intervention (concentric)	Yes	No. Only 5 tendons remained in the concentric group.
Visnes et al. [39]	Yes	Yes	Yes, with some uncertainty about duration	No, not possible according to authors	No HV and AK know who they were in contact with and were not blinded to the other group’s intervention	Don’t know, unable to identify the outcome assessor	Yes? self-recorded on weekly basis but not clear whether it was similar in both groups	No, 59%	Yes	Yes	Yes

Table 1 continued

Study	Criteria									
	A	B	C	D	E	F	G	H	I	J	K

Study	A	B	C	D	E	F	G	H	I	J	K
Young et al. [40]	Yes	Yes	Yes, duration lacks	Don't know, no information on whether the patients knew what was given to the other group	Don't know, no information on whether the care provider was blinded to the aim of intervention or to the intervention given to the other group	Yes	Don't know, a diary was used to monitor compliance, additional activity, and drugs, but no information regarding whether there were co-interventions or whether they were similar in both groups	Yes, 72%	Yes	Yes	Yes
Stasinopoulos and Stasinopoulos [27]	Yes?	Don't know, unclear who drew the lots	Don't know, no information on prognostic factors such as duration, severity, and the main outcomes	Don't know, no information on patient blinding	No, same care provider in all groups	Yes	Yes	Yes	Yes? In introduction it says that "if one patient drops-out a new one included" but later on the text indicates that there were "no drop-outs."?	Yes	Yes? as it is reported as "no dropouts" but see I
Giombini et al. [9]	Yes No mention of dropouts, nor is *n* given	Yes, although not explicitly expressed whether the person who recruited patients was different from the person who allocated them.	Don't know, unclear about previous duration and distribution of symptoms in the groups	Yes, blinded to type of treatment received	Don't know, blinding of care provider not described	Yes	Don't know, not mentioned	Don't know, does not mention compliance	Don't know	Yes	Don't know. N is not reported and therefore unclear whether there were any dropouts

Table 1 continued

Study	Criteria									
	A	B	C	D	E	F	G	H	I	J	K
Cannell et al. [3]	Yes, by sealed opaque envelopes	Don't know, who randomized? Were any of the sports medicine experts who included patients involved in assignment, or was there an independent person?	Yes	Don't know, was the patient blinded to what the other group did?	No, care provider trained both groups	Yes, assessor blinded to group collected data	Yes, ice, anti-inflammatories, rest recommendation. The drop squat group was instructed to ice after performance	Yes, at least 55 out of 60	Yes, no dropouts	Yes, baseline, 6 and 12 weeks	Yes, no need for ITT

Criteria for quality assessment according to van Tulder et al. All criteria answered with Yes/No/Don't know: (A) Was the method of randomization adequate? (B) Was the treatment allocation concealed? (C) Were the groups similar at baseline regarding the most important prognostic indicators? (D) Was the patient blinded to the intervention(s) given to the other groups? (E) Was the care provider blinded to the aim of the intervention and/or the interventions given to the other groups? (F) Was the outcome assessor blinded to the intervention? (G) Were co-interventions avoided or similar? (H) Was the compliance acceptable in all groups? (I) Was the dropout rate described and acceptable? (J) Was the timing of the outcome assessment in all groups similar? (K) Did the analysis include an intention-to-treat analysis?

Interpretation of checklist: (A) A random (unpredictable) assignment sequence. Examples of adequate methods are computer-generated random number table and use of sealed opaque envelopes. Methods of allocation using date of birth, date of admission, hospital numbers, or alternation should not be regarded as appropriate. (B) Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient. (C) In order to receive a "yes," groups have to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of patients with neurological symptoms, and value of mail outcome measure(s). (D) The reviewer determines whether enough information about the blinding is given in order to score "yes." (E) The reviewer determines whether enough information about the blinding is given in order to score "yes." (F) The reviewer determines whether enough information about the blinding is given in order to score "yes." (G) Co-interventions should either be avoided in the trial design or similar between the index and control groups. (H) The reviewer determines whether the compliance to the interventions is acceptable based on the reported intensity, duration, number, and frequency of sessions for both the index intervention and control intervention(s). (I) The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawers and dropouts does not exceed 20% for short-term follow-up and 30% for long-term follow-up and does not lead to substantial bias a "yes" is scored. (N.B. these percentages are arbitrary, not supported by literature). (J) Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments. (K) All randomized patients are reported/analyzed in the group to which they were allocated by randomization for the most important moments of effect measurement (minus missing values) irrespective of non-compliance and co-interventions

