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Effectiveness of Eccentric Exercises in the Management of Chronic Achilles Tendinosis

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Abstract
Background: Chronic Achilles tendinosis is commonly seen in clinical practice however the causes are largely unknown. In the last ten years good results have been reported with a range of approaches, one of which is eccentric training.
Objective: This study reports on a systematic review of the literature to determine the effectiveness of eccentric training compared with other types of interventions for chronic Achilles tendinosis. **Method:** A systematic review of the published research literature was conducted to examine the quantity, nature, quality and significance of literature relevant to the effectiveness of eccentric training for chronic Achilles tendinosis. Subject inclusion criteria were being at least 16 years of age, having a minimum of three months of complaints and no other underlying pathologies. **Results:** Seven databases were searched, and 25 studies were included. They reflected a variety of research designs and study quality. Comparison interventions included surgery, medications and passive treatment. An index combining results and quality showed that the best options for managing Achilles tendinosis were medication and eccentric exercises. Taking account of factors such as cost, safety and inconvenience, eccentric exercises are favoured over drug intervention. **Conclusion:** Eccentric exercises are simple to perform and provide a cost effective, safe and efficient way to treat Achilles tendinosis. They should be considered first for all patients, before invasive interventions such as surgery and drug therapy.

Background

Chronically painful Achilles tendons are a common feature in Western society and are often treated in physiotherapy clinics. The condition is mostly found in recreational athletes, especially runners, or in participants in sports involving running. It is estimated that 6-18% of the injuries related to running are Achilles tendon disorders. The condition can also be present in sedentary or older people; however, with unknown aetiology.[1] It is important to treat individuals with this condition appropriately as early as possible, as left untreated, this condition can be debilitating and frustrating.[2] The socio-economic impact of treatments should be considered, as treatment requiring time off work and invasive treatment such as surgery or injections represents a higher cost to society than non-invasive treatments that can be carried out at home.

In the literature, a range of terms is used to describe painful Achilles tendons, often producing diagnostic confusion. Other diagnostic nomenclature includes achillodynia, tendinopathy, tendonitis, and tendinosis, and other terms which often do not reflect the underlying pathology.[3] The most widely accepted term is tendinosis, which is linked to the presence of degenerative changes in the tendon.[3] Alfredson et al reported that there were no signs of inflammation (i.e. higher levels of prostaglandin E2 levels) in a chronic painful Achilles tendon, however this incurs ongoing discussion in the literature.[4,5] The debate further complicates the diagnosis of painful Achilles tendons.

It is commonly accepted that chronic musculoskeletal conditions are those of three months duration or longer.[2] The etiology of chronic Achilles tendon problems is largely unknown, with speculation on a number of causes believed to contribute to the problem. It is agreed that it is most likely a combination of anatomical and biomechanical factors, as well as persistent overuse, resulting in repetitive micro-trauma to the tendon.[1,6]

Congruent with difficulties in establishing etiology and causal factors, treatment regimes are controversial. Different techniques are proposed as being effective and

are underpinned by variable research evidence. An approach which has become increasingly popular with physiotherapists is eccentric exercises which consist of heel drops on the injured side and the contralateral side assisting with a concentric contraction to regain the starting position. The purpose of eccentric exercises is to strengthen the muscle by lengthening muscle fibers whilst contracting against gravity. This approach was first introduced by Stanish et al and later developed and described by Alfredson et al.[7,8] In light of this debate, it seems important to take a closer look at the types of management described in the literature to see how their effectiveness compares and what evidence is available for each as a viable intervention in a general clinical setting. Examples of interventions that are commonly used are medication, exercises/stretching, electrotherapy, and surgery. Since eccentric exercises have been well documented over the last decade, and good results have been consistently reported, it seems relevant to compare this approach with all other treatment approaches.

The aim of this study was to investigate the evidence of effectiveness of eccentric exercise programs compared with the effectiveness of other approaches in the management of chronic Achilles tendinosis in adults.

Methods

Search terms:

A systematic search was conducted in all available and relevant databases at the University of South Australia comprising Medline, CINAHL, SPORTDiscus, PubMed, Cochrane, AMED, and Google Scholar. The keywords used to search the databases were Achilles tendon, tendinosis, tendinopathy, achillodynia, eccentric, exercise, treatment, management, physiotherapy, and all possible variants of these terms.

