The effects of eccentric training and heavy slow resistance training on symptom reduction in patients with chronic mid-portion achilles tendinopathy

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Abstract

Purpose: To evaluate the effects of eccentric training (ET) and heavy slow resistance training (HSRT) on symptom reduction in patients with chronic mid-portion achilles tendinopathy (AT).
Method: Academic Journals from Pubmed was searched between February 15th and April 15th, using the search terms«Achilles Tendinopathy AND Eccentric Training/Heavy Slow Resistance Training». Human interventional studies investigating the effects of ET and HSRT on symptom reduction in patients with chronic mid-portion AT were included. All studies reported their results by using either the Victorian Institute of Sports Assessment Achilles(VISA-A) questionnaire or the Visual Analog Scale(VAS)
Results: A total of seven studies was included in this review (seven ET and one HSRT). Six studies found a significant improvement in either VISA-A or VAS using the ET-protocol, and one found significant improvement in patient symptoms using HSRT. One of the studies found no significant improvement using ET.
Conclusion:
ET as proposed by Alfredson and colleagues has showed good results through this systematic review. However, one study found contradicting results, and one study found equally as good result by using the HSRT protocol. The magnitude of improvement varied greatly in between the studies supporting ET and more research is needed to confirm the effects of HSRT.

Abstrakt

Formål: Å evaluere effektene av eksentrisk trening (ET) og tung langsom styrketrening (HSRT) på symptom reduksjon i pasienter med kronisk tendinopati i midtre del av akillessenen.
Metode: Det ble gjennomført et søk av Akademiske Journaler fra Pubmed mellom 15. februar og 15. april, og søkeordene,” Achilles Tendinopathy AND Eccentric Training/Heavy Slow Resistance Training” ble brukt. Intervensjonsstudier utført på mennesker som undersøkte effektene av ET og HSRT på symptom reduksjon i pasienter med kronisk tendinopati i midtre del av akillessenen ble inkluder. Alle studiene rapporterte resultatene sine ved hjelp av enten Victorian Institute of Sports Assessment Achilles spørreskjema (VISA-A) eller en Visuell Analog skala (VAS).
Resultat: Totalt syv studier ble inkludert i denne systematiske oversikten (syv ET og en HSRT). Seks studier fant signifikante forbedringer i enten VISA-A eller VAS etter ET, og ett studie fant signifikante forbedringer etter HSRT. Ett studie fant ingen signifikante forbedringer etter ET.
Konklusjon: ET som foreslått av Alfredson og kollegaer har vist gode resultater i denne systematiske oversikten, men ett studie fant motsigende resultater og ett annet studie fant like gode resultater med HSRT. Omfanget av forbedringene varierte kraftig mellom studiene som støtter ET og mer forskning er nødvendig for å bekrefte effektene etter HSRT.

Introduction

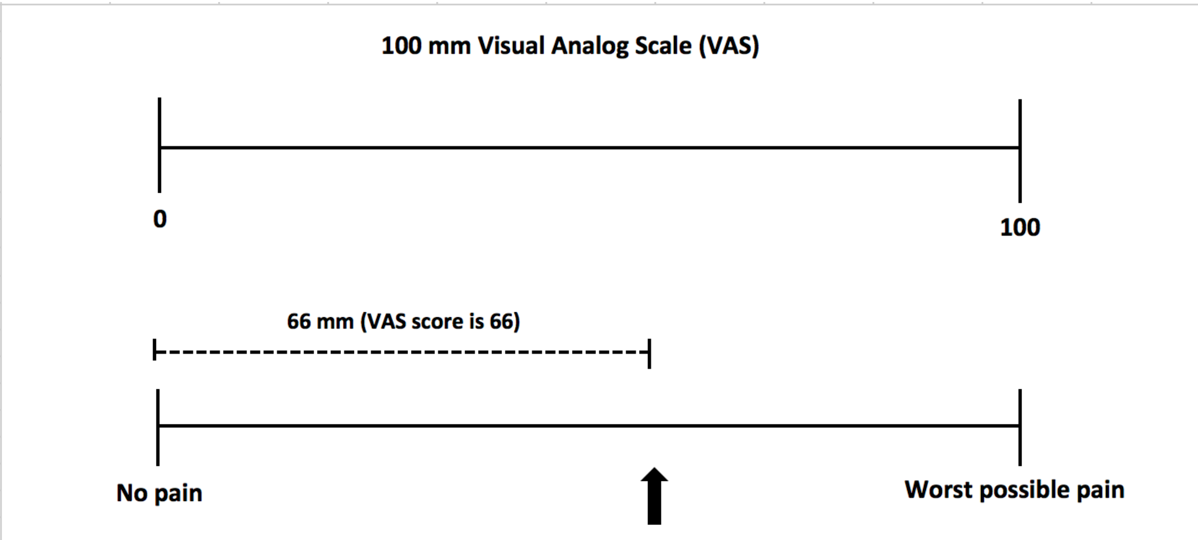
Achilles tendinopathy (AT) is an overuse injury common in sports with repetitive loading of the achilles tendon, and especially in sports where the achilles tendon is required to store large amounts of energy, like in sprinting or jumping.(1, 2) Overuse occurs when applying tension through the tendon that exceeds its current load bearing capacity. If sufficient recovery is present this will lead to positive strength adaptations, however if not, over time it will lead to an overuse injury.(3) Although we tend to think that this type of injury relates to athletes who constantly try to push their bodies to the limit, it is important to remember that overuse is relative to a person's baseline activity level. Because tendons adapt to the adding or removal of mechanical load the athletes tendon will be much stronger and it will require much more stimuli to achieve overuse than for the sedentary person who's tendon is much weaker.(4) For this reason AT is a common injury in the sedentary and non-athlete population, as well. (5) Acute overuse can be dealt with quite easily by the removal of mechanical load, however if it is not dealt with early on and you continue to exceed the tendons capacity, the condition eventually becomes chronic and much harder to treat. Kaux and colleagues considers the condition as chronic after symptoms have persisted for a minimum of twelve weeks. (6)

Tendinopathy is commonly used as a broad term covering all overuse injuries of tendons.(7) Tendinitis have been used to describe the initial acute faze with the presence of inflammation within the tendon, and tendinosis describe the chronic stages where the tendon is degenerated and with an absence of inflammation. The terms have often been confused with one another leading to most conditions being labelled tendinitis although an inflammatory state not is present in most cases.(8) The distinction between the different terms is important because it could heavily impact the rehabilitation process. Tendinitis and tendinosis have previously been thought of as two different types of injuries that not necessarily follows one another, meaning that you could develop tendinitis or tendinosis independently. Recently Cook and Purdam proposed a continuum of tendon pathology that consists of the three stages, reactive tendinopathy, tendon disrepair (failed healing) and degenerative tendinopathy. (4) They look at a tendons stages in pathology as one injury instead of as different injuries and propose that the tendon moves back and forth along a continuum and that it does so by either adding or removing load from the tendon. Following this idea, the early stages of tendon pathology might resemble the characteristics of tendinitis, although Cook and Purdams first stage is a non-inflammatory stage, while the later stages of the continuum more closely resembles tendinosis. Where a tendon lies within the continuum will heavily impact the reversibility of the condition and how you manage it. Evaluating where a patient's tendon lies within the continuum could therefore be extremely important in guiding clinical treatment.

A healthy tendon depends on mechanical loading in order to maintain its homeostasis and prevent excessive degradation. (9) According to Cook and Purdam, the adding or removal of mechanical loading is what moves the tendon across the continuum of pathology, and manipulation of mechanical loading is therefore what drives tendon adaptations, either by strengthening it or by weakening it.(4) Because of mechanical loadings role in tendon adaptations, resistance training has been and still is the preferred treatment when it comes to tendon injuries. Much like placing the muscle under progressively more and more stress in order to increase its cross-sectional area and strength, the idea is to progressively increase the mechanical loading placed on the injured tendon in order to create positive adaptations and improve load capacity. Based on this idea, rest is rarely recommended when dealing with tendinopathies and the development of different resistance training protocols has occurred. Until recently, most of the focus has been pointed towards eccentric training (ET) because of promising results, however little convincing research suggests that isolated eccentric contractions is the only effective way of loading the injured tendon.(10) Because of this, more focus has been pointed towards the use of isotonic or eccentric-concentric contractions using a slow tempo. Training as treatment, considered conservative, is not the only form of treatment when it comes to tendinopathies. Other alternatives include corticosteroid injections, sclerosing injections, braces, shockwave therapy and surgery, however these treatment options have limited support in the literature and conservative treatment remains the preferred option.

Several specific training protocols have been developed based on isolated eccentric contractions, however the protocol developed by Alfredson in 1998 is the most promising. (11) When it comes to isotonic or eccentric-concentric contractions, only the protocol developed by Kongsgaard in 2015 called heavy slow resistance training (HSRT) exists and a version of this protocol has previously shown great results in the treatment of patellar tendinopathy. These two protocols differ substantially in training frequency and training volume, because the Alfredson protocol is a home-based training protocol including two daily training sessions seven days a week, while the HSRT protocol only includes three weekly gym sessions. Both protocols aim to progressively add resistance over time although the HSRT protocol is more specific regarding this matter and instructs you to progress from a resistance equal to 15 repetition maximum to 6RM over the course of twelve weeks. The aim of this systematic review is to investigate the effects of ET and HSRT on symptom reduction in patients with chronic mid-portion AT.

In this review, we focused on symptom reduction and the most acknowledged method for accessing this with regards to injured achilles tendons is through the Victorian Institute of Sports Assessment Achilles questionnaire (VISA-A). It is used as a clinical measure of AT and was firstly introduced in 2001 by Robinson et al. (12) The questionnaire is based upon the Visual Analog Scale (VAS) which is a scale made out of either a horizontal or a vertical line, 100 mm in length, with to polar opposite descriptors, one at each side of the line to explain each extreme. When VAS is used for pain, these descriptions would be «no pain» and «Worst possible pain». The patient ticks of a mark at the point that best represents their pain intensity. The score is obtained by measuring the distance between «no pain» and the patient's mark. (13) (Pic. 1.1)



Picture 1.1: Illustrating the Visual Analog Scale (VAS)

Method

Search criteria

A literature search using Pubmed as search engine was undertaken between February 15th and April 15th. Search terms related to “Achilles”, “Tendinopathy”, “Eccentric Training”, “Heavy Slow Resistance Training” and variations were initially searched before the final keywords “Achilles Tendinopathy AND Eccentric Training” and “Achilles Tendinopathy AND Heavy Slow Resistance Training” were searched. This showed an initial result of 92 studies published in English, conducted on humans. The “sort by” box were checked for “most recent” to get access to the full list of studies.

Selection criteria

Randomized controlled trials investigating the effects of either the ET or HSRT protocol on symptom reduction in patients with chronic mid-portion AT were included. Studies were deemed eligible if they either covered the effects of one of the training protocols alone, compared them to each other, compared them with another form of treatment or compared them to a combination of treatments. Minimum required symptom duration was set to three months as this review aims to investigate chronic AT. The duration of the training protocol was set to twelve weeks following the instructions of the ET and HSRT protocols, and the minimum follow up period was also set to twelve weeks. To be able to compare results, only studies using the VISA-A questionnaire or the VAS were included. Studies solely investigating the effects on insertional tendinopathy were excluded in addition to all meta-analysis or systematic reviews.

Review process

All titles and abstracts of the retrieved studies were reviewed independently. If the information received from the titles and abstract were insufficient to validate inclusion or exclusion, the full text was reviewed for further evaluation. Consensus decision-making was utilised when disagreement between authors occurred. After reviewing the titles, abstracts and full texts if necessary, the pool was narrowed down from 92 to 15 studies, 15 of them investigating eccentric training and one of them investigating heavy slow resistance training. Full texts were obtained and reviewed, and eight studies were excluded due to inconsistencies in training protocols, lack of follow up and the use of different outcome measures.

Data extraction

Data relating to group demographics like sample sizes, gender distribution, age, height, weight, body mass index (BMI), and symptom duration were extracted from each study along with data relating to clinical outcome via VISA-A and VAS scores. With regards to outcomes, only data from the relevant training groups, either isolated ET/HSRT-groups or groups that combined one of the two protocols with other forms of treatment, were extracted. If available, data relating to patient satisfaction and compliance rate was also extracted.

Patient Characteristics

Seven studies were finally included in this systematic review with all studies investigating the effects of ET and one study also investigating the effects of HSRT. The studies included a total of 390 patients across all studies and 325 of them were in groups performing either HSRT, ET, or a combination of ET and another treatment. More details about these participants in table 1.1

Patient Characteristics

Studies	Groups within studies	Participants	Male / Female Participants	Total participants	Tendons	Population	Age (Years)	Height (cm)	Weigth (kg)	Body Mass Index (BMI)	Symptom Duration (months)	Mid-portion / Insertional
Heavy Slow Resistance (HSRT) versus Eccentric Training (ET) as Treatment for Achilles Tendinopathy: Arandomized Controlled Trial	HSRT-Group	22	14/8	47	47	Recreational Athletes	48 ± 2 (31-60)	178 ± 2 (164-195)	81 ± 3 (65-112)	26 ± 1 (18-40)	17 ± 3 (3-80)	47/0
	ET-Group	25	18/7				48 ± 2 (31-60)	179 ± 2 (164-196)	81 ± 2 (62-96)	25 ± 1 (21-35)	19 ± 5 (3-120)	
The limited Effectiveness of a Home-Based Eccentric Training (ET) for Treatment of Achilles Tendinopathy	ET-Group	20	11/9	48	25	Recreational Athletes	49,2 ± 9 (33-65)			27,2 ± 7,48 (19-51,5)	>3	16/4
	Control-Group	21	8/13		42		27,9 ± 2,93 (25-37)			23,4 ± 4,38 (15-34,9)		
	2. Controll-Group	7	2/5		14		45,9 ± 10,51 (30-59)			25,9 ± 5,83 (20,6-37,3)		
Heavy-Load Eccentric Calf Muscle Training (ET) for the Treatment of Chronic Achilles Tendinosis	ET-Group	15	12/3	30	15	Recreational Athletes	44,3 ± 7	176,3 ± 9,4	77,4 ± 10,1		18,3 (3-100)	30/0
	Surgey-Group	15	11/4		15		39,6 ± 7,9	175,5 ± 9,4	75,5 ± 11,7		33,5 (6-88)	
Chronic Achilles Tendon Pain Treated with Eccentric Calf-Muscle Training (ET)	ET-Group (Mid-portion)	78	53/25	108	101	Recreational Athletes	46,1 ± 9,5			26 ± 3,6	19,2 ± 28,6 (3-240)	78/0
	ET-Group (Insertional)	30	24/6		31		37,9 ± 11,6			26,5 ± 4,6	32 ± 42,4 (6-180)	0/30
Eccentric Loading (ET) versus Eccentric Loading Plus Shock-wave Treatment (SW) for Midportion Achilles Tendinopathy	ET-Group	34	14/20	68	34	Healthy Adults	46,2 ± 10,2 (18-70)				13 ± 7	68/0
	ET + SW-Group	34	16/18		34		53,1 ± 9,6 (18-70)				16 ± 5	
Eccentric Calf Muscle Training (ET) in Athletic Patients with Achilles Tendinopathy	ET-Group	45	29/16	45	45	Athletic Patients	Males: 26 ± 12,8 (18-42) Females: 28 ± 13,1 (20-46)	173 ± 16,8 (158-191)	70,3 ± 15,3 (51,4-100,5)		16,4 ± 9,2 (7-31)	45/0
Superior Short-Term Results with Eccentric Calf Muscle Training (ET) compared to Concentric Training (CT) in a Randomized Prospective Multicenter Study on Patients with Chronic Achilles Tendinosis	ET-Group	22	12/10	44		Not Specified	48,1 ± 9,5 (36-72)	173 ± 9,7	76,2 ± 11,3		21 (3-120)	44/0
	CT-Group	22	12/10				48,4 ± 8,3 (34-61)	172,2 ± 8,7	79,7 ± 15,2			

Table 1.1: Patient characteristics shown as Mean ± Standard Deviation (Range)

Results

Eccentric training has previously been established as the preferred rehabilitation method for treating chronic AT. Six out of the seven studies included in this systematic review confirms the positive effect of eccentric training on symptom reduction in patients with chronic mid-portion AT. (11, 14-18) These studies all reported significant improvements in VISA-A scores or various VAS scores following ET although the magnitude of the improvements differed between studies. Ref. 11 Compared the effects of (ET) with the effects (HSRT), and was the only study comparing ET with HSRT. The ET group significantly improved their VAS-running, VAS-heel rises and VISA-A scores from 0-52 weeks ($P<0,0001$). The HSRT group also achieved significant improvements in their VAS-running, VAS-heel rises and VISA-A scores from 0-52 weeks ($P<0,0001$). No significant difference between the groups were observed for VAS-running, VAS-heel rises or VISA-A scores ($P=0,71$, $P=0,77$, $P=0,62$), indicating that HSRT is equally effective as ET. Compliance rate on the other hand differed significantly between the groups with a mean training session compliance rate of 76% for the ET-group and 92% for the HSRT-group ($P<0,005$). Patient satisfaction also differed between groups with 80 and 100% patient satisfaction at 12 weeks for ET and HSRT, and 76% and 96% at 52 weeks. Although patient satisfaction differed, there were no significant difference ($P=0,052$, $P=0,10$). Another study compared isolated eccentric contractions as per the Alfredson protocol, to isolated concentric contractions and after 12 weeks, patient satisfaction differed significantly between groups in favour of the ET-group with 82% and 36% ($P<0,002$). This study split their results into good results and bad results for both training groups and reported changes in VAS scores within these groups. No P-values was reported regarding change in VAS scores. (15)

Among the other studies supporting the use of ET in treating chronic AT, Alfredson and colleagues were the first utilising the Alfredson protocol and the study included one ET group and one group receiving surgical treatment as a comparison. The ET group significantly improved their VAS-running scores from baseline to follow up at 12 weeks ($P<0,001$). (18) Another study compared the effects of ET on chronic mid-portion AT with the effect of ET on chronic insertional AT and split their results into bad or good results. In the mid-portion group, 90 out of 101 tendons achieved good results with a significant improvement of VAS scores from baseline to follow up at 12 weeks ($P<0,001$), while the remaining 11 tendons achieved bad results with no significant improvement in their VAS scores. For this study, VAS was not specified. The study reported a compliance rate of 100%, an estimated patient satisfaction in the good results-group of 83,3% ± 17,3%, and an estimated patient satisfaction in the bad results-group of 12,9% ± 23,7%. (17) Both these studies investigated the effects of ET on recreational athletes, however Maffulli and colleagues investigated the effects on an athletic population, and utilised the VISA-A questionnaire as outcome measure. Significant improvements in VISA-A scores were observed from baseline to a mean follow up of 24 ± 6 months (P<0,001), indicating that the effects of ET are present in an athletic population as well. The study reported a mean training session compliance rate of 82% ± 4% and participants were required to complete at least 75% of all training. (16)

One of the studies included in this review compared the effects of ET only with the effects of ET plus shock-wave therapy (SWT). Both groups in this study showed significant improvements in VISA-A scores after 16-weeks, with a significantly better improvement in the combination group (p<0,0045), suggesting that ET might be more effective on symptom reduction in chronic mid-portion AT when combined with SWT. (14)

The last study included in this review found contradicting results regarding ET despite trying to replicate previously successful studies. The study followed the home-based Alfredson protocol, like all other studies included in this review, however no significant improvements in VAS-tendon loading, VAS-Activities of daily living og VISA-A scores were observed (P>0,05). A patient satisfaction of 10% were reported. (19)

Results

Studies	Groups within studies	Outcome Measures							
Heavy Slow Resistance (HSRT) versus Eccentric Training (ET) as Treatment for Achilles Tendinopathy: A Randomized Controlled Trial		VAS-Running		VAS-Heel Rises			VISA-A		
		Baseline (0 weeks)	12 weeks	0 weeks	12 weeks	52 weeks	0 weeks	12 weeks	52 weeks
	HSRT-Group	54 ± 5,4 (43,3 - 64,3)	17 ± 4,1 (9,3 - 25,2)	29 ± 5,5 (17,7 - 39,2)	7 ± 2,4 (2,1 - 11,7)	5 ± 2,5 (-0,2 - 9,4)	54 ± 3,2 (48,6-61,6)	76 ± 3,7 (70,5-83,1)	89 ± 2,8 (83,6 - 94,8)
	ET-Group	49 ± 5,5 (38,3 - 60,1)	20 ± 5,7 (9,3 - 31,5)	19 ± 5 (8,8 - 28,6)	12 ± 3,6 (4,8 - 18,9)	6 ± 2,6 (0,9 - 11)	58 ± 3,9 (50,6-65,8)	72 ± 3,7 (64,7-79,3)	84 ± 3,5 (78-91,9)
The limited Effectiveness of a Home-Based Eccentric Training (ET) for Treatment of Achilles Tendinopathy		Vas-Tendonloading Baseline		VAS ADL (Activities of Daily Living)			VISA-A		
		0 weeks	12 weeks	0 weeks	12 weeks		0 weeks	12 weeks	
	ET-Group	43 ± 23,22 (0-71)	32,79 ± 20,24 (0-58)	29,6 ± 21,09 (0-59)	25,37 ± 20,24 (0-58)		59,8 ± 19,03 (26-90)	63,95 ± 19,67 (32-95)	
Heavy-Load Eccentric Calf Muscle Training (ET) for the Treatment of Chronic Achilles Tendinosis		VAS-Running							
		0 weeks	12 weeks						
	ET-Group	81,2 ± 18	4,8 ± 6,5						
Chronic Achilles Tendon Pain Treated with Eccentric Calf-Muscle Training (ET)		VAS - Good Results		VAS-Bad Results					
		0 weeks	12 weeks	0 weeks	12 weeks				
	ET-Group (Mid-portion)	66,8 ± 19,4	10,2 ± 13,7	74,0 ± 18,9	64,9 ± 26,4				
	ET-Group (Insertional)	68,3 ± 7	13,3 ± 13,2	79,5 ± 11,2	75,4 ± 11,2				
Eccentric Loading (ET) versus Eccentric Loading plus Shock-wave Treatment (SW) for Midportion Achilles Tendinopathy		VISA-A							
		0 weeks	16 weeks						
	ET-Group	50,6 ± 10	73 ± 19 (28-100)						
	ET + SW-Group	50,2 ± 11,2	86,5 ± 16 (34-100)						
Eccentric Calf Muscle Training (ET) in Athletic Patients with Achilles Tendinopathy		VISA-A							
		0 weeks	24 ± 6,3 months						
	ET-Group	36 ± 23,8	52 ± 27,5						
Superior Short-Term Results with Eccentric Calf Muscle Training (ET) compared to Concentric Training (CT) in a Randomized Prospective Multicenter Study on Patients with Chronic Achilles Tendinosis		VAS-Running/Walking (Good Results)		VAS-Running/Walking (Bad Results)					
		0 weeks	12 weeks	0 weeks	12 weeks				
	ET-Group	69	12		44				

Table 1.2: Results shown as Mean ± Standard Deviation (Range) VAS = Visual Analog Scale, VISA-A = Victorian Institute of Sports Assessment Achilles

Discussion

In this systematic review of the literature we investigated the effects of eccentric training (ET) and heavy slow resistance training (HSRT) on symptom reduