

Effectiveness of eccentric exercise in patellar tendinopathy. Literary review

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Summary

Introduction: Chronic patellar tendinopathy is described as the appearance of pain, inflammation and a loss of function of the patellar tendon. It is a pathology that develops through overuse in sports that involve racing, repetitive trauma and jumps.

Objectives: Demonstrate the effectiveness of eccentric exercises on patellar tendinopathy, analysing some of the physiological changes that occur to the tendon and attempt to establish a protocol of specific exercises.

Materials and methods: A literary search was performed of the Cochrane, ScienceDirect, Pubmed and PEDro databases. 10 articles were found that compared eccentric exercises with shockwaves, concentric exercises, a night-worn splint and stretches, grading improvements in pain, function and the quality of life of the patients.

Results: The eccentric exercises were effective in treating patellar tendinopathy in comparison with other therapies such as shockwaves, stretches, night-worn splints, etc. In some of these articles evidence emerged regarding the effectiveness of eccentric exercises, in others the possibility was left open for continued research into the existence of a combination of various therapies, perhaps being the most effective and quick way of recovering from this injury.

Conclusion: Eccentric exercises are effective in treating patellar tendinopathy; however, no evidence has shown that they are better than other currently applied treatments. On the other hand, no specific protocol for applying these exercises has been established.

Key words:

Tendinopathy.
Eccentric. Patellar.

Eficacia de los ejercicios excéntricos en tendinopatías rotulianas. Revisión bibliográfica

Resumen

Introducción: La tendinopatía crónica rotuliana se describe por la aparición de dolor, inflamación y pérdida de la función del tendón rotuliano. Es una patología desarrollada por el uso excesivo en deportes que implican carreras, traumatismos repetitivos y saltos.

Objetivos: Evidenciar la eficacia de los ejercicios excéntricos en las tendinopatías rotulianas, analizar algunos de los cambios fisiológicos que se dan en el tendón e intentar determinar un protocolo de ejercicios concreto.

Materiales y métodos: Se ha realizado una búsqueda bibliográfica en las bases de datos Cochrane, ScienceDirect, Pubmed, PEDro. Se han encontrado 10 artículos donde se han comparado los ejercicios excéntricos con ondas de choque, ejercicios concéntricos, férula de noche y estiramientos, valorándose la mejora del dolor, la función y la calidad de vida de los pacientes.

Resultados: Los ejercicios excéntricos han sido efectivos en el tratamiento de la tendinopatía rotuliana, en comparación con otras terapias como las ondas de choque, estiramientos, férulas de noche, etc. En algunos de éstos artículos se evidencia la eficacia de los ejercicios excéntricos, en otros deja abierta la posibilidad de seguir investigando en la existencia de combinación de varias terapias, pudiendo ser más efectiva y rápida la rehabilitación de esta lesión.

Conclusión: Los ejercicios excéntricos son efectivos en la tendinopatía rotuliana, sin embargo no se ha demostrado que sean superiores a otros tratamientos aplicados actualmente. Por otro lado, no se ha podido determinar un protocolo concreto de aplicación de estos ejercicios.

Palabras clave:

Tendinopatía.
Excéntrico. Rotuliano.

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Introduction

Anatomical Note

Tendinopathy is a clinical syndrome that describes the injuries caused through overuse of the tendon. It is characterised by a combination of pain, diffuse or localised inflammation, and a loss of function. It is a failing response to healing, associated with the degeneration of tendon cells, a disorder of the collagen fibres, an increase in the cellular matrix without collagen along with neurogenic inflammation¹.

The patellar tendon is one of the most powerful in the human body: it is 4 or 5 centimetres long by a little under 3 cms wide, and approximately 1 cm thick². It can be considered part of the Extensor Apparatus of the Knee, made up of the quadriceps muscle, quadriceps tendon, the kneecap and the patellar tendon, which goes into the tibia. It is a fundamental structure in order to stand up with the weight of gravity, to walk, run and jump^{3,4}.

The nomenclature surrounding chronic pain of this tendon is confusing. Up to a few years ago, chronic patellar pain was considered to be marked by the presence of an inflammatory component, and the terms tendinitis and tendinosis were frequently used.