Selection criteria

Studies were included in which subjects presented with symptoms of Achilles tendinosis, present for at least 3 months in one limb, and confirmed by a clinical diagnosis. This consisted in almost all studies of a clinical examination of the tendon and a confirmation with diagnostic ultrasound. Two studies, however, used only this clinical examination and two studies used MRI as a diagnostic tool.[1,2,14,21] An intervention for the affected Achilles tendon was an essential inclusion criterion. Excluded were studies where subjects were less than 16 years of age, had symptoms existing no longer than 3 months, or were diagnosed with underlying pathologies such as rheumatoid arthritis or a previously ruptured tendon.

Any outcome measure was included as there is currently no gold standard outcome measure battery specifically for Achilles tendinosis. This encompassed any domain of the International Classification of Functioning (impairments, activity limitations, and participation restrictions), quality of life, and patient satisfaction.

Research in the area of eccentric exercises for Achilles tendinosis appeared in journal publications around the mid 1980's. Until 1996, however, little literature was published. There was a noticeable increase in research volume from 1990 onwards. Consequently, the time frame of this systematic review was set from 1990 until September 2006 (when this review was completed) to ensure inclusion of all relevant research conducted in the last 15 years. Only experimental studies in full text in English language were included.

The database search was conducted by the principal author, and the identification and selection of articles was validated by the liaison librarian at the author's institution.

Evaluation of evidence

The hierarchy of evidence model proposed by Lloyd-Smith was used.[9] This hierarchy is part of Table 1. For critical appraisal, the 11 item PEDro instrument was modified (see appendix I). The original PEDro system has three items which focus on blinding (subject, investigator, and measurer) and one on concealed allocation.[10] Satisfying these items may potentially be too stringent for clinical studies where blinding of subject (Q3) or investigator (Q5), or concealment of allocation (Q6) may not be possible, as in research on Achilles tendons. The questions relating to blinding of patient and therapist and concealed allocation were therefore replaced by questions that were considered to be of more clinical relevance to this topic, these being, "Was there a clear intervention of the description?", "Were the outcome measures relevant and well described?", and "Were the outcome measures valid and reliable?"

The methodological quality of the included studies was appraised initially by two independent reviewers, who then conferred regarding discrepancies between scores. All discrepancies were discussed and resolved by consensus. Considered independently, the hierarchy of evidence and quality scoring provide fragmented information on study rigour. A composite score was therefore established for the purpose of assessing each study, by multiplying the level of the Lloyd-Smith hierarchy by the quality appraisal score.

Data extraction

Data relevant to the review was extracted into a purpose-built MS Excel spreadsheet, including type of intervention, outcome measures used, study findings, and nature of intervention. The country of origin was examined in order to consider the applicability and the generalisability of the study findings. Effect size was either extracted directly from studies if it was reported, and if it was not available, it was calculated with the available data.[11]

