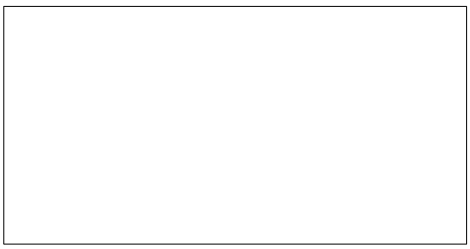

International Journal of Therapy and Rehabilitation

The Effectiveness of Shockwave Therapy on Improving Pain and Symptoms Severity for Patients with Chronic Patella Tendinopathy: A Literature Review

--Manuscript Draft--

Manuscript Number:	ijtr.2023.0066R1
Full Title:	The Effectiveness of Shockwave Therapy on Improving Pain and Symptoms Severity for Patients with Chronic Patella Tendinopathy: A Literature Review
Article Type:	Critical review
Keywords:	Knee pain; musculoskeletal care; rehabilitation; physiotherapy; jumping athletes.
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Abstract:	Background Patellar tendinopathy is a very common and debilitating condition affecting the anterior aspect of the knee. This review aimed to determine the effectiveness of shockwave therapy on pain and quality of life for all types of patients with chronic patellar tendinopathy. Methods A search for quantitative primary studies was conducted in AMED, CINAHL, MEDLINE, SPORTDiscus, PEDRO and the Cochrane database. Grey literature sources, Google Scholar and hand citation searching also took place. All searches were completed between the 1st and 8th of January 2022. Papers were included if the patients' symptoms were chronic (12+ weeks), but any dose, method and type of shockwave therapy were accepted. Results Six articles were accepted following screening, all published after 2010. This review included a total of 270 patients of which 145 received shockwave therapy. Overall, the methodological quality of the six papers was moderate to low. Despite this, and the variation in application of shockwave therapy, the results showed positive improvement in both pain and quality of life outcome measures. Conclusion Shockwave therapy was effective in improving patients' pain and quality of life, although more high-quality research trials are needed to investigate the effects of this therapy. The clinician's first line of treatment for patellar tendinopathy should be education and exercise but if this fails then shockwave therapy should be considered.

The Effectiveness of Shockwave Therapy on Improving Pain and Symptom Severity for Patients with Chronic Patellar Tendinopathy: A Literature Review

Abstract

Background: Patellar tendinopathy is a very common and debilitating condition affecting the anterior aspect of the knee. This review aimed to determine the effectiveness of shockwave therapy on pain and symptom severity for all types of patients with chronic patellar tendinopathy.

Methods: A search for quantitative primary studies was conducted in AMED, CINAHL, MEDLINE, SPORTDiscus, PEDRO and the Cochrane database. Grey literature sources, Google Scholar and hand citation searching also took place. All searches were completed between the 1st and 8th of January 2022. Papers were included if the patients' symptoms were chronic (12+ weeks), but any dose, method and type of shockwave therapy were accepted.

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Conclusion: Shockwave therapy was effective in improving patients' pain and symptom severity, although more high-quality research trials are needed to

investigate the effects of this therapy. The clinician's first line of treatment for patellar tendinopathy should be education and exercise but if this fails then shockwave therapy should be considered.

Keywords

Shockwave therapy, ESWT, Chronic patellar tendinopathy**,** Jumper's knee, Literature review.

Knee pain; musculoskeletal care; rehabilitation; physiotherapy; jumping athletes.

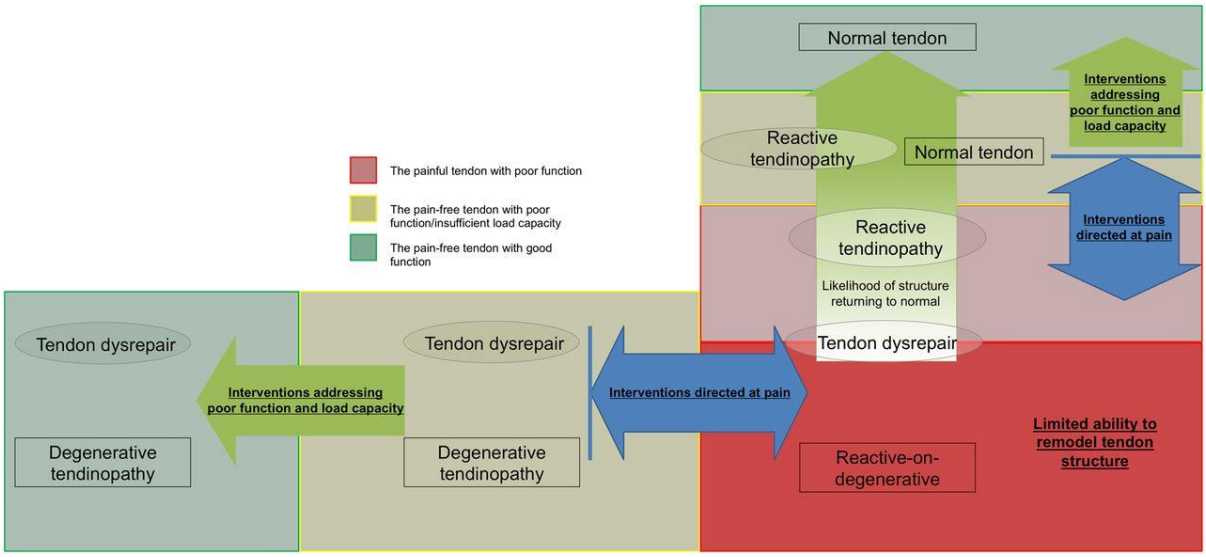
Introduction

Patellar tendinopathy, also known as Jumper's knee, is a diagnosis of dysfunction and pain in the patellar tendon (Rudavsky & Cook, 2014). Patellar tendinopathy has an incidence and prevalence rate of 1.6 per 1000 person-years (Albers et al. 2016). The patellar tendon originates from the apex of the patella and inserts at the tibial tuberosity (removed reference). Its function is to attach the quadriceps muscle to the tibia to allow for extension of the knee (Soames & Palastanga, 2019). Patellar tendinopathy is characterised by pain localised to the inferior pole of the patella (removed reference). Repetitive jumping and landing create high patella tendon loads and are key aggravating factors (Malliaras et al., 2015).