Table 2 Summary of each study, including its results and scientific quality assessment

Study	Summary	Within-group results	Between-group results	Quality assessment
Kongsgaard et al. [16]	Aim: Investigate clinical, structural, functional effects of corticosteroid injections (CORT), eccentric decline squat training (ECC), and heavy slow resistance training (HSR)	VISA-P and VAS improved significantly in all groups from baseline to 12 weeks	The relative VISA-P improvement from baseline to the half-year follow-up was higher in the HSR and ECC groups than in the CORT group	7/11 (high)
	Subjects: 39 patient who had applied for inclusion in trial	Tendon thickness decreased significantly in the CORT and HSR groups from baseline to 12 weeks	The relative improvement in VAS from baseline to half-year follow-up was significantly greater in the HSR group than the CORT group	
	Intervention: Group 1, CORT: Two injections administrated 4 weeks apart	VISA-P and VAS decreased significantly in CORT but were unchanged in ECC and HST from 12 weeks to the half-year follow-up	The HSR group showed significant improvements in tendon abnormalities compared to the CORT group	
	Group 2, ECC: 15 sets of slow repetitions reps of eccentric unilateral squats on a 25° decline board twice daily for 12 consecutive weeks	Tendon abnormalities showed significant improvement in the HSR group at 12 weeks	The HSR group was the most satisfied (significant)	
	Group 3: HSR, three weekly sessions of three bilateral concentric and eccentric exercises for 12 weeks			
	Evaluation/outcome: Primary outcome: VISA-P score			
	Secondary outcome: VAS, tendon abnormality, patient satisfaction			
Warden et al. [37]	Aim: To investigate clinical efficacy of LIPUS	For the entire cohort, VAS-U decreased by 1.6 ± 1.9 cm	No significant difference in VAS-U, VAS-W, VISA, patient-perceived response, compliance, or adverse events	10/11 (high)
	Subjects: 37/156 volunteers were randomized into two groups	VAS-W decreased by 2.5 ± 2.4		
	Intervention: Active LIPUS ($n = 17$) or non-active LIPUS ($n = 20$). Both groups also performed eccentric exercises	VISA improved		
	Evaluation/outcome: After 12 weeks of intervention: primary, pain during the most aggravating activity VAS-U (usual), VAS-W worst; secondary, VISA scale, patient-perceived response to treatment 5-point scale; additional secondary, ultrasound, exercise compliance, adverse events, blinding success			

Table 2 continued

Study	Summary	Within-group results	Between-group results	Quality assessment
Fredberg et al. [7]	Aim: To evaluate whether prophylactic eccentric training and stretching reduced the frequency of asymptomatic ultrasonographic changes in patellar tendon and the risk of becoming symptomatic or injured Subjects: 244 soccer players in the Danish Super League Intervention: Intervention group: eccentric training and stretching Control group: none of the above Evaluation/outcome: Ultrasonography of the tendon, injury risk	N/A	Reduced proportion of players with ultrasonographic changes in the intervention group of those with normal tendons Increased risk of injury in the intervention group in players with abnormal patellar tendons at the beginning	3/11 (low)
Wang et al. [35]	Aim: To evaluate the efficacy and safety of shockwave treatment and to compare it to conservative treatment Subjects: Study group $n = 27$ (30 knees), control group $n = 23$ (24 knees), three patients (4 knees) lost to follow-up Intervention: Study group: single shockwave treatment; three patients (4 knees) received two treatments Control group: conservative treatment as NSAIDs, physical therapy, exercise, knee strap—no cortisone Evaluation/outcome: Performed at 1, 3, 6, and 12 months, then once per year Pain score, VISA, ultrasound. Unclear from which test the follow-up data was retrieved; abstract says 2–3 years of follow-up	Significant changes in the study group but not in control group	Significant difference at follow-up in pain, VISA score, ROM, functional improvement, overall outcome and ulstrasound vascularity in favor of study group	4/11 (low)
Frohm et al. [8]	Aim: To compare the efficacy and safety of two eccentric rehabilitation protocols Subjects: 20 patients with verified patellar tendinopathy Intervention: Group I: Squat training with Browsman's device Group II: One-legged squat training on a decline board Evaluation/outcome: Primary: VISA-P, isokinetic strength test. Secondary: functional tests, VAS, safety	Both groups improved significantly	No significant differences	6/11 (high)