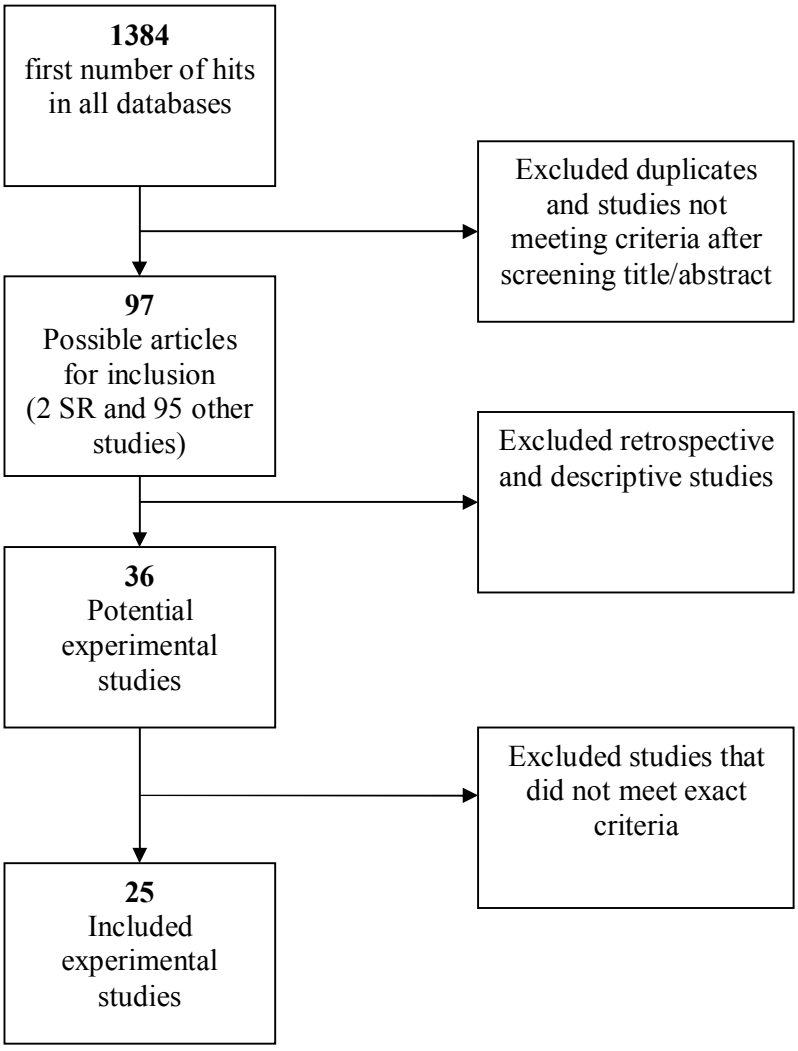
Results

Study data

Figure 1 outlines the consort diagram detailing the findings from the search. Twenty-five studies were eligible for inclusion after the initial search identified 1384 hits. Most studies were excluded as they were descriptive, observational/retrospective, or did not fit the study inclusion criteria. Three systematic reviews were identified, all being excluded because not all studies included matched the required inclusion criteria for this study, and thus the inclusion of the review itself would not have provided useful findings.[12-14] The relevant primary studies of all three reviews were extracted and added to the other primary references identified in the search. The remaining included primary studies consisted of:

- eight randomized controlled trials were identified [2,5,6,15-19]
- another six randomized, non-controlled trials were found[8,20-24] and
- 11 other experimental designs were included.[1,25-34]

Figure 1 Consort diagram of search strategy results



The hierarchy of evidence of the included studies is outlined in Table 1, along with the hierarchical score which was assigned to the study design.[9]

Table 1 Hierarchy of evidence according to Lloyd-Smith and associated score[9]

Study design	No. of studies	Score
1a Meta analysis of randomised controlled trials	0	6
1b One individual randomised controlled study	8	5
2a One well-designed, non-randomised controlled study	6	4
2b Well designed quasi-experimental study	11	3
3 Non-experimental descriptive studies – comparative/case studies	0	2
4 Respectable opinion	0	1

Quality of study methodology

The frequency distribution of critical appraisal scores from the modified PEDro tool is presented in appendix II. The median score approximated 70%, with the most commonly reported occurring at 7/11 (64%) and 8/11 (73%). Five studies had high methodological quality, scoring 10 or 11 of the possible score of 11. This appendix also highlights the most commonly met criteria, these being clear description of the intervention (Q4), reliable and valid outcome measures (Q6), relevant outcome measures (Q7) and dropouts (Q8). The poorest met criterion was Q5 which reports on blinding of the assessor.

The frequency distribution of the composite index score (multiplying hierarchy and quality score) is reported in appendix III along with the raw data for each individual study. When the information in appendix II was compared with the information on hierarchy and quality, it confirmed the sensitivity of the composite index for analysis, as the data distribution was over a wider range (from 135- 500 points).

Interventions

The interventions reported in the included studies were classified into four groups (eccentric exercises, surgery, medication and electrotherapy). In Table 2 these groups are outlined, with the specifics for each main intervention outlined for each study that incorporated that intervention.

Table 2. Main interventions

Eccentric exercises (11)	Surgery (6)	Medication (5)	Electrotherapy (3)
• Program according to Alfredson et al [1,8,18,19,25,26,30-32] • Isokinetic program [23] • Program according to Silbernagel et al [2]	• Core biopsies[24] • Excision of degenerative tissue [20-22,33] • Tenotomy [34]	• Sclerosing injections [15,29] • Glucocorticoid [28] • Topical glyceryl trinitrate [6] • Electrocoagulation (not real drugs) [27]	• Shock wave [17] • Low level laser [5] • Microcurrent treatment [16]

Outcome measures

There was a wide range of outcome measures reported in the included studies. It appeared to be most useful to put this information into global headings, similar to the approach taken with the interventions (see Table 3).

The most frequently used outcome measure was pain intensity, using a VAS scale. A range of interpretations applications of this scale was found, such as pain on activity, rest or palpation. Strength, functional ability, and patient satisfaction were also well represented. There was a deal of overlap between studies regarding outcome measures, as many studies used several outcome measures for the same group of subjects. Patient satisfaction with the treatment process was always measured retrospectively, and was generally assessed through an interview or questionnaire. Functional ability was reflected in a combination of tests usually linked to the most impaired movement or activity. A range of tests was therefore described, since advanced stage Achilles tendinosis impairs most walking or running activities. Ultrasound was utilised to measure the intratendinous structure to scan for the presence of degenerative tissue or neovessels. These are signs that there is something wrong with the tendon.[29] Range of motion outcomes were as specified, and the remaining outcome measures were specifically linked to the interventions, and the aims of those studies in which they were used.