In active individuals, different sports and training levels can influence the prevalence of patella tendinopathy. Lian et al. (2005) found a prevalence of 45% in professional volleyball players and a prevalence of 32% in professional basketball players. Similarly, Zwerver, Bredewag and van den Akkker-Scheek (2011) reported a

prevalence of 8.5% in amateur athletes and 14.4% for amateur volleyball, handball, and basketball players.

There is debate as to whether degeneration or inflammation are the primary drivers of this pathology (Cook & Screen, 2018). Nonetheless, repetitive overload is commonly proposed to be the cause of patellar tendinopathy (Aicle, Oliviero & Maffulli, 2020). Cook and Purdem's (2016) continuum model has become a widely accepted framework to explain tendinopathy pathophysiology. The model proposes three phases (reactive tendinopathy, tendon disrepair and degenerative tendinopathy) which the tendon can move through by adding or removing load (see Figure 1). In a healthy tendon, the collagen fibres are predominantly type one and are tightly bundled together (Brukner & Khan, 2006; Scott et al, 2015). In tendinopathy, collagen fibres are thinner and more loosely organised (Brukner & Khan, 2006; Scott, Backman & Speed, 2015) and the tendon contains a higher proportion of type three collagen with an increase in proteoglycans, leading to increased water content (swelling) within the tissue (Scott et al, 2015). Brukner and Khan (2006) suggested the tendon will have both degenerative areas (extensive cell death and metaplasia) and reactive areas where healing or fibrosis appears to occur. In contrast, Cook and Purdem (2016) suggested much of the literature varies and the relationship between structure, pain and function of tendons is still not fully understood, which adds to the complexity of their management.



This review investigated chronic patellar tendinopathy, where the patients' symptoms have lasted over 12 weeks (Kaux et al., 2011). Chronic patellar tendinopathy is the most debilitating and has the greatest impact on quality of life (Kaux et al., 2011). Hopkins et al. (2016) state that chronic patellar tendinopathy impacts people's productivity at work, the economy due to work loss and professional athletes' careers. Management of symptoms is lengthy and costly (Malliara et al., 2015). Shockwave therapy may provide a solution to these challenges.

Figure 1. The Continuum Model (Cook and Purdem, 2016)

Shockwave therapy was first established in clinical practice in the 1980s as a lithotripsy technique (Chaussy, Brendel & Schmeidt, 1980). Today, it is indicated as a secondary conservative treatment for chronic mid-substance and insertional tendinopathy as well as other musculoskeletal disorders (Challoumas et al., 2021). There are two technically distinct forms of shockwave: radial and focused (Al-Abbad et al., 2020). Focused shockwaves are produced in three ways (electrohydraulic, piezoelectric, and electromagnetic) which turns electric energy into kinetic energy,

whereas radial shockwaves are generated pneumatically (Al-Abbad et al., 2020). The proposed mechanism of shockwave therapy is mechano-transduction (van der Worp et al., 2013a). This theory proposes that the high energy acoustic waves that are fired into the tendon, via a handheld probe, stimulate a molecular, cellular and tissue response (Moya et al., 2018). However, there is still uncertainty on how shockwave therapy works.

One of the main changes is an increase in blood flow to the area, which helps to deliver oxygen and nutrients to the damaged tissue and accelerate the healing process (Wang, 2012). Shockwave therapy may also stimulate the production of collagen, which is a key component of healthy tendons and can help reduce inflammation and pain (Wang, 2012). Research has also suggested that shockwave stimulates the production of certain growth factors that promote the repair of the damaged tissue (Wang, 2012). Holfeld (2014) suggested an anti-inflammatory effect from shockwave therapy through modulating the expression of interleukins and other cytokines which can reduce nociception.

According to the National Institute for Health and Care Excellence (NICE, 2016), shockwave therapy's effectiveness is uncertain. To date, there are no clinical guidelines for patellar tendinopathy and no standard protocols for shockwave therapy (NICE, 2016). In 2009, van Leeuwen, Zwerver and van den Akker Scheek published the last literature review on the effectiveness of shockwave therapy for chronic patellar tendinopathy. Based on the findings of Van Leeuwen, Zwerver and van Der Asker Scheek paper, shockwave therapy appeared to be a safe and effective treatment for patellar tendon pain and function.

This new review aims to analyse if more recent research continues to support the effectiveness of shockwave therapy for chronic patellar tendinopathy.

Methodology

A systematised review was undertaken, with the search, extraction and data analysis completed by one researcher (Kysh, 2013). The focus was on quantitative studies to investigate pain and severity of symptoms through outcome measures such as the Visual Analogue Scale (VAS) and VISA-p. The conduct and reporting of this systematised review were based on the PRISMA statement (Page et al., 2020).

Data Sources

A comprehensive search strategy was conducted to reduce selection bias and ensure that the review was valid and representative of the existing literature (Bettany-Saltikov & McSherry, 2016). The following electronic databases were searched individually: Allied and Complementary Medicine Database (AMED), Cumulative Index of Nursing and Allied Health Literature (CINHAL), MEDLINE, SPORTDiscus, The Physiotherapy Evidence Database (PEDro) and Cochrane.

To ensure that the search had limited publication bias, the following grey literature sources were used to identify conference proceedings, unpublished literature, and theses: Zetoc conferencing, OpenGrey and EThOS (Bowling, 2014). In addition, experts in the field were contacted who may be aware of unpublished work (Bowling, 2014). A secondary search was conducted using Google Scholar, alongside hand

searching the reference lists of the included studies. All searches were performed in January 2022.

Search Strategy

The search strategy was developed in conjunction with a specialist academic librarian (see Table 2). The PICO format was used to identify keywords (Bettany-Saltikov & McSherrys, 2016) (see Table 1). The databases were instructed to search for the keywords in the full text rather than the title, reducing the risk of excluding valuable papers (Aveyard, 2019; Penning De Verries et al., 2020).