Table 2 continued

Study	Summary	Within-group results	Between-group results	Quality assessment
Bahr et al. [2]	Aim: Comparison of surgery and eccentric training Subjects: 35 patients/40 knees Intervention: Group I: Primary surgery, $n = 20$ knees Group II: eccentric training, $n = 20$ knees Evaluation/outcome: VISA score, global evaluation score, functional tests, return to sports	Both groups improved significantly in VISA score, GES, and functional test only between baseline and 12 months	No significant differences (difference at 3 months GES in favor of eccentric training)	8/11 (high)
Hoksrud et al. [11]	Aim: To investigate sclerosing treatment using polidocanol on a group of elite athletes Subjects: 33 patients (42 tendons) mainly recruited from the Norwegian elite divisions in basketball, team handball, and volleyball. 17 patients (23 knees) in treatment group, 16 patients (20 knees) in control group Intervention: Treatment group: polidocanol injections Control group: injections with lidocaine/epinephrine After 4 months the control group was crossed over to active treatment Evaluation/outcome: Main outcome: VISA score at 4, 8, and 12 months after the first injection Second outcome: overall satisfaction using VAS	The treatment group reported significant improvement in VISA score compared with no change for the control group at the first treatment period (4 months) The control group (now also receiving active treatment) showed a greater improvement from 4 to 8 months	Trend toward a group-by-time interaction in VISA score during treatment period 1 in favor of intervention group	10/11 (high)

Table 2 continued

Study	Summary	Within-group results	Between-group results	Quality assessment
Jonsson and Alfredson [12]	Aim: To compare painful eccentric quadriceps training with painful concentric quadriceps training on a decline board Subjects: 15 patients (19 knees) with long duration of pain from proximal patellar tendon Intervention: (a) painful eccentric quadriceps training (b) painful concentric quadriceps training on a decline board. 15 exercises ×3, twice daily, 7 days/week, 12 weeks Evaluation/outcome: VAS pain, VISA score, patient satisfaction	The eccentric training group experienced a significant decrease in VAS and increase in VISA score. 7/8 patients (9/10 tendons) satisfied	At 12 week follow-up, VAS was significantly lower in the eccentric group	2/11 (low)
Visnes et al. [39]	Aim: To investigate effect of eccentric training for volleyball players during competitive season Subjects: 29 volleyball players who volunteered for the study Intervention: Training group squats on a 25° decline board 3 × 15, twice daily, 12 weeks Control group: no extra intervention/training Evaluation/outcome: VISA score, global evaluation score, jumping performance at 6 weeks and 6 months	No statistical significant difference in improvement (except for the first week)	Not statistical significant difference between groups at 6 weeks or 6 months	7/11 (high)
Young et al. [40]	Aim: To investigate short- and long-term efficacy of (a) trad. ecc. protocol—step group and (b) more contemporary treatment—decline group Subjects: 17 people with clin diagnosed and imaging confirmed pat. tendinopathy 8 decline/9 step group Intervention: 12 week (a) trad. ecc. protocol—step group and (b) more contemporary treatment—decline group Evaluation/outcome: VISA score and VAS pain	Both groups improved significantly from baseline to 12 weeks and 12 months	No difference between groups. The decline group had a higher likelihood of a practically important increase in VISA score. The step group had a higher likelihood of reduced pain	8/11 (high)