Today, the histological assessment of biopsies, intra-tendon microdialysis and technological genetic analyses of the biopsies have all revealed that there are no signs of inflammation due to prostaglandin and therefore, these terms should not be used. On the other hand, it has been shown that the tendons are metabolically more active; today the term tendinopathy is used to assign chronic painful symptoms in a sensitive and painful area of the tendon⁵.

These clinical pictures can be complicated by the inflammation of the external covering of the tendon, called the para-tendon. Inflammation of this connective covering may make an isolated appearance, earning the name of para-tendinitis, or in connection with a tendinopathy or tendinosis, almost always characterised by a grating of the structure⁶ (Table 1).

The clinical presentation is variable: often characterised by pain in the front part of the knee which initially does not prevent the activity but over time, if it is not diagnosed and treated, progresses in such a way that the pain is incapacitating, continues after exercise, and may

Table 1. Classification of tendinopathies (adapted from Brukner and Khan, 1993)⁷.

Diagnosis	Microscopic findings
Tendinosis	Tendon degeneration caused by age, ageing of the connective tissue, overuse and vascular disorder
Tendinopathy /Partial rupture	Symptomatic degeneration with vascular disruption
Para-tendinitis	Inflamación del paratendón, sin tener en cuenta si está cubierto o no de sinovial
Para-tendinitis with tendinosis	Para-tendinitis associated with intra-tendon degeneration

even cause problems in everyday life, causing pain when walking, going down stairs, sitting, etc⁷.

In 1973, Blazina⁸ suggested a symptom-related classification to assess the state of the injury:

- I. Pain after the activity.
- II. Pain during and after the activity.
- III. As above but prevents the athlete from performing the activity.
- IV. Tendon rupture.

Despite the specific aetiology being unknown, it is prevalent among people that are sedentary, overweight, elderly, have mellitus diabetes, hypertension, dyslipidaemia, rheumatoid arthritis, or other inflammatory conditions, consume certain antibiotics, etc.⁹⁻¹¹. On the other hand, it is linked to environmental conditions and training errors, along with some morphological differences (poor alignment of the patellar, weakness or muscular imbalance, reduction of flexibility, joint laxity, etc.). In other cases it may arise due to alterations in the vascularisation or genetic predisposition of the patient¹².

Protocols and current treatment

Conservative treatment starts by correcting both intrinsic and extrinsic aetiological factors, e.g. biomechanical corrections whilst performing exercise¹³.

On the other hand, there are a wide range of possibilities within rehabilitation, such as shockwaves, low-intensity laser, splints, injections (corticoids, heparin, dextrose, Glycosaminoglycan polysulphates (GA-GPS), autologous growth factors (Platelet-Rich Plasma), etc.) cryotherapy, stretches, ultrasound...^{4,5,8,10,11}

A common treatment used is that of eccentric exercises or those that generate contraction strength whilst the muscle elongates¹⁴.

Eccentric exercises were initially proposed by Stanish and Curwin in 1986, planning 6 weeks of eccentric exercises among 200 patients with Achilles tendinopathy, which obtained a complete improvement in 44% of patients and a considerable improvement in 43% of patients. They were performed once a day, increasing the performance speed¹⁵.

Later, in 1998, Alfredson (9) proposed 6 series of 15 repetitions of eccentric exercises (3 series with the knee extended and 3 flexed) performed twice a day, every day over 12 weeks. The exercises progressed by increasing the load, always carried out slowly, suggesting that their performance was not speed-dependant.

Surgical treatment will be implemented with patients whose conservative treatment has previously failed¹⁶.

Objetives

- Observe the existing scientific evidence regarding the effectiveness of applying eccentric exercises on patellar tendinopathy.
- Compare eccentric exercises with other physiotherapeutic treatments that are currently applied to patellar tendinopathy.
- Prove some of the physiological effects of eccentric exercises on the tendon.
- Establish, if it exists, a protocol of specific eccentric exercises to be applied to patients with patellar tendinopathy.

Material and method

For this systematic review, similar reviews were used, randomised controlled trials (RCT) and meta-analyses that are controlled and randomised studies.

The search was performed within the following databases: PubMed, The Cochrane Library, ScienceDirect, PEDro. (Figure 1).