Table 1.
PICO

Population	Patients with chronic patellar tendinopathy
Intervention	Shockwave therapy
Comparison	-
Outcome	Pain and symptom severity

Table 2.
Table of Search Terms

Concept		**Search terms**
Chronic patellar tendinopathy		“Chronic patella* tendin*” OR “Jumpers knee”
Shockwave therapy	AND	“Shockwave therapy” OR ESWT

Study Selection

Results were imported into an Excel spreadsheet, and duplicates were removed. Screening was undertaken in two stages using the criteria listed below. Firstly, through a title and abstract screen and then for remaining papers with full text screening.

The inclusion Criteria were:

- Human participants over 18 years old
- Shockwave therapy was used as an intervention.
- Chronic patellar tendinopathy- symptoms for 12+ weeks
- All studies published in the English language.
- Papers published after August 2007
- A pain and/or symptom severity outcome measure was reported e.g. Visual Analogue scale (VAS) and Victorian institute of sports assessment- patellar tendon (VISA-p)
- Quantitative study design
- Grey literature- dissertations, unpublished literature, and conferences

The e*xclusion criteria were:*

- Patellar tendinopathy with a duration of fewer than 12 weeks
- Participants younger than 18 years old
- Acute patellar tendon inflammation
- Study designs- literature reviews and animal studies

Assessment of Methodological Quality

The methodological quality of each paper was assessed using the Critical Appraisal Skills Programme (CASP) tool which contains checklists for several types of research designs that could have appeared in the search results (CASP, 2020).

Data Extraction and Synthesis of Results

The headings for the data extraction were selected based on the extraction table from van Leeuwen, Zwerver and van den Akker Scheeks (2009) previous review on this topic. Please see the data extraction table with the study characteristics in Table 3. Due to the heterogeneity of the study's population, intervention and outcome measures, a meta-analysis could not be conducted.

Results

Figure 2 shows the PRISMA flow chart detailing the search process.

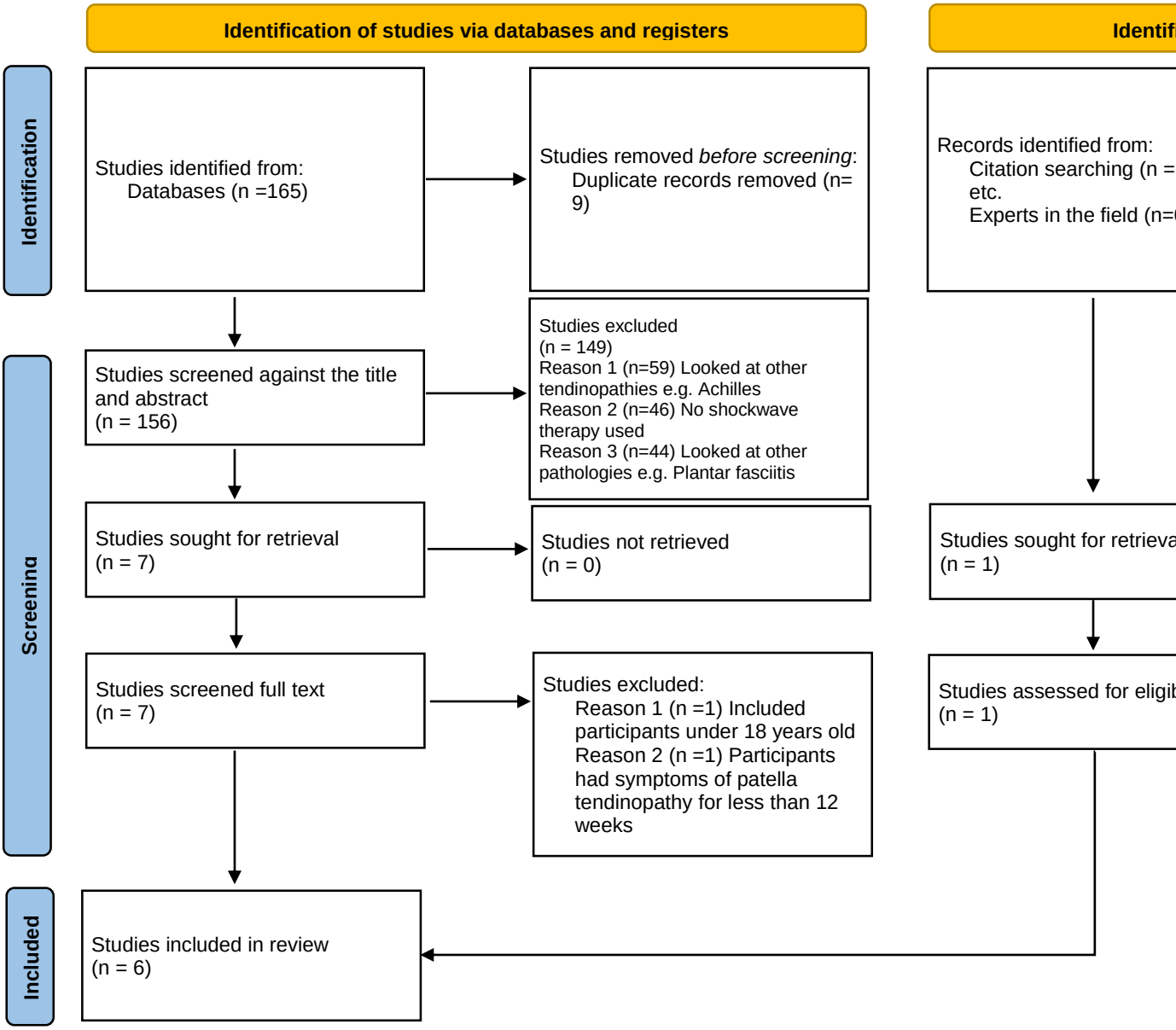


Figure 2. PRISMA flow diagram outlining the screening process for studies included in the revie

Participants

In this review, 270 participants were included and 239 of these were athletes. Participants in all six studies were over the age of 18, but the mean age varied from 21.1 to 37 years old. However, Furia et al. (2012) did not state the mean age of their participants. Half of the included studies investigated both male and female participants. In contrast, Zhang, Lee and Fu (2020) and Zwerver, Dekker and Pepping (2010) only examined male participants, while Furia et al. (2012) did not specify the participants' sex. Most studies reported the mean duration of symptoms, which ranged from 7.3 (± 3.6) to 38.6 (± 56.9) months.