Table 3 Grouped outcome measures

Pain	Strength	Pt satisfaction	ROM	Ultrasound	Functional ability	Rest
• VAS after activity[17,18, 26, 28,29] • VAS in rest[8,15,17, 20-23,25,28] • Likert pain scale [27]	• Isokinetic [6,8,20-23] • Isometric [34] • Functional (PF, DF, eccentric and concentric)[2,33]	• Pt satisfaction [15, 18,26,26-32,34] • Return to previous activities[23] • General assessment of function[16,24 ,33]	• DF and PF [2,16,17, 33]	• Tendon vascularity[5 ,27,29,32] • Tendon thickness[1,19 ,31] • Tendon structure[1,19, 23,24,31]	• Hoptest[2,6] • Functional Index Lower Limb[17] • Climbing stairs[33]	• Bone mass density[20] • PGE2 levels[5]

Pt = patient

VAS = Visual Analoge Score

PF = Plantar flexion

DF = Dorsal flexion

PGE2 = Prostaglandin E2

Findings

In Table 4 the study results are linked with interventions, using estimates of significance ($p<0.05$,or 95% confidence intervals not spanning 0). The results were classified into three headings (good, fair, and equivocal). The results from use of the main outcome measure were prioritised; however, the secondary outcomes were also considered. For example, if all outcome measures in a study (main and secondary) demonstrated significance, the findings were considered to be "good;" however, if only the main outcome (but no secondary outcome measures) showed significant changes, the results were regarded as "fair." No significant change in any outcome measure was considered "equivocal." In Table 4, for each category of outcome type and significance, the relevant studies are referenced.

Table 4 Significance of results per interventions in each study

Results / Intervention	Good results (significant)	Fair results	Equivocal results
Eccentric training	**N=7** 1,2,8,18,19,25,31	**N=4** 23,26,30,32	**N=0**
Surgery	**N=3** 20,21,24	**N=3** 22,33,34	**N=0**
Medication	**N=5** 6,15,27-29	**N=0**	**N=0**
Electrotherapy	**N=1** 16	**N=1** 5	**N=1** 17

Of note is that all the drug trials demonstrated good results, and there was a high frequency of studies on eccentric training that also demonstrated good results. Surgery was relatively evenly divided between good and fair outcome findings, and the electrotherapy findings were spread over all three result categories.

Applicability, Generalisability and Invasiveness

The majority of the studies were conducted in Scandinavia (Sweden, Norway, Finland and Denmark). Other studies were from the UK, Australia, one from Belgium and one from Italy.[6, 16,17,23,34] The implications of this are discussed in the next section.

The applicability of the intervention was considered in terms of how the treatment could, or had to, be administered, inconvenience for the patient and duration of intervention.

- Eccentric training
  The training program for eccentric training could be undertaken at home after an initial demonstration, except for the one reported by Croisier et al where patients had to train on an isokinetic machine.[23] (Appendix IV gives an outline of the eccentric program described by Alfredson et al which is currently the most widely accepted and used regime).[8] Apart from the patients in this last study, it could be considered that there was minimal inconvenience for the patient, as the program could be performed at home at their convenience. A disadvantage however, may be that there was no control over the way the exercises were undertaken, and it requires compliant patients to maximise the outcome. The duration of the exercise program was for the same in all studies (three months).

- Drug intervention
  Two of the interventions consisted of sclerosing injections into the tendon.[15,29] The patients received 1 or 2 injections over a period of three months and had no other restrictions other than to attend a clinic for them. One study that has the same purpose, destroying neovessels, used electrocoagulation as their method. This can not be classified as medication; however, for the purpose of this review, it is categorised under this heading. The procedure was performed under local anaesthesia once only, but needed to be repeated in some cases. The other study describing injections is Koenig et al in which glucocorticoid is once-only injected.[28] The last study worked with patches that patients applied themselves (after having had instructions) for the duration of six months.[6] None of these interventions appeared to represent an inconvenience for patients, except perhaps the patches, with respect to reapplication and skin damage.

- Surgery
  In the study where biopsies were taken, patients were returned to full activities after two weeks, after which they followed an eccentric training program. For the tenotomy, the period to full activity was six to eight weeks, whereas in the studies in which an excision was also performed, the return time was three to six months. As surgery involves admission to hospital, undergoing an anaesthetic, and following a subsequent rehabilitation period, this was considered to be the most invasive, inconvenient time consuming and expensive approach.