The keywords used according to the terminology described in MeSH were:

- "Tendinopathy".
- "Exercise therapy".
- "Tendon".
- "Patellar tendon".
- "Chronic tendinopathy".
- "Eccentric".

Selection criteria

Inclusion criteria:

- Articles from 2008 to 2014.
- Articles whose subjects/participants were of both sexes.
- Articles related to chronic patellar tendinopathy.
- Articles in English and Spanish.

Exclusion criteria:

- Articles with less than 30 participants.
- Studies with participants aged under 18 or over 65 years.
- Articles that were not controlled and/or randomised trials.
- Not related to eccentric exercises and the treatment of chronic patellar tendinopathy.

Results

After searching through the various aforementioned databases, 134 articles were obtained in total. A selection was performed taking into account the titles (70 articles were selected). Then the abstracts were read to establish whether or not the selected studies were valid for this systematic review.

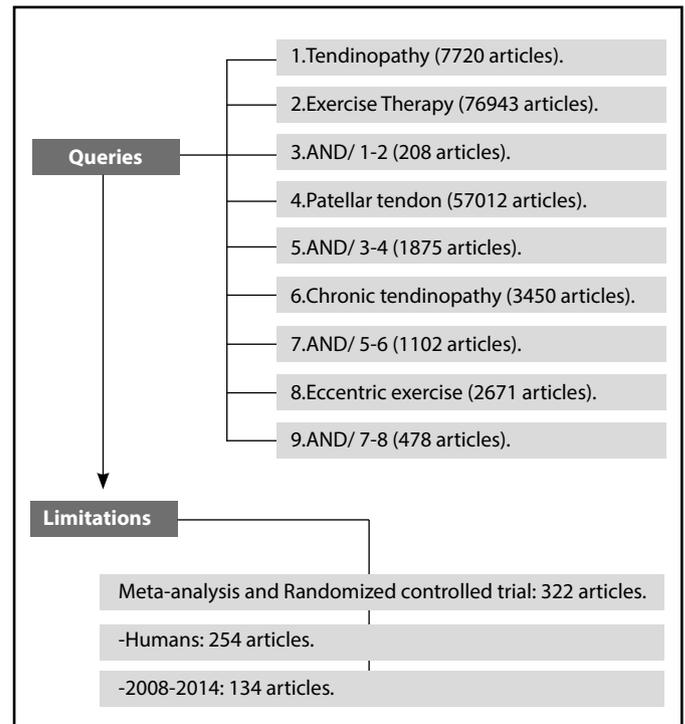
When the abstract reading was not enough to decide which articles to choose, the entire study text was read (this was performed in 47 articles).

This meant that of the 134 articles identified using the literary search, 47 were selected to be assessed in more detail and to be read in full. Two articles were excluded as they did not provide results. Another was excluded as it did not correspond to the type of study for inclusion in this review.

Next, the articles were selected or excluded depending on the previously mentioned selection criteria. 26 articles were excluded from the review for not adhering to these criteria.

After excluding all the studies that did not adhere to the selection criteria required for inclusion within the study, the review of the entire texts of the selected studies was repeated, this time with the aim of evaluating if the study included a clearly described rehabilitation process of tendinopathy through the use of eccentric exercises (8 studies were excluded).

Figure 1. PubMed search explanation.