Outcome Measures

The only outcome measure used by all six studies was the VAS. Most of the studies investigated VAS at rest, while Zwerver et al. (2011) and van der Wolp et al. (2013b) examined VAS during activities of daily living or during specific exercises. Other outcome measures e.g. VISA-p are reported in Table 3.

Intervention

There was significant variation in how shockwave therapy was delivered. In this review, a total of 55 participants received radial shockwave therapy and 90 received focused shockwave therapy. In each paper, the energy level, dose and frequency were different. The energy level varied from 0.1 to 0.65 mJ/mm^2 and was altered depending on the patient's pain level and tolerability in all studies. In some papers, additional treatments were given after the shockwave intervention, see Table 3.

Table 3. A Summary of the Included Studies

Author	Zwerver et al.	Zhang, Z. Lee, W. and Fu, S.	Zwerver, J. Dekker, F. and Pepping, G.	Furia et al.	van der Wolp et al.	
Title	Effect of ESWT on Patellar Tendinopathy in Jumping Athletes During the Competitive Season.	One session of ESWT- induced modulation on tendon shear modulus is associated with reduction in pain	Patients guided Piezo-electric Extracorporeal Shockwave Therapy as treatment for chronic severe patellar tendinopathy	A single application of low energy radial extracorporeal shockwave is effective for the management of chronic patellar tendinopathy	No difference in effe between focused an shockwave therapy patellar tendinopath	
Publication year	2011	2020	2010	2012	2013	
Study design	Randomised control	Randomised control	Pilot	Retrospective cohort control	Randomised control	
Group	ESWT	ESWT	ESWT	RSWT	FSWT	RS
Outcome measures	VISA-P VAS	VAS PT shear modulus	VISA-P VAS	VISA-P VAS Roles and Maudsley score	VISA-P VAS	
Follow up period in months	5.5	Post intervention	3	12	3.5	
Number of patients (total/study group)	62/31 Athletes	34/17 Athletes	19 Athletes	66/33 Athletes and the general population	43/21 Athletes	43 At
Mean Age ± SD or (range)	24.2 ± 5.2	21.1 ± 2.2	37 (20-58)	>18	28.8 ± 10.3	33
Sex (Men/Women)	20/11	17/0	19/0	Not reported	16/5	16

Duration of symptoms in months Mean ± SD or (range)	7.3 ± 3.6	36.3 ± 21.9	>3	>3	32.3 ± 28.7	38
Severity before ESWT Mean ± SD VISA, VAS	59.4 ± 11.7 2.9 ± 1.8	PT shear modulus (KPa)= 57.4 ± 25.5 Pressure pain= 7.0 ± 1.4	36.1 ± 18.8 7.2 ± 1.2	49.5 7.8 Maudsley= 4	48.6 ± 18.7 3.9 ± 2.4	48 3.
ESWT type	Piezowave Focused	STORZ Focused	Piezoson 100 plus Focused	DolorClast Radial	STORZ Focused	ST Ra
Energy level (mJ/mm^2) and dosage	0.1-0.58 2000 impulses at 4 HZ	0.13- 0.33 1500 impulses at 4 Hz	0.35-0.65 2000 impulses at 4Hz	0.18 2000 impulses	0.12 2000 impulses at 4Hz	2. 8H
Number of treatments	3 sessions at 1-week intervals	1	3 sessions at 1-week intervals	1	3 sessions with 1-we	
Local anaesthetic	None	None	None	None	None	
Method of localisation	Palpation	Palpation	Patient guided feedback	Anterior to posterior technique used	Not reported	
Additional treatments	None	None	None	None	Eccentric exercise p weeks after the final session	
Mean VISA-P and VAS after ESWT	70.5 ± 18.9 2.1 ± 2.5	PT shear modulus (Kpa)= 40.6 ± 17.6 Pressure pain= 6.2 ± 1.8	50.1 ± 23.9 3.7 ± 2.8	74.5 2.7 Maudsley=2.1	63.6 ± 24.2 2.0 ± 2.0	58 2.

Significant difference in advantage of ESWT treatment	No	Yes	Yes	Yes	Yes
Conclusion	ESWT as a solitary treatment has no benefit over the placebo treatment in the management of actively competing jumping athletes with patellar tendinopathy.	A single session of ESWT induced a significant reduction in tendon stiffness, which is associated with self-perceived pain.	Patient guided piezo-electric focused ESWT is a safe and well tolerated treatment which should be considered as a treatment for patients with patellar tendinopathy	Low energy radial SWT is safe and effective up to 12 months from the last application.	Both FSWT and RSW their VISA-P and VA there was no signific difference.

Key

ESWT- Extracorporeal Shockwave Therapy

FSWT- Focused Shockwave Therapy

RSWT- Radial Shockwave Therapy

VAS- Visual Analogue Scale

VISA-p- Victorian Institute of Sport Assessment Questionnaire Patellar Tendinopathy

ADL- Activities of Daily Living

SD- Standard Deviation

PT- Patellar Tendon

KPa- Kilopascal

Hz- Hertz

Significant difference $P<0.05$

Effect of shockwave therapy on pain

Differences in the effect of shockwave therapy on pain are shown in Table 3. Furia et al. (2012) found that at the three, six and twelve months of follow up, both the control and shockwave therapy groups improved VAS scores (*P*<0.001). However, it was shown that the shockwave therapy group had significantly better effects on the VAS scores compared to the control group. Likewise, Zwerver et al. (2011) found that both the control group and the shockwave therapy group significantly improved the VAS scores. But, unlike Furia et al. (2012), Zwerver et al. (2011) found no significant difference between the shockwave group and the control group over the 22-week study period. Zwerver et al.'s (2010) pilot study also demonstrated that shockwave therapy could significantly improve VAS scores (*P*<0.05). It was reported that 63% of patients had their VAS decrease by three or more points. According to Van der Wolp (2013b) both FSWT and RSWT significantly improved VAS scores. There was, however, no significant difference in the VAS scores between the two shockwave therapies. Vetrano et al. (2013) concluded that both PRP injections and shockwave therapy improved VAS scores at two, six and twelve months (all *P* values <0.05). During the two month follow up, the VAS score between the PRP and shockwave groups did not differ significantly. However, at the six month and twelve month follow ups, the PRP injection group showed significantly better results than the shockwave group (*P*=0.28; *P*=0.009). Zhang, Lee and Fu (2020) investigated the VAS on palpation and the single decline squat test. There was no *P* value reported making it difficult to draw any conclusions.