- Electrotherapy
  In the study by Bjordal et al, where only one application was administered, and the study by Costa et al, where three treatments were spread out over three months, the interventions were not invasive; however, they needed to be performed at a clinic setting.[5,17] However, Chapman-Jones & Hill describe their microcurrent treatment as requiring a period of 30 minutes daily for 14 consecutive days at a hospital, which would be a considerable inconvenience for patients.[21]

Information on effect size could only be extracted directly from one study. Paoloni et al calculated the effect size of their study as 0.14 (representing a small effect), and this was derived from all outcome measures at 24 weeks.[6] Only from a further few studies was it possible to calculate the effect size from the statistical data given in the article. From these studies, only the main outcome measure was used for the calculation. Four studies by Alfredson et al provided a range of effect sizes[8, 20-22]:

- Alfredson et al: 0.14. for isokinetic strength plantar flexion (PF) concentric at 90˚ at 52 weeks.[21]
- Alfredson et al: 0.23. for isokinetic strength PF eccentric 90˚ at 52 weeks.[20]
- Alfredson et al: 0.56. for isokinetic strength PF eccentric 90˚ at 52 weeks.[22]
- Alfredson et al: 0.44. for isokinetic strength PF eccentric 90˚ at 52 weeks.[8]

In contrast, Costa et al reported an effect size of 0.59 using VAS in sporting activity after 3 months (0.58. VAS in walking activity after 3 months.[17]) and Silbernagel et al reported 0.6 for strength in PF after 6 months.[2]

The effect sizes differ considerably and were reported for outcome measures mainly of strength and VAS. The effect size finding (0.6) by Silbernagel et al is the most convincing.[2] It represents a moderate effect of eccentric exercises on the increase of strength, whereas Costa et al have reasonable good effect on the VAS with shock wave compared to the comparison group.[2,17]

Discussion

This systematic review identified a considerable volume of literature on the research topic. By selecting the experimental studies only, this review presents a synthesis of the most rigorous way of investigating treatment effectiveness across a range of treatments and patient types. It is of note that no metanalysis was found that fitted the eligibility criteria of this review, given the level of discussion in the literature on this subject since 1990 and the number of experimental studies published since then. As the included studies provided information

on effectiveness of a range of interventions compared with a range of comparators, it was not possible to conclude anything other than relative effectiveness. However, this systematic review highlighted the potentially greater usefulness of eccentric exercises and drug therapy for the management of chronic Achilles tendonitis, compared with the usefulness of passive treatment and surgery.

The experimental study designs were assigned to different hierarchy levels (see Table 2). A striking element of the hierarchy of evidence was the high frequency of non-controlled and non-randomised studies. The range of study approaches is further highlighted by the use of the modified PEDro instrument, where the questions regarding a control group were mostly answered negatively (appendix IV). Some authors explain, quite legitimately, that they had ethical reasons for not including a control group, as they believed it was not justified to leave a patient with a chronic Achilles tendinosis untreated for any longer simply to serve as a control.[34] This, however, does not increase the validity of the study in a research sense. Some authors tried to meet this objective by taking the tendon from the contralateral side as a control; however, this too has disadvantages. The baseline for control and intervention groups is not similar, and the effect on a supposedly healthy tendon is not comparable with an injured one. [8,20,23]

However the lack of capacity to combine study findings using a meta-analysis approach was largely that the reported outcome measures varied across studies, which constrained comparison and synthesis. Additionally, not finding relevant published secondary evidence may relate to subject inclusion criteria. While this review made no distinction between athletes or recreational athletes or where in the tendon the lesion was located, these distinctions were made in some studies. In the clinic, physiotherapists consult with a range of patients, and thus this review was intentionally kept as broad as possible to ensure its generalisability and therefore its relevance for the "average" physiotherapist and the "average" patient.

For future research, a standardised assessment protocol is recommended that can be used to assess effectiveness of any intervention for Achilles tendinosis. The large number of outcome measures identified in the studies in this review generally represented functionally-related activities; however, it was not possible to synthesize them. However of note regarding functionality is the outcome measure of isokinetic strength.[8,23,30] Both the speed and the movement are controlled and this leaves little room for coordination or motor control input, which is known to be essential for gait and sports related activities. What is required in this instance is a valid, reliable, and functional test that relates to the situations a patient might encounter in real life.