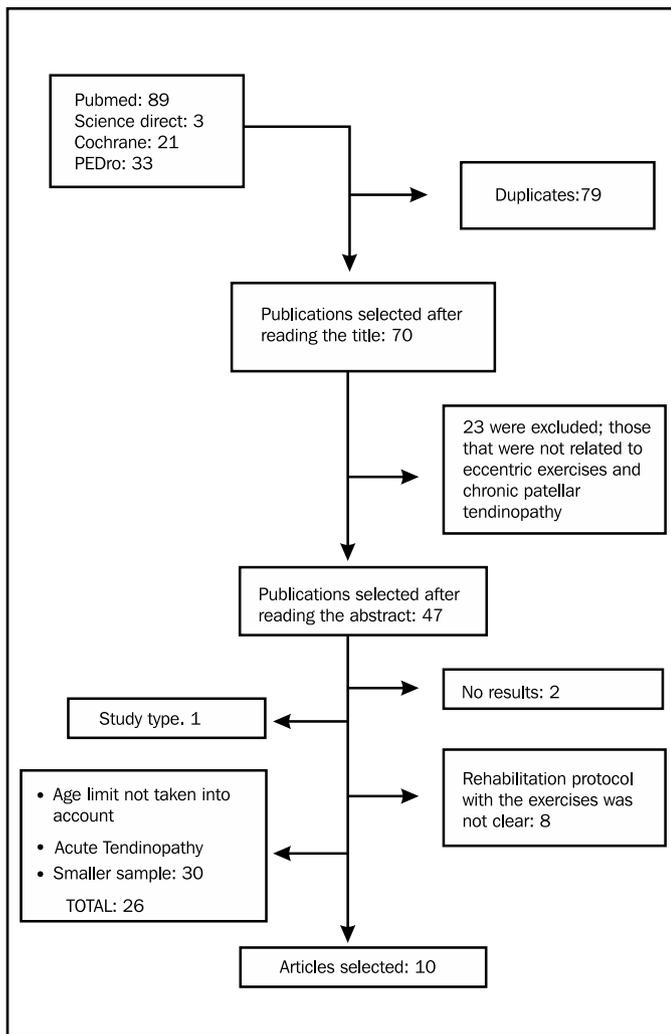


Once the suitable articles had been established, a comprehensive reading of these articles was carried out to prove the effectiveness of eccentric exercises. 10 articles were selected for this review (Figure 2 and Table 2).

In this review, the majority of the articles showed evidence of the effectiveness of eccentric exercises, though a large part of the articles added nuances. In the 2008 article by Cook *et al.*¹⁸, the number of participants was divided into two groups to perform exercises following the Alfredson protocol, differentiating the position of the ankle. The first group performed the eccentric exercises with their feet in a neutral position (Figure 3)¹⁶ and the other group performed the same exercises with their feet on the affected side in plantar flexion position (Figure 4)¹⁶. The results obtained by Cook *et al.* in 2008¹⁸ were very similar in both groups, but one of the assessment disadvantages was that the study did not specify if all the injuries were located in the same place in all the participants or if they were located in different parts of the tendon. Another article by Mark Young *et al.* in 2010¹⁶ also compared the performance of exercises on a plane tilted at 25° and another on a flat plane, the results of this study alluded to the fact that both protocols were optimum for tendon rehabilitation, but that after 12 months using a tilted plane, better results were achieved on the VISA scale, with no improvement difference shown between the groups within 12 months. However, in the 2009 article by Rees *et al.*¹⁹ it is revealed that for patellar inserted tendinopathies, standard eccentric exercises are ineffective, suggesting the possibility of continuing research on eccentric exercises and the most effective postures depending on the location of the injury.

In other studies, eccentric exercises were compared to other types of exercise (concentric, shockwaves, plasma infiltration, ultrasound, etc.).

Figure 2. Flowchart explaining the selection criteria.



Eccentric exercises vs. concentric exercises

In 2012, Jonsson *et al.*³ compared concentric and eccentric exercise in the treatment of tendinosis. The pain and mobility of the knee were assessed before, during and after the 12-week intervention programme. When the authors assessed both the movement and pain after 4 weeks, the eccentric exercises group had significantly less pain. It was observed that eccentric exercises were effective in encouraging the formation of tendon collagen fibres, facilitating its remodelling (Figure 5).

In 2008, Cannell *et al.*²⁰ compared squats and concentric knee flexion and extension exercises for the treatment of knee tendinosis. They assessed the pain, extension of the knee and the flexor torque. No significant differences were found between the groups in any of the aspects assessed.