Effect of shockwave therapy on severity of symptoms

The VISA-p was the most commonly used outcome measure for severity of symptoms. Furia et al. (2012) found significantly better results in the shockwave group compared to the control group on the VISA-p (P<0.001). Similarly, Zwerver et al. (2011) found that the VISA-p score improved after a 22-week follow-up. However, they concluded there was no significant difference between the shockwave and the control group. Zwerver et al. (2010) pilot study found that after three sessions of shockwave at a twelve week follow-up the VISA-p had increased by an average of fourteen points (P<0.005). Van der Wolp et al. (2013b) found no difference between the radial and focused shockwave groups on VISA-p score at any of the follow ups. However, they reported that both the focused and radial shockwave groups significantly improved VISA-p score (P<0.001). Vetrano et al. (2013) found that both PRP injections and shockwave therapy were effective at improving baselines VISA-p scores at two, six and twelve month follow-ups (P<0.05 for all). The results between the 2 groups were similarly to what they found with the VAS; the PRP group had better VISA-p score improvements at the six month (P=0.014) and twelve month (P=0.026) follow-ups compared to the shockwave group. Zhang, Lee and Fu (2020) did not investigate severity of symptoms.

Adverse Effects

Five of the six included studies reported on adverse effects. Zwerver et al. (2011) and Zwerver, Dekker and Pepping (2010) reported no adverse effects to shockwave therapy. Vetrano et al. (2013) noted some participants having mild reddening of the skin. Furia et al. (2012) and van der Wolp et al. (2013b) reported some moderate pain and discomfort post intervention.

Methodological quality

Four of the six included papers were randomised control trials, suggesting a higher hierarchy of evidence (Curtis & Drennan, 2013). Using randomisation techniques such as computer-generated randomisation in Zwerver et al. (2011) paper reduces selection bias and confounding variables such as sex, age and duration of symptoms. Three of the four randomised control trials mentioned double blinding which is an effective way to limit detection and researcher bias. Zwerver et al. (2011) and van der Wolp et al. (2013) report using intention-to-treat analysis which limits attrition bias and allows the researcher to yield an unbiased estimation of the effectiveness of the intervention (Langdorf, 2017). Vetrano et al.'s (2013) randomised control trial was the most ethical due to comparing shockwave to another intervention (Gupta & Verma, 2013; Curtis & Drennan, 2013). However, this study does not mention a power calculation, which increases the probability of type one and type two errors (Crispino, 2013). A limitation of Zhang, Lee and Fu (2020) RCT is the absence of the VISA-p outcome measure, a specific and valid outcome measure for the quality of life for people with patellar tendinopathy (Visentini et al., 1998; Hernandez-Sanches, Hidalgo & Gomez, 2012). In addition, this study only examined male participants which limit its application in practice since clinicians will have to treat both male and female patients (Harvey & Land, 2016). CASP tool appraisal indicated all four RCTs were of moderate methodological quality.

Zverwer et al (2010) conducted a pilot study. The combination of a small and unrepresentative population size with no control group means it has low methodological quality (Harvey & Land, 2016). Furia et al. (2012) study was a

retrospective study, which is lower on the hierarchy of evidence than a randomised control trial (Curtis & Drennan, 2013). In this study, no randomisation occurred, participants were matched based on their age and gender, however, other confounding variables could affect results, such as BMI, duration, and severity of symptoms (Bowling, 2014). Additionally, there is a lack of detail in the explanation of the characteristics of the control group and population, which lowers its quality.

Discussion

This review aimed to investigate the effectiveness of shockwave therapy on pain and severity of symptoms amongst individuals with chronic patellar tendinopathy. Overall shockwave therapy remains a safe and effective treatment for individuals who have had symptoms of patellar tendinopathy for 12 weeks or longer. In addition, all the studies included in this review reported no harmful adverse effects associated with shockwave therapy, which is also reflected in the previous literature review conducted by van Leeuwen, Zwerver and Scheek (2009). Therefore, based on the available literature, clinicians can be confident that this treatment continues to be safe and will not harm patients.

Currently, limited research has been conducted to compare different types of shockwave therapy, so personal preference and clinical experience guide this decision (van der Worp et al., 2014). This means the method used is not necessarily based on sound evidence and clinicians could be choosing a specific method pragmatically, related to access to a specific type of machine. Furthermore, two of the included papers investigated the effects of a single shockwave application. Furia

et al. (2012) found a single application of radial shockwave therapy had significant improvement in VAS, VISA-p and the Role and Maudsley score up to 12 months after the application. Zhang, Lee and Fu (2020) found that one single application of focused shockwave can reduce tendon stiffness in volleyball and basketball players by 29.5%. This reduction in tendon stiffness was associated with a reduction in pain during a single legged decline squat. However, the impact of this reduction in stiffness on quality of life was not reported. From the basis of these two papers, a single application of shockwave therapy could have some benefits for a patient's pain. However, long-term follow-ups are essential for assessing the effectiveness of the treatment over time (Woolard et al., 2004). Furthermore, the quality of the six papers was moderate to low and the risk of bias in each of them was high. Many papers had small and unrepresentative sample sizes, which creates issues with generalising the results (Harvey and Land 2016). Additionally, some of the literature included in this review did not mention and meet their power calculations, increasing the likelihood of type 1 errors; therefore, the results of the review should be interpreted with caution (Akobeng, 2016). To guide clinical practice and optimise patient outcomes, high quality randomised control trials are needed to compare shockwave to a placebo group.

This literature review concurs with the previous literature review (van Leeuwen, Zwerver & Scheek 2009), acknowledging that shockwave therapy is a safe and effective treatment for chronic patellar tendinopathy. Despite this, both reviews included studies with low methodological quality, due to a lack of high-quality research. Research suggests that shockwave therapy may not be the most effective monotherapy to treat patellar tendinopathy (Challoumas et al., 2021). As a result,

both this literature review and van Leeuwen, Zwerver and Scheek's (2009) review agree that shockwave therapy should be considered as a secondary treatment. Core treatments, such as exercise programs, have a greater impact on pain and quality of life and should be used as the first line of treatment (Challoumas et al., 2021). There is some controversy regarding whether shockwave therapy and exercise provide better results than exercise as a stand-alone treatment. A recent double blinded randomised study by Thijs et al. (2017) agreed with Challoumas et al. (2021) in finding that there was no effect of combining exercise and shockwave therapy.

This review also suggests that shockwave therapy may not be the only secondary line treatment to consider for patellar tendinopathy. According to Vetrano et al.'s (2013) randomised control study, platelet rich plasma injections were as effective as shockwave therapy in the short term but more effective in the long-term. This finding could be explained by the injections' multifaceted mechanism, which includes both platelet action and injection-related relief. Currently, Vetrano et al.'s (2013) study is the only RCT that compares these two interventions, but the review by Challoumas et al. (2021) investigated management options for patellar tendinopathy and found that PRP injections and eccentric exercise combined had better outcomes than shockwave therapy and eccentric exercise. Despite this, shockwave therapy is less invasive than PRP injections and that could be an influencing factor for some patients and services. Furthermore, PRP injections are more technically difficult to perform and require the handling of blood products which could be another factor in choosing shockwave therapy. Although there have been no clinical trials looking at combining PRP injections and shockwave therapy for patellar tendinopathy, there has been a prospective clinical trial on knee osteoarthritis (Su et al., 2019). This

paper found that combining PRP injections and shockwave therapy produced better outcomes than using them individually. Therefore, further research could be considered to see if there is any benefit from PRP injections combined with shockwave for chronic patellar tendinopathy.

Zwerver et al.'s (2011) randomised control study demonstrated that shockwave therapy may have a strong placebo effect. In this randomised control trial of 127 athletes, no significant difference was found between the shockwave therapy group and the placebo group on the VAS and VISA-p outcome measures. Both the shockwave and placebo groups significantly improved in both outcome measures. This study suggests the placebo effect has the potential to improve pain and symptom severity among individuals with patellar tendinopathy. Conversely Furia et al (2012) suggests that shockwave therapy produces significantly better results and can benefit the tendon beyond the placebo effect. It remains unclear as to how much of the effects are a result of the therapy itself or placebo.

Implications for Practice

This review has highlighted a body of moderate to low quality evidence in favour of shockwave therapy as a treatment for chronic patellar tendinopathy. However, in clinical practice the research does not support its use as a first line of treatment or a routine adjunct to exercise. Therefore, shockwave therapy should be offered as a second line treatment.

Patients who are offered shockwave therapy should be educated about the modality and its effectiveness so that they can make an informed decision regarding their

healthcare (NICE, 2016). For shockwave therapy to become more widely accepted, high-quality research on dosing and a standardised protocol should be developed.

Limitations of this Review

This literature review does have some limitations. Firstly, only one researcher completed the search, extraction, and analysis which increases the possibility of errors and bias. A strict protocol was put in place to minimise this bias, but in a systematised review researcher bias is more likely to occur (Gough, Oliver & Thomas, 2017). Secondly, due to limited resources in translation, only English published literature was included. Unfortunately, this increases the risk of both publication and language bias (Gough, Oliver & Thomas, 2017). It is also important to note that this review focuses on shockwave therapy in general, which results in significant variations in shockwave technique, type, dose, follow up and comparison, making it difficult to compare results across studies and draw meaningful conclusions (Gough, Oliver & Thomas, 2017).

Conclusion

Based on moderate to low quality evidence, shockwave therapy appears to be a safe and effective treatment for chronic patellar tendinopathy. Despite its potential for improving both pain and symptom severity, shockwave therapy should be used as a secondary line treatment and not as a routine adjunct or monotherapy. The evidence is still not sufficient to formulate a clear protocol for shockwave therapy and inform robust clinical guidelines. Further high quality research is necessary to investigate the true effects of this interesting adjunct.

Ethics

This review was granted ethical approval from the Health Ethics Committee at York St John University on the 9th November 2021.

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The Effectiveness of Shockwave Therapy on Improving Pain and Severity of Symptoms for Patients with Chronic Patella Tendinopathy: A Literature Review

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Abstract

Background: Patellar tendinopathy is a very common and debilitating condition affecting the anterior aspect of the knee. This review aimed to determine the effectiveness of shockwave therapy on pain and severity of symptoms for all types of patients with chronic patellar tendinopathy.

Methods: A search for quantitative primary studies was conducted in AMED, CINAHL, MEDLINE, SPORTDiscus, PEDRO and the Cochrane database. Grey literature sources, Google Scholar and hand citation searching also took place. All searches were completed between the 1st and 8th of January 2022. Papers were included if the patients' symptoms were chronic (12+ weeks), but any dose, method and type of shockwave therapy were accepted.

Results: Six articles were accepted following screening, all published after 2010. This review included a total of 270 patients of which 145 received shockwave therapy. Overall, the methodological quality of the six papers was moderate to low. Despite this, and the variation in application of shockwave therapy; the results showed positive improvement in both pain and severity of symptom outcome measures.

Conclusion: Shockwave therapy was effective in improving patients' pain and severity of symptoms, although more high-quality research trials are needed to investigate the effects of this therapy. The clinician's first line of treatment for patellar tendinopathy should be education and exercise but if this fails then shockwave therapy should be considered.

Acknowledgements

Thanks to Ruth Patterson for her help with the search strategy.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

None

Table 1.
PICO

Population	Patients with chronic patellar tendinopathy
Intervention	Shockwave therapy
Comparison	-
Outcome	Pain and Quality of life

Table 2.

Table of Search Terms

Concept		**Search terms**
Chronic patellar tendinopathy		“Chronic patella* tendin*” OR “Jumpers knee”
Shockwave therapy	AND	“Shockwave therapy” OR ESWT

Table 3. A Summary of the Included Studies

Author	Zwerver et al.	Zhang, Z. Lee, W. and Fu, S.	Zwerver, J. Dekker, F. and Pepping, G.	Furia et al.	van der Wolp et al.		Vetrano et al.
Title	Effect of ESWT on Patellar Tendinopathy in Jumping Athletes During the Competitive Season.	One session of ESWT- induced modulation on tendon shear modulus is associated with reduction in pain	Patients guided Piezo-electric Extracorporeal Shockwave Therapy as treatment for chronic severe patellar tendinopathy	A single application of low energy radial extracorporeal shockwave is effective for the management of chronic patellar tendinopathy	No difference in effectiveness between focused and radial shockwave therapy for treating patellar tendinopathy		Platelet Rich Plasma Versus Focused Shock Wave in the Treatment of Jumpers Knee in Athletes
Publication year	2011	2020	2010	2012	2013		2013
Study design	Randomised control	Randomised control	Pilot	Retrospective cohort control	Randomised control		Randomised control
Group	ESWT	ESWT	ESWT	RSWT	FSWT	RSWT	ESWT
Outcome measures	VISA-P VAS	VAS PT shear modulus	VISA-P VAS	VISA-P VAS Roles and Maudsley score	VISA-P VAS		VISA-P VAS Modified Blazina scale

Follow up period in months	5.5	Post intervention	3	12	3.5	3.5	12
Number of patients (total/study group)	62/31 Athletes	34/17 Athletes	19 Athletes	66/33 Athletes and the general population	43/21 Athletes	43/22 Athletes	46/23 Athletes
Mean Age ± SD or (range)	24.2 ± 5.2	21.1 ± 2.2	37 (20-58)	>18	28.8 ± 10.3	33.4 ± 10.7	26.8 ± 8.5
Sex (Men/Women)	20/11	17/0	19/0	Not reported	16/5	16/6	17/6
Duration of symptoms in months Mean ± SD or (range)	7.3 ± 3.6	36.3 ± 21.9	>3	>3	32.3 ± 28.7	38.6 ± 56.9	17.6 ± 20.2
Severity before ESWT Mean ± SD VISA, VAS	59.4 ± 11.7 2.9 ± 1.8	PT shear modulus (KPa)= 57.4 ± 25.5 Pressure pain= 7.0 ± 1.4	36.1 ± 18.8 7.2 ± 1.2	49.5 7.8 Maudsley= 4	48.6 ± 18.7 3.9 ± 2.4	48.8 ± 17.2 3.7 ± 2.3	56.1 ± 19.9 6.3 ± 2.0
ESWT type	Piezowave Focused	STORZ Focused	Piezoson 100 plus Focused	DolorClast Radial	STORZ Focused	STORZ Radial	STORZ Focused

Energy level (mJ/mm^2) and dosage	0.1-0.58 2000 impulses at 4 HZ	0.13- 0.33 1500 impulses at 4 Hz	0.35-0.65 2000 impulses at 4Hz	0.18 2000 impulses	0.12 2000 impulses at 4Hz	2.4 bars 8Hz	0.17- 0.25 2400 impulses
Number of treatments	3 sessions at 1-week intervals	1	3 sessions at 1-week intervals	1	3 sessions with 1-week intervals		3 sessions at 48-72 hour intervals
Local anaesthetic	None	None	None	None	None		None
Method of localisation	Palpation	Palpation	Patient guided feedback	Anterior to posterior technique used	Not reported		Inline ultrasonic guidance
Additional treatments	None	None	None	None	Eccentric exercise programme 2 weeks after the final ESWT session		One week after the last ESWT session they were given a standardised stretching and strengthening programme to follow for 2 weeks
Mean VISA-P and VAS after ESWT	70.5 ± 18.9 2.1 ± 2.5	PT shear modulus (Kpa)= 40.6 ± 17.6 Pressure pain= 6.2 ± 1.8	50.1 ± 23.9 3.7 ± 2.8	74.5 2.7 Maudsley=2.1	63.6 ± 24.2 2.0 ± 2.0	58.4 ± 22.1 2.1 ± 2.1	77.6 ± 19.9 3.2 ± 2.4

Significant difference in advantage of ESWT treatment	No	Yes	Yes	Yes	Yes	Yes
Conclusion	ESWT as a solitary treatment has no benefit over the placebo treatment in the management of actively competing jumping athletes with patellar tendinopathy.	A single session of ESWT induced a significant reduction in tendon stiffness, which is associated with self-perceived pain.	Patient guided piezo-electric focused ESWT is a safe and well tolerated treatment which should be considered as a treatment for patients with patellar tendinopathy	Low energy radial SWT is safe and effective up to 12 months from the last application.	Both FSWT and RSWT improved their VISA-P and VAS however there was no significant difference.	Both PRP injections and ESWT are safe and effective in the treatment of athletes with jumpers' knee

Key

ESWT- Extracorporeal Shockwave Therapy

FSWT- Focused Shockwave Therapy

RSWT- Radial Shockwave Therapy

VAS- Visual Analogue Scale

VISA-p- Victorian Institute of Sport Assessment Questionnaire Patellar Tendinopathy

ADL- Activities of Daily Living

SD- Standard Deviation

PT- Patellar Tendon

KPa- Kilopascal

Hz- Hertz

Significant difference $P<0.05$

Figure 1

Click here to access/download;Figure (i.e. diagram, illustration, photo);Figure 1.docx