Quality index

This systematic review used a novel approach to evaluate study construction by combining hierarchy and quality score. This provided an opportunity for comprehensive comparison between the different methodological aspects of the included studies. Our decision to modify the PEDro instrument was made on the basis that the only studies in the review likely to have scored positively for patient or therapist blinding were the drug studies. Thus, retaining these critical appraisal elements would simply have attenuated the quality score of the remaining included literature, and constrained sensitive comparison between the papers. A review of critical appraisal instruments highlighted the lack of any gold standard instrument, and encouraged reviewers to construct instruments that were relevant to their own review purpose.[35] It has been common to add criteria to existing critical appraisal instruments where they do not fully address the review requirements -- for instance, elements on reliability of outcome measures and evidence of sample size calculation.[35] Our index combining hierarchy – critical appraisal scores provides readers with composite information on the relevance and quality of papers in this review, and assists them to focus on the review findings rather than study methodology.

Eccentric exercises

The most striking aspect of the findings for eccentric exercises was the consistently good outcomes, where a "good" classification was given to the results inform the studies that applied exercises in a closed chain and functional manner.[1,2,8,18,19,25,30,31] It is worth noting however, that three of the studies that reported good results had only a fair rating of quality in the composite hierarchy/quality index.[23, 26, 32] This may be explained by the lack of control groups in these studies, which automatically reduces quality appraisal scores. Some authors attempted to compensate for this by using the patient's contralateral side as a control, and the implications of this have already been discussed. This is also a reason for the lack of comparative data needed to calculate effect size. From the two studies where it was possible, only Silbernagel et al employed a true control group.[2] Alfredson et al used the contralateral side as a control, which reflects doubt on his 44% effect size.[8] Silbernagel's 60% effect is more convincing, since the baseline measures for his groups were comparable.[2]

All the studies that reported using eccentric training as an intervention were performed in Scandinavia. This could indicate a geographical bias; however, all the studies and intervention methods have been well described and there is no reason to believe that if the same intervention was applied elsewhere, the results would change. The main concern is that good outcomes require good patient compliance. This should not be country specific, and therefore it should not be an issue in generalisability of study findings.

Surgery

There were no excellent study findings, although fair to good composite index scores related to fair to good outcome results.[20-22, 24, 33, 34] One reason for the lack of excellent studies relates to the type of intervention; as with surgery, it is difficult to blind a subject or assessor to the treatment. This automatically means a lower quality appraisal score. An explanation for the reasonably positive results in all the surgery studies is that surgery is a longer process that includes rest. It is therefore questionable whether the positive results are derived from the operative technique or the compulsory accompanying rest. In the Shalabi et al study, these authors report significant results after a core biopsy, however rehabilitation exercise included eccentric exercises, thus it is unclear which component of the intervention (surgery or exercise program) contributed to the improvement.[24] Despite the significant results reported for surgery, the costs, rehabilitation time, and inconvenience for the patient need to be taken into account. Thus it seems reasonable to suggest that surgery should not be the first line of management, rather the last resort.

Medication

When linking the good results that were reported in all five medication studies to the outcome measures, useful observations can be made. Three of the studies used only the VAS as an outcome measure, whilst Ilum and Boesen used the Likert scale.[27] This does not provide information on functionality. For example, in the sclerosing studies by Alfredson & Öhberg and Öhberg & Alfredson and in the studies by Ilum and Boesen et al and Koenig et al, the authors discuss only a decrease in pain, but not how this influences the structure of the tendon and consequences for future performmance.[15,27-29] Thus, pain is reduced but potentially not the cause, compared with the good results in healthier tendon structures after eccentric training, where there is a decrease in pain reported as well as positive structural changes.[1,23] One could imagine that a change in tendon structure tends to be a better outcome in the long term especially for resumption of usual activities. This has been described as an essential element in the healing process.[23] Functionality is not mentioned in any of these studies, and long term functional outcomes are not considered except in Paoloni's work where heterogenous functional outcome measures are reported.[6] The explanation given by Paoloni et al for their relatively low effect size is that a mean of all outcomes was reported.[6] This implies that the treatment has had different effects on different outcome measures, but combining measures, it is not clear how treatment impact on different outcome measures was interpreted. This underpins the need to develop a standardised, valid and reliable set of outcome measures which can truly compare results across studies.

Whilst the drug therapy studies mostly demonstrated good results, the functionality of outcomes and intratendinous effects have not been clearly shown. This makes the findings of these studies less convincing for the management of Achilles tendinosis. An unresolved issue is how medication affects patients. The study most convincing in its results and quality describes medication intervention as an application of patches to the skin for three months.[6] The authors mention the need to rotate the patches over time to avoid skin irritation, and no adverse effects are reported over the three month period of review. More information on adverse effects would seem to be important before the effectiveness of medication intervention for this condition is established.