Table 2 continued

Study	Summary	Within-group results	Between-group results	Quality assessment
Stasinopoulos and Stasinopoulos [27]	Aim: To compare the effectiveness of an exercise program, pulsed ultrasound, and transverse friction Subjects: 30 patients with chronic patellar tendinopathy Intervention: A: exercise program B: pulsed ultrasound C: transverse friction Evaluation/outcome: Pain response categorized as worse/no change/slightly better or much better/no pain at end of treatment, 1 month, 3 months	No evaluation reported	The exercise group was significantly better than the other two groups at all follow-up assessments	7/11 (high)
Giombini et al. [9]	Aim: To compare hyperthermia at 434 MHz to conventional ultrasound Subjects: 33 males, 11 women Intervention: 12 treatments 3 times per week for 4 weeks. 30-min duration for the hyperthermia group, 15-min duration for the ultrasound group Evaluation/outcome: VAS pain on pressure, VAS pain on isometric contraction at start, end, and after 1 month, and global outcome of treatment	Both groups showed a significant decrease in VAS pain pressure and pain isometric contraction	Significant difference between the groups; hyperthermia led to a better effect in VAS scores regarding pain pressure and pain on contraction	5/11 (low)
Cannell et al. [3]	Aim: To compare the therapeutic effects of two exercise protocols Subjects: 13 men, 6 women Intervention: 12-week intervention of drops squats or leg extension/leg curl Evaluation/outcome: Main outcome: pain, return to sports. Secondary outcome: quadriceps and hamstrings moment of force	Both groups experienced significant decreases in pain. No gain in quadriceps strength occurred in either group. Significant increases in hamstrings in both groups	No differences between groups regarding pain, return to sports, or moment of force	8/11 (high)

Table 3 Methodological quality scores

Study	Year	Scores for A–K (yes = 1, don't know and no = 0)	Total score (max 11)	Number of patients
Kongsgaard et al. [16]	2009	11100111110	8/11	39
Warden et al. [37]	2008	11111111011	10/11	37
Fredberg et al. [7]	2008	00100010010	3/11	244
Wang et al. [36]	2007	00100100110	4/11	50
Frohm et al. [8]	2007	10100001111	6/11	20
Bahr et al. [2]	2006	11100011111	8/11	35
Hoksrud et al. [11]	2006	11111111101	10/11	33
Jonsson and Alfredson [12]	2005	00100000010	2/11	15
Visnes et al. [39]	2005	11100010111	7/11	29
Young et al. [40]	2005	11100101111	8/11	17
Stasinopoulos and Stasinopoulos [27]	2004	10000111111	7/11	30
Giombini et al. [9]	2002	11010100010	5/11	44
Cannell et al. [3]	2001	10100111111	8/11	19

injections [16]. Stasinopoulos and Stasinopoulos were unable to detect differences between the two other forms of treatment either within or between the groups [27], while Konsgaard et al. [16] reported that heavy slow resistance training also resulted in significant improvement compared with corticosteroid injections.

Another high-quality article compared active low-intensity pulsed ultrasound (LIPUS) with non-active LIPUS [37], with improvements observed for the entire cohort but no significant differences detected between the groups. Both groups also performed eccentric exercises. When sclerosing injections were compared with non-sclerosing injections of lidocaine/epinephrine [11], a trend toward a group-by-time interaction in favor of the intervention group was noted.

Eccentric training was also evaluated in two low-quality articles [7, 12]. Compared with concentric training, eccentric training resulted in statistically significant improvements [12]. Prophylactic eccentric training and stretching led to a reduced risk of developing ultrasonographic changes in the patellar tendon; however, an increased risk of injury was observed in the intervention group [7]. Low-quality studies also compared shockwave therapy with conservative treatment, such as NSAIDs, physical therapy, exercise, and knee straps [35], revealing a significant improvement in favor of shockwave therapy. This improvement was also the case when hyperthermia at 434 MHz was compared with conventional ultrasound [9].

An analysis of "levels of evidence" [23, 34] was carried out to synthesize the results of our literature review. Strong evidence denoted consistent findings in multiple high-quality randomized controlled trials; strong evidence was uncovered in favor of the use of eccentric training in the treatment of patellar tendinopathy. Moderate evidence, which is defined as findings in a single high-quality randomized controlled trial or consistent findings in multiple low-quality trials, indicated that heavy slow resistance training results in significant improvement compared with corticosteroid injections and that LIPUS treatment does not influence patellar tendinopathy treatment outcomes. Finally, limited evidence from a single low-quality randomized trial supported the use of shockwave therapy and sclerosing injections. However, there may be a group-by-time interaction in favor of the sclerosing intervention, because when the control group had also received active treatment with polidocanol, they experienced greater improvement compared with the treatment group.

Discussion

The most important finding of the present study was that only physical training (particularly eccentric training) could be considered as having strong evidence for the treatment of patellar tendinopathy.