Eccentric exercises vs. stretches

In 2008, Norregaard *et al.*²¹ assessed the effectiveness of a 12-week eccentric exercise and stretching programme. Both the stretching

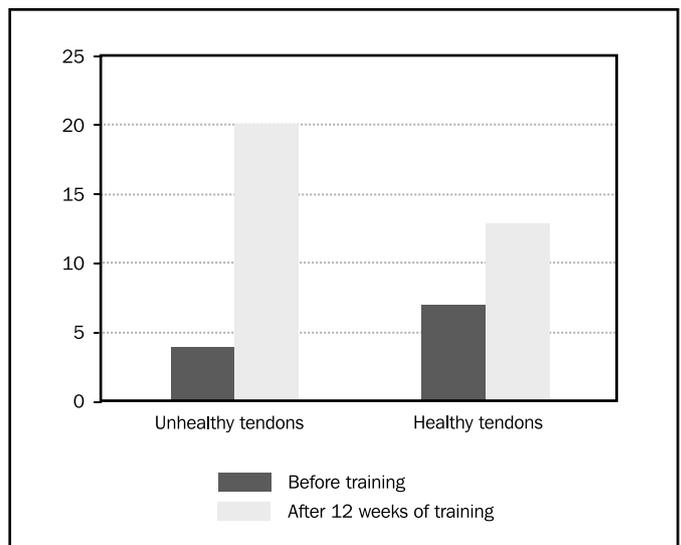
Figure 3. Standard position for carrying out the eccentric exercises¹⁶.



Figure 4. Exercises with declining plane to carry out the eccentric exercises¹⁶.



Figure 5. Eccentric training and the synthesis of type 1 collagen. Rehabilitation via eccentric exercise increases the synthesis of type 1 collagen peritendineum.



group and the eccentric exercises group displayed mild reductions in pain, the eccentric exercise group obtaining the most improvement. Strength was not assessed.

Eccentric exercises vs. night splint

In 2010, Roos *et al.*²² compared the effectiveness of eccentric exercises and night splints over 12 weeks. All the groups displayed substantial improvements in pain. There were no significant differences between the two groups. Strength was not assessed.

Table 2. Results of the studies classed by Article Name, Author, Objectives, Results and Conclusion.

Article Name	Author	Objectives	Results	Conclusion
A pilot study of the eccentric decline squat in the management of painful chronic patellar tendinopathy	Purdam CR, et al ¹⁵	Perform a protocol of treatment for patellar tendinopathy, performing within this protocol different positions of the ankle in dorsi-flexion and compare the progress. Two groups: -Ankle in dorsi-flexion -Ankle in neutral position	No major differences were found in the improvement of tendinopathy with regards to the position of the ankle. Though the location of the injury is not specified.	Indicates that treatment with eccentrics responded well in the treatment of patellar tendinopathy in both groups
Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players	Young MA, et al ¹⁶	Prove the effectiveness of rehabilitation using an eccentric exercise inclined by 25° in the treatment of chronic patellar tendinopathy, compared to the traditional protocol of eccentric exercises. Performed 2 times a day, 3 series of 15 repetitions over 12 weeks.	Doctors may safely use both protocols: both the conservative and eccentric exercises researched in this study have a positive effect on pain, and more importantly, the athlete's capacity to readapt to the physical activity without any problem or aftermath.	Both protocols are effective treatment in the rehabilitation of chronic patellar tendinopathy, with the inclined-plane eccentric exercises proving more effective after 12 months, achieving better VISA marks. Practically, the result is very similar.
Does Eccentric Exercise Reduce Pain and Improve Strength in Physically Active Adults With Symptomatic Lower Extremity Tendinosis? A Systematic Review	Wasielowski J, et al ¹⁷	Compare treatment using eccentric exercises with stretches and concentric exercises.	All the treatments are effective, but the degree of effectiveness of the eccentric exercises is not clear.	Current research indicates that eccentric exercises are an effective way to treat lower-extremity tendinosis, but there is little evidence to suggest that they are better than other forms of therapeutic exercise, such as concentric exercise or stretching. Eccentric exercise may produce better results than some treatments such as wearing a splint, non-thermic ultrasound and friction massage, and be more effective during a break from activity related to the training load.
Treatment of patellar tendinopathy—a systematic review of randomized controlled trials	Maria EH, et al ¹⁴	Review of the different treatment types for patellar tendinopathy	Clear evidence for the use of eccentric training to treat patellar tendinopathy. Moderate evidence for the conservative treatment as an alternative to eccentric training. Moderate evidence suggests that under the intensity of pulsed ultrasound treatment it did not influence the results of the treatment. Limited evidence found for surgery, injection sclerotherapy, and shockwave therapy.	Physical training and in particular eccentric exercises seem to be the treatment of choice for patients suffering from patellar tendinopathy. However, the type of exercise, the frequency, the load and dosage are very important factors that should also be analysed.
The treatment of patellar tendinopathy	Rodriguez-Merchan EC ⁴	The aim of this review is to review the strategies used in treating patellar tendinopathy, distinguishing between conservative and surgical.	Clear evidence eccentric training, moderate improvement with shockwave therapy and different injection treatments (Plasma-rich platelets, polydocanol-sclerosant. steroids, etc.)	Physical training and in particular eccentric training seem to be the treatments of choice. The literature does not clarify which is the most effective surgical technique in recalcitrant cases.
Eccentric exercises; why do they work, what are the problems and how can we improve them?	Rees JD, et al ⁵	Provide evidence for the effectiveness of eccentric exercises.	It specifies that depending on the position level of the injury, a variation is required to the position of the patient to ensure the affected zone is worked specifically. Especially by modifying the dorsiflexion of the ankle and the angle of flexion of the knee.	Evidence does exist regarding the benefits of EE.

(keep going)

Superior results with eccentric compared to concentric quadriceps training in patients with jumper's knee: a prospective randomised study	Jonsson P, et al ³	Compare eccentric exercises to concentric exercises in the treatment of patellar tendinopathy	In the eccentrics group, 9 out of 10 patients were satisfied with the treatment, VAS reduced 73-23 (p, 0.005), and the VISA points rose 41-83 (p, 0.005). In the concentric group, 9.9 patients were not satisfied, and there were no significant differences in the VAS (from 74 to 68, p, 0.34) and VISA points (41-37, p, 0.34).	In conclusion, eccentric but not concentric, the formation of quadriceps on a descending surface seems to reduce pain in jumper's knee.
The role and implementation of eccentric training in athletic rehabilitation: tendinopathy, hamstring strains, and ACL reconstruction	Lorenz D, et al ⁵	Establish the eccentric exercise in rehabilitation.	Evidence of patellar and Achilles tendinopathy rehabilitation using eccentric exercises	In conclusion, the use of eccentric exercises led to a notable improvement in tendinopathies.
Eccentric exercise training: modalities, applications and perspectives	Eve M, et al ⁶	Prove the beneficial properties of EE, applied to the rehabilitation of injuries and explain all the modalities.	Toning the muscles exercised is beneficial. When monitored by a specialist, eccentric exercises can be used to strengthen any weakened muscle following an injury.	Eccentric exercises are beneficial to building muscle strength.
Muscle architecture adaptations to knee extensor eccentric training	Esparza F, et al ⁶	See the changes that occur in the muscular architecture of the knee with extensor eccentric training. Understand the effects of the two eccentric training programmes on the morphology of patellar tendon.	The results are not clear.	With the eccentric exercises there was an increase in muscle thickness, very similar to when concentric exercises are performed. Eccentric training results in hypertrophy of the tendon in patients without patellar tendinopathy. These improvements should be based on the adequate progression of load training, taking particular care with the individual processes needed for each subject.

Eccentric exercises vs. non-thermic ultrasound vs. friction massages

In 2009, Stasinopoulos *et al.*²³ compared three treatment groups that carried out eccentric exercises, non-thermic ultrasound, and transversal friction massage for tendinosypatellar over 8 weeks. There were significant improvements in pain by the end of the treatment.

Discussion

Eccentric exercises have been recommended since the mid-eighties for the rehabilitation of different pathologies and to strengthen muscle. The theory suggests that they reduce pain quicker than stretches, hardening and strengthening the tendinous muscle unit^{8,19,24}. On the other hand, eccentric exercises are considered to promote the alignment of collagen fibres, generating more resistant fibres, stimulating the activity of the fibroblasts and preventing adhesions during the healing stage between the tendon and the adjacent tissues⁵.

Alfredson (1998)^{3,9,16} put forward three possible theories to explain their effectiveness. The first suggests that they create a change in the patient's perception of pain as the exercises are painful. The second suggests the vascularisation that appears in tendinopathy is destroyed and with it the accompanying nerve endings. Finally, the third theory explains that eccentrics increase the tendon's resistance to traction,

producing an elongation of the tendinous muscle unit, with the tendon bearing less tension during movement²⁵⁻²⁷.

Although there are various possible explanations to understand the effectiveness of eccentrics, none have been researched fully²⁸. However, regardless of the underlying mechanisms, they have produced significant improvements in pain reduction and patient satisfaction in between 60-90% of patients²⁹.

The eccentric training model of Alfredson *et al.*, (1998)^{3,9,16} at no point involves a concentric contraction of the affected tendon and makes particular mention of the importance of performing the exercises despite the patient feeling some discomfort, always in the event that this pain does not prevent the exercises from being performed correctly¹⁶. If patients feel no pain or discomfort during the exercise, they may increase the load using a weighted backpack or with weight machines. The programme consisted in a daily training session over 12 weeks and obtained good short and long-term results. It was effective when other conventional treatments such as NSAIDs (non-steroidal anti-inflammatory drugs), rest, a change of footwear, orthosis, and other physical therapies had not worked, whilst the exercise programme had a 90% success rate among patients participating in the study³⁰.

A follow-up study of the patients treated with the eccentric training, performed by the same people around 4 years later, indicated that all were satisfied and returned to their daily and physical activities with no discomfort at all. A relevant piece of data from this study is that the

tendon thickness had reduced and using a sonograph, the tendon structure was more normal³¹⁻³³.

The exercises are performed with the entire load on the affected extremity, with the load progressively increasing. For a sedentary person this load will require a greater effort than for someone that regularly performs exercise. Therefore, despite there being limited evidence that the exercises should be performed with pain, it may be the case that some patients experience more pain than others³⁴, which should be considered an important aspect for the physiotherapist to take into account when applying them^{35,36}.

Another important aspect for the physiotherapist to consider is the possible error-factor on the part of the physiotherapist and the patient, in the number of repetitions, the speed or position. Therefore, from a practical point of view, apart from explaining the exercises clearly, simply and several times, it would also be convenient to accompany this explanation with written information so as to avoid these errors^{37,38}. Another option would be for the physiotherapist to supervise the patient during the first week, twice a day until the patient becomes used to the movements, the exercise and the correct position to perform the exercise, ensuring that when they are performed at home they are done so correctly³⁹⁻⁴¹.

Moreover, according to the Alfredson (1998) protocol^{3,9,16}, the rehabilitation period of 3 months is long, making it easier for the patient to not complete the process. In one of the articles the patients related that they did not complete 50% of the exercises for completion at home, either because of work, time or a lack of motivation³. This is why it should be made clear to the patient that to ensure optimum rehabilitation in the established time period, the patient should complete the exercises recommended in the protocol. One way of ensuring that the patient performs the exercises is through a daily telephone call to monitor the patient, which both from the financial perspective of the physiotherapist, and the perspective of the patient's privacy, is not viable. Even so, it is very important, on the one hand, to motivate the patient to perform them so as to recover quicker: here the physiotherapist could motivate the patient as much as possible⁴²⁻⁴⁴. On the other hand, for a person that regularly performs physical exercise, carrying out these exercises will be less effort than for a sedentary person⁴⁵.

There is also the possibility that, during the treatment protocol, injuries may occur associated with the eccentric exercises. This risk increases among patients that do not perform regular exercises and among patients that do not respect the rest phases⁴⁶.

In this review, the effectiveness of eccentric exercises has been proven for the rehabilitation of chronic patellar tendinopathy, but it is considered that for a more effective and optimum rehabilitation, the recommendation would be to use all the tools available or training possible to recover from the injury.

Within physiotherapy there is the opportunity of combining different treatment types, with the majority being compatible with each other, meaning that the work is not monotonous, and the patient will see improvements each day, observing how the physiotherapist is skilled in approaching this particular injury with different suggestions⁴⁷.

Conclusions

- It has been shown that eccentric exercises are one of the fundamental treatment types in the rehabilitation of patellar tendinopathy, given that they increase the tendon's resistance to traction, producing an elongation of the tendinous muscle unit, thus meaning the tendon bears less tension.
- Some of the physiological effects of the exercises on the tendon have been proven. They are effective in encouraging the formation of tendon collagen fibres, improving its remodelling and requiring less oxygen consumption, greater muscle tension and less energy expenditure.
- No specific exercise protocol was established for patient recommendation.

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