Electrotherapy

Three electrotherapy studies reported the largest contrast in results.[5,16,17] Even though the interventions differ, the main conclusion is that passive treatment such as electrotherapy has limited effectiveness. This may be because all interventions are applied externally and superficially, and no active component of treatment was expected from the patient. It is generally understood that in order to change structure and collagen turnover rates, an active approach is required.[1, 23] Thus, electrotherapy potentially had no influence on tendon structure.

Intervention summary

Linking the intervention study findings with external generalisability and applicability, the most effective interventions are those which utilise eccentric exercises. They are relatively simple to perform; they can be undertaken at home and incur no additional costs, except for the intervention described with isokinetic exercises where an expensive machine was required to carry out the treatment.[23] What appears to make the most difference in the drug, surgery, or electrotherapy studies compared to the eccentric exercises studies is patient ownership. When participating in an exercise program, patients potentially have a significant influence on their recovery, as they are required to commit to the exercise program. This empowers the patient, and engenders confidence that is invaluable in any healing process.[36] It has been shown in studies that utilised eccentric exercises that, if the exercises are undertaken correctly, the outcome is likely to be positive. Thus, it seems important that the patient should be convinced that participation in a treatment program will enhance its effectiveness. This psychological factor is important especially in light of the current biopsychosocial approach in allied health management.[36,37] Another positive is that the patient is not likely to become dependent on a therapist or a treatment, and is equipped with techniques that can be applied if the condition reoccurs.

Conclusion

On balance in terms of strength of evidence, clinical application, generalisability, and patient choice, the findings of this systematic review suggest that eccentric exercises are a better first option than any other intervention to improve function for chronic Achilles

tendinosis. These exercises can be performed at home; thus, it is important to engage patient compliance in this process. To test the findings of this review, further research is required, using standardised definitions of outcomes and standard application of interventions. Subsets of studies could be considered within this review -- for instance, specific outcome measures and outcomes, elite athletes versus recreational athletes, and localisation of the lesion. More research needs to be undertaken to compare the effectiveness of eccentric exercises with other interventions, preferably within the same study, to be able to draw appropriate conclusions regarding the effectiveness of eccentric exercises compared with other single treatments, or treatment combinations.

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Appendix I. Modified PEDro score

1.	Eligibility criteria were specified	Y/N
2.	Subjects were randomly allocated to groups (NB: if control group was contralateral tendon, treatment was randomly allocated to either tendon)	Y/N
3.	Groups were similar at baseline	Y/N
4.	There was a clear description of the intervention	Y/N
5.	There was blinding of the assessor	Y/N
6.	Outcome measures were relevant to the condition and were well described	Y/N
7.	Outcome measures were reliable and valid	Y/N
8.	Drop outs were reported	Y/N
9.	Intention to treat (If there were no drop outs, intention to treat was assumed)	Y/N
10.	Report of between group statistical comparisons are described for at least one outcome measure (NB: when the tendon on the other side was used as a control, this was accounted for as between group comparison)	Y/N
11.	The study provides both point measures and measures of variability for at least one key outcome	Y/N

Appendix II. Individual scores for modified PEDro (refer to appendix I for specifications of criteria)

PEDro / Authors	1	2	3	4	5	6	7	8	9	10	11	Total	%
Alfredson et al 1998a	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	8	73
Alfredson et al 1996	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	8	73
Alfredson et al 1998b	Y	N	N	Y	N	Y	Y	Y	N	Y	Y	7	64
Alfredson et al 1998c	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	9	82
Alfredson & Lorentzon 2003	N	N	N	Y	N	Y	Y	Y	Y	N	N	5	45
Alfredson & Öhberg 2005	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	91
Bjordal et al 2006	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	9	82
Chapman-Jones & Hill 2002	Y	Y	Y	N	N	Y	N	Y	N	Y	Y	7	64
Costa et al 2005	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11	100
Croisier et al 2001	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	8	73
Fahlström et al 2003	Y	N	N	Y	N	Y	Y	Y	Y	N	Y	7	64
Ilum Boesen et al 2006	Y	N	N	Y	N	Y	Y	Y	Y	N	Y	7	64
Koenig et al 2004	N	N	N	Y	N	Y	Y	Y	Y	N	N	5	45
Mafi et al 2001	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	10	91
Norregaard et al 2006	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	9	82
Öhberg & Alfredson 2002	N	N	N	Y	N	Y	Y	Y	Y	N	Y	6	55
Öhberg et al 2001a	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	8	73
Öhberg et al 2001b	N	N	N	Y	N	Y	Y	Y	N	N	Y	5	45
Öhberg & Alfredson 2004	Y	N	N	Y	N	Y	Y	Y	N	N	N	5	45
Paavola et al 2002	Y	N	Y	Y	N	Y	Y	Y	N	Y	Y	8	73
Paoloni et al 2004	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	10	91
Shalabi et al 2004a	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	7	64
Shalabi et al 2004b	N	N	N	Y	N	Y	Y	Y	N	N	Y	5	45
Silbernagel et al 2001	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	10	91
Testa et al 2002	Y	N	N	Y	N	Y	Y	Y	N	N	Y	6	55
Total for each item	18	9	10	24	5	25	24	24	13	16	22		