We were initially unable to identify a checklist specific for randomized studies of patellar tendinopathy. We considered the scale used in a meta-analysis of treatment of acute Achilles tendon ruptures [14]; however, as the scale included performance biases by the surgeon, it was unsuitable for this review (surgery was rarely evaluated in well-designed randomized controlled trials for patellar tendinopathy treatment). Scales were more likely than checklists to include criteria that do not directly relate to internal validity, suggesting that scales should not be used to determine a summary score [10]. The Cochrane Musculoskeletal Group advises use of the Cochrane risk of bias from Chapter 8 of the Cochrane Handbook for Systematic

Reviews of interventions [10] in complete Cochrane reviews; otherwise, the van Tulder checklist [34] is an alternative, and eventually became our choice of quality assessment tool. However, all methods have their advantages and disadvantages, some of which we discuss later. Assessment checklists may need to be diagnosis specific to best assess study quality, suggesting a benefit to the development of a patellar tendinopathy-specific checklist.

In general, it was difficult to draw conclusions about the best evidence for patellar tendinopathy treatment because the study designs varied to an extent that complicated the direct comparison of various treatment protocols. However, an eccentric exercise program for patellar tendinopathy treatment appears to be the leading candidate, a conclusion strengthened by a recent study in which long-term (5-year) follow-up revealed that the majority of patients with Achilles tendinopathy recovered fully when treated with exercise alone [26]. No intervention, a so-called "wait-and-see" policy, was evaluated in patients with Achilles tendinopathy; however, it was not very effective and seems, therefore, to not be a viable treatment alternative for tendinopathy [22]. It is also important to separate pain in the midtendon from pain at the osteotendinous junction, a differentiation that is not always performed in published studies [21].

Previously, LIPUS was not shown to provide any benefit beyond that of a placebo [37], in agreement with another investigation suggesting that LIPUS is questionable in the treatment of tendinopathies [15]. Injection treatments for the management of patellar tendinopathy have shown promising results [28, 30] although the response to injections cannot be generalized due to variation in effect between different sites of tendinopathy [4]. The etiology for patellar tendinopathy remains uncertain, with one explanation citing neovascularization and anticipation of pain by accompanying nerves. If this explanation is valid, sclerosing injections of polidocanol [19, 20] in the area with neovessels should reduce pain in patellar tendinopathy patients. Although Hoksrud et al. [11] reported reduced pain after ultrasound-guided sclerosing in patients with patellar tendinopathy, contradictory results were recently presented in a retrospective study [33] in which sclerosing injections in 48 patients with chronic Achilles tendinopathy revealed less promising results than expected [33]. We note, however, that while two of the studies in our review [11, 37] received high-quality scores (10/11), both studies suffered from limitations, including small numbers of participants and short durations of the intervention period. Further investigation is required to fully reveal the effect of treatment method.

A previous extensive study of prophylactic training for patellar tendons reported that ultrasound could reveal changes in the patellar tendon before symptoms developed; prophylactic training certainly decreased the risk of abnormalities in the tendon, but led to an increased risk of injury in patients without symptoms [7]. While this study was difficult to evaluate with our assessment tool and received a relatively low-quality score (see Table 2), its inclusion of a large patient population and a prophylactic intervention provided valuable information regarding the utility of prophylactic training. Compliance and dropout rates for the intervention were not reported (lowering the quality score) and may not be relevant, since the intervention was prophylactic and supposedly performed by all participants.

Another study with a low-quality score compared ECSW therapy with conservative treatment [35]. The conclusion that ECSW was more effective than conservative treatment in reducing pain had an indeterminate basis. The control group was offered NSAIDs, a knee strap, exercise, and physiotherapy. Even if this study, as well as a review by van Leeuwen et al. [32], indicates a benefit of ECSW for treating patellar tendinopathy, a larger randomized controlled trial is necessary to elucidate the benefit of this treatment.

Incomplete reporting is a key difficulty in assessing risk of bias or quality. For example, while Bahr et al. [2] reported that both patient groups continued to take pain-reduction medicine, the study lacked details of the dosage and frequency for each patient, as well as information regarding between-group differences.