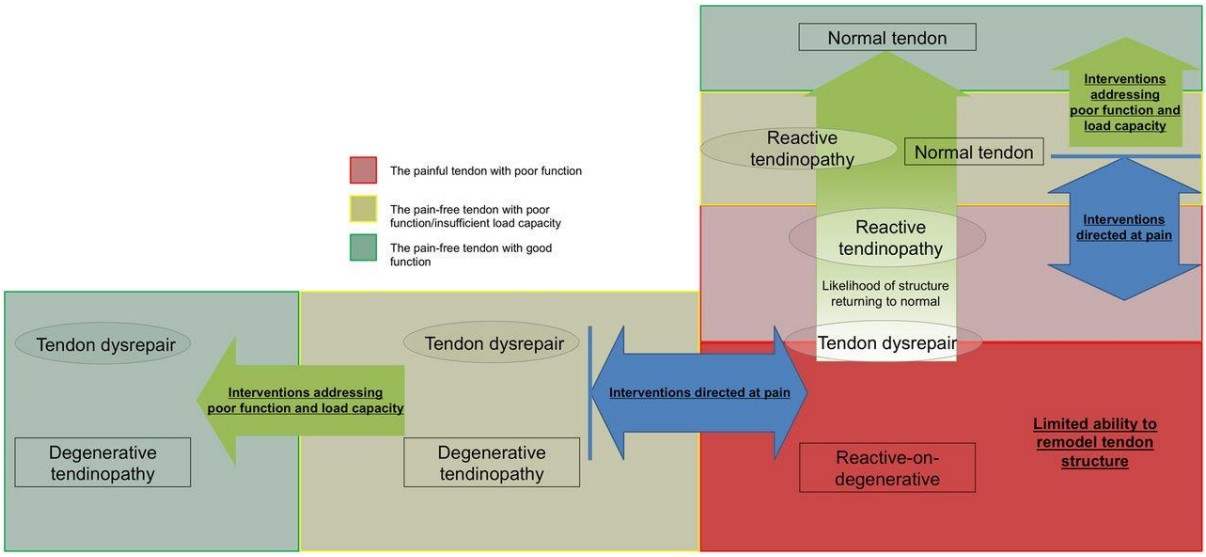

Figure 1. The Continuum Model (Cook and Purdem, 2016)

Figure 2

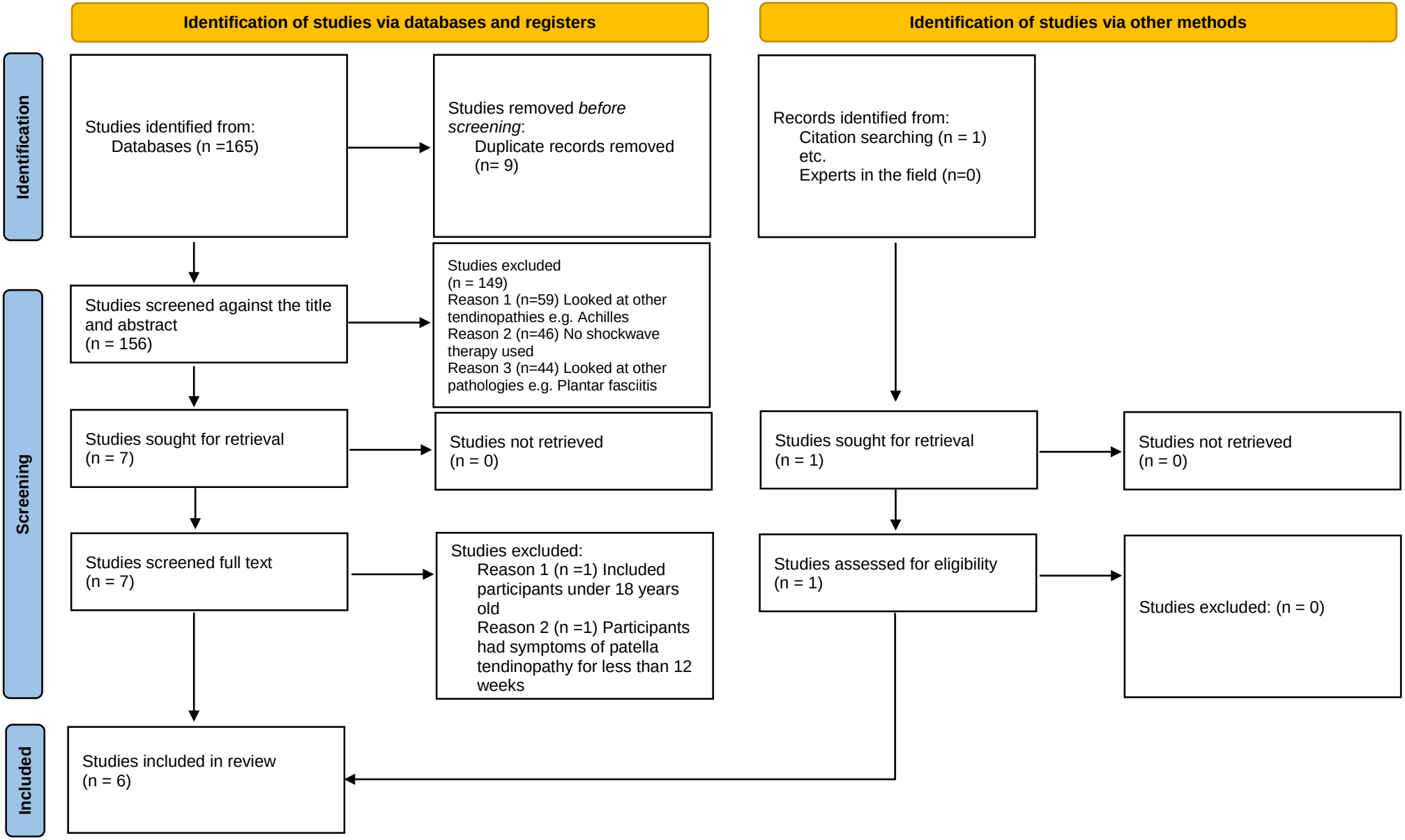

Figure 2. PRISMA flow diagram outlining the screening process for studies included in the review. (Page et al., 2020)