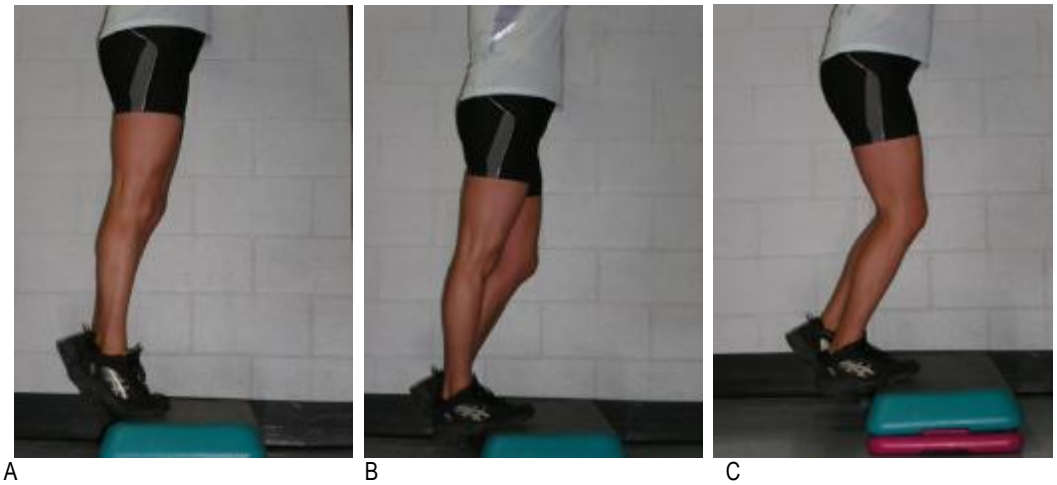
Appendix III. Raw data for combined level of evidence

Author	Hierarchy score	Quality %	Combined results
Alfredson et al 1998a	4	73	292
Alfredson et al 1996	4	73	292
Alfredson et al 1998b	4	64	256
Alfredson et al 1998c	4	82	328
Alfredson & Lorentzon 2003	3	45	135
Alfredson & Öhberg 2005	5	91	455
Bjordal et al 2006	5	82	410
Chapman-Jones & Hill 2002	5	64	320
Costa et al 2005	5	100	500
Croisier et al 2001	4	73	292
Fahlström et al 2003	3	64	192
Ilum Boesen et al 2006	3	64	192
Koenig et al 2004	3	45	135
Mafi et al 2001	5	91	455
Norregaard et al 2006	5	82	410
Öhberg & Alfredson 2002	3	55	165
Öhberg et al 2001a	4	73	292
Öhberg et al 2001b	3	45	135
Öhberg & Alfredson 2004	3	45	135
Paavola et al 2002	3	73	219
Paoloni et al 2004	5	91	455
Shalabi et al 2004a	3	64	192
Shalabi et al 2004b	4	45	180
Silbernagel et al 2001	5	91	455
Testa et al 2002	3	55	165

Appendix IV. Description of Eccentric exercise regime developed by Alfredson et al[8]

The program consists of a 12-week regime in which the patients were instructed to do the eccentric exercises twice daily seven times per week. Each exercise is performed in 3 sets of 15 repetitions each time. Pain during the exercises was tolerated however it should not become disabling. When the patient was able to perform the exercise without minor pain or discomfort, the load was increased by using a backpack with weights.
Two types of exercises are used:

1. Eccentric contraction of calf muscle with knee straight (A and B)
2. Eccentric contraction of calf muscle with knee bent (C) to maximise the activation of the soleus muscle



A B C

Photograph A of a deidentified colleague of the principal author shows the starting position in an upright body position and standing with all body weight on the forefoot and the ankle joint in plantar flexion lifted by the non-injured leg.
Photograph B shows the calf muscle loaded eccentrically by having the patient lower the heel with the knee straight.
Photograph C shows the same position but with the knee bent.