In this review, quality assessment was based only on what was reported in the published articles. We did not contact the authors for additional information or in the case of a "Don't know" assessment, as it seemed reasonable to base our assessments on information that was available to all readers. One article in particular generated discussion among the reviewers in this regard. Stasinopoulos and Stasinopoulos [27] indicated in their introduction that "if one patient drops-out a new one is included"—a strategy not in accordance with standard procedures—but later the text indicates that there were no dropouts. If these two "Yes" responses to criteria I and K (Table 1) were changed to "No," the quality assessment would have dropped from high to low quality. Does a "No" response provide more valuable information about the study design than a "Don't know" response, and should it increase the quality ranking? Although the study by Visnes et al. [39] received a relatively low-quality score (Table 2), the quality assessment criteria were clearly addressed, permitting analysis and interpretation of the study design.

A study by Jonsson and Alfredson [12] reported superior results after eccentric training compared with concentric quadriceps training in patients with jumper's knee. The quality assessment score for this study was very low (Table 2) because it lacked several specific details, including the randomization procedure. However, clinically important information that was accessible to the reader indicated that concentric training was painful for patients. It is interesting to note that these patients were then treated with sclerosing injections or surgery, but not eccentric training. Corticosteroid injections, heavy slow resistance training, and eccentric decline squat training were compared in a highly ranked study [16]. All three therapies led to good short-term outcomes. Eccentric decline squat training and heavy slow resistance training showed good long-term clinical results, and heavy slow resistance training also resulted in advantages in pathological improvement and increased collagen turnover. Only one study [2] compared eccentric training with surgical treatment; both groups experienced greater improvement than patients receiving conservative treatment [2]. According to published literature, surgical treatment for patellar tendinopathy appears to be used when conservative treatment fails. An observational study of arthroscopic treatment [24] as well as a retrospective, multicenter study revealed a greater than 80% success rate for surgical treatment in patients suffering from patellar tendinopathy and refractory to conservative treatment [5]. This observation should be further investigated with well-designed randomized controlled studies to determine the possible benefit of surgical treatment in patients suffering from symptomatic patellar tendinopathy.

Visnes et al. [38] suggested that eccentric training had a positive effect on patellar tendinopathy and recommended that athletes suspend sports activity during rehabilitation. This critical review was limited by the small number of patients and a short follow-up period, and no specific treatment protocol was recommended. Another review [32] stating that ECSW therapy was a promising method also suffered from the above limitations. Tendon repair is known to be a long-term process when treating patellar tendinopathy, suggesting that a follow-up period of 12 weeks is insufficient.

A major limitation of the assessment tool used in this review is that it does not include a question about power analysis; a study can therefore be evaluated as high-quality despite the possibility that the results could be due to type II error. This may have been the case in the study by Cannell et al. [3], who reported no difference between interventions with drop squats versus leg extension/curl, or in a study by Young et al. [40], indicating no difference between the decline group and the step group (although they did report a considerable difference in the likelihood of improvement in VISA scores at 12 months). As our quality assessment only considered internal validity, studies of high quality can be underpowered and still lack information about external validity connected with the generalizability or applicability of a study's findings. Following the CONSORT 2010 statement [25] when planning and reporting randomized controlled trials would probably also improve the correct assessment of study quality.

The clinical relevance of this systematic review is that eccentric treatment should be the recommended first choice to treat patellar tendinopathy. Surgery demonstrated a similar effect to eccentric treatment and might be indicated if conservative treatment is unsuccessful; however, this possibility still requires further investigation. Evidence regarding the use of sclerosing injections and shockwave therapy remains limited, while ultrasound can probably be excluded as a therapeutic option.

Conclusions

Until now, physical training (and particularly eccentric training) has appeared to be the treatment of choice for patients suffering from patellar tendinopathy. However, exercise type, frequency, load, and dosage require further investigation. Shockwave therapy, sclerosing injections, and surgery all require additional research before their use can be recommended. Ultrasound can probably be excluded for patellar tendinopathy treatment. Overall, there are still few studies that have evaluated the long-term effectiveness of patellar tendinopathy treatment, and cost-effectiveness is not addressed in these studies.

Homogenous outcome variables would increase the utility of the evaluation of evidence-based practice for patellar tendinopathy. A recommendation of outcome variables should be formed, as for studies of chronic pain [29]. A diagnosis-specific quality checklist may also improve quality assessment of studies of patellar tendinopathy.

References

1. Andres BM, Murrell GA (2008) Treatment of tendinopathy: what works, what does not, and what is on the horizon. Clin Orthop Relat Res 466:1539–1554
2. Bahr R, Fossan B, Loken S, Engebretsen L (2006) Surgical treatment compared with eccentric training for patellar tendinopathy (Jumper's Knee). A randomized, controlled trial. J Bone Joint Surg Am 88(8):1689–1698
3. Cannell LJ, Taunton JE, Clement DB, Smith C, Khan KM (2001) A randomised clinical trial of the efficacy of drop squats or leg extension/leg curl exercises to treat clinically diagnosed jumper's knee in athletes: pilot study. Br J Sports Med 35(1):60–64
4. Coombes BK, Bisset L, Vicenzino B (2010) Efficacy and safety of corticosteroid injections and other injections for management of tendinopathy: a systematic review of randomised controlled trials. Lancet 376(9754):1751–1767
5. Cucurulo T, Louis ML, Thaunat M, Franceschi JP (2009) Surgical treatment of patellar tendinopathy in athletes. A retrospective multicentric study. Orthop Traumatol Surg Res 95(8 Suppl 1):S78–84

6. Ferretti A (1986) Epidemiology of jumper's knee. Sports Med 3(4):289–295
7. Fredberg U, Bolvig L, Andersen NT (2008) Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in Achilles and patellar tendons: the Danish Super League Study. Am J Sports Med 36(3):451–460
8. Frohm A, Saartok T, Halvorsen K, Renstrom P (2007) Eccentric treatment for patellar tendinopathy: a prospective randomised short-term pilot study of two rehabilitation protocols. Br J Sports Med 41(7):e7
9. Giombini A, Di Cesare A, Casciello G, Sorrenti D, Dragoni S, Gabriele P (2002) Hyperthermia at 434 MHz in the treatment of overuse sport tendinopathies: a randomised controlled clinical trial. Int J Sports Med 23(3):207–211
10. Higgins J, Altman D (2008) Assessing risk of bias in included studies. In: Higgins J, Green S (eds) Cochrane handbook for systematic reviews of interventions. Blackwell, Chichester
11. Hoksrud A, Ohberg L, Alfredson H, Bahr R (2006) Ultrasound-guided sclerosis of neovessels in painful chronic patellar tendinopathy: a randomized controlled trial. Am J Sports Med 34(11):1738–1746
12. Jonsson P, Alfredson H (2005) Superior results with eccentric compared to concentric quadriceps training in patients with jumper's knee: a prospective randomised study. Br J Sports Med 39(11):847–850
13. Khan KM, Cook JL, Bonar F, Harcourt P, Astrom M (1999) Histopathology of common tendinopathies. Update and implications for clinical management. Sports Med 27(6):393–408
14. Khan RJ, Fick D, Keogh A, Crawford J, Brammar T, Parker M (2005) Treatment of acute achilles tendon ruptures. A meta-analysis of randomized, controlled trials. J Bone Joint Surg Am 87(10):2202–2210
15. Khanna A, Nelmes RT, Gougoulias N, Maffulli N, Gray J (2009) The effects of LIPUS on soft-tissue healing: a review of literature. Br Med Bull 89:169–182
16. Kongsgaard M, Kovanen V, Aagaard P, Doessing S, Hansen P, Laursen AH, Kaldau NC, Kjaer M, Magnusson SP (2009) Corticosteroid injections, eccentric decline squat training and heavy slow resistance training in patellar tendinopathy. Scand J Med Sci Sports 19(6):790–802
17. Lian OB, Engebretsen L, Bahr R (2005) Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. Am J Sports Med 33(4):561–567
18. Maffulli N, Khan KM, Puddu G (1998) Overuse tendon conditions: time to change a confusing terminology. Arthroscopy 14(8):840–843
19. Ohberg L, Alfredson H (2002) Ultrasound guided sclerosis of neovessels in painful chronic Achilles tendinosis: pilot study of a new treatment. Br J Sports Med 36(3):173–175
20. Ohberg L, Alfredson H (2003) Sclerosing therapy in chronic Achilles tendon insertional pain-results of a pilot study. Knee Surg Sports Traumatol Arthrosc 11(5):339–343
21. Rees JD, Maffulli N, Cook J (2009) Management of tendinopathy. Am J Sports Med 37(9):1855–1867
22. Rompe JD, Nafe B, Furia JP, Maffulli N (2007) Eccentric loading, shock-wave treatment, or a wait-and-see policy for tendinopathy of the main body of tendo Achillis: a randomized controlled trial. Am J Sports Med 35(3):374–383
23. Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB (2000) Evidenced-based medicine: how to practice and teach EBM, 2nd edn. Churchill Livingstone, Edingburgh
24. Santander J, Zarba E, Iraporda H, Puleo S (2011) Can arthroscopically assisted treatment of chronic patellar tendinopathy reduce pain and restore function? Clin Orthop Relat Res. doi: 10.1007/s11999-011-1886-y
25. Schulz KF, Altman DG, Moher D (2010) CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMC Med 8:18
26. Silbernagel KG, Brorsson A, Lundberg M (2011) The majority of patients with Achilles tendinopathy recover fully when treated with exercise alone: a 5-year follow-up. Am J Sports Med 39(3):607–613
27. Stasinopoulos D, Stasinopoulos I (2004) Comparison of effects of exercise programme, pulsed ultrasound and transverse friction in the treatment of chronic patellar tendinopathy. Clin Rehabil 18(4):347–352
28. Taylor DW, Petrera M, Hendry M, Theodoropoulos JS (2011) A systematic review of the use of platelet-rich plasma in sports medicine as a new treatment for tendon and ligament injuries. Clin J Sport Med 21(4):344–352
29. Turk DC, Dworkin RH, Allen RR, Bellamy N, Brandenburg N, Carr DB, Cleeland C, Dionne R, Farrar JT, Galer BS, Hewitt DJ, Jadad AR, Katz NP, Kramer LD, Manning DC, McCormick CG, McDermott MP, McGrath P, Quessy S, Rappaport BA, Robinson JP, Royal MA, Simon L, Stauffer JW, Stein W, Tollett J, Witter J (2003) Core outcome domains for chronic pain clinical trials: IMMPACT recommendations. Pain 106(3):337–345
30. van Ark M, Zwerver J, van den Akker-Scheek I (2011) Injection treatments for patellar tendinopathy. Br J Sports Med 45(13):1068–1076
31. van der Worp H, van Ark M, Roerink S, Pepping GJ, van den Akker-Scheek I, Zwerver J (2011) Risk factors for patellar tendinopathy: a systematic review of the literature. Br J Sports Med 45(5):446–452
32. van Leeuwen MT, Zwerver J, van den Akker-Scheek I (2009) Extracorporeal shockwave therapy for patellar tendinopathy: a review of the literature. Br J Sports Med 43(3):163–168
33. van Sterkenburg MN, de Jonge MC, Sierevelt IN, van Dijk CN (2010) Less promising results with sclerosing ethoxysclerol injections for midportion achilles tendinopathy: a retrospective study. Am J Sports Med 38(11):2226–2232
34. van Tulder M, Furlan A, Bombardier C, Bouter L (2003) Updated method guidelines for systematic reviews in the cochrane collaboration back review group. Spine (Phila Pa 1976) 28(12):1290–1299
35. Wang CJ, Ko JY, Chan YS, Weng LH, Hsu SL (2007) Extracorporeal shockwave for chronic patellar tendinopathy. Am J Sports Med 35(6):972–978
36. Warden SJ, Kiss ZS, Malara FA, Ooi AB, Cook JL, Crossley KM (2007) Comparative accuracy of magnetic resonance imaging and ultrasonography in confirming clinically diagnosed patellar tendinopathy. Am J Sports Med 35(3):427–436
37. Warden SJ, Metcalf BR, Kiss ZS, Cook JL, Purdam CR, Bennell KL, Crossley KM (2008) Low-intensity pulsed ultrasound for chronic patellar tendinopathy: a randomized, double-blind, placebo-controlled trial. Rheumatology (Oxford) 47(4):467–471
38. Visnes H, Bahr R (2007) The evolution of eccentric training as treatment for patellar tendinopathy (jumper's knee): a critical review of exercise programmes. Br J Sports Med 41(4):217–223
39. Visnes H, Hoksrud A, Cook J, Bahr R (2005) No effect of eccentric training on jumper's knee in volleyball players during the competitive season: a randomized clinical trial. Clin J Sport Med 15(4):227–23440
40. Young MA, Cook JL, Purdam CR, Kiss ZS, Alfredson H (2005) Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players. Br J Sports Med 39(2):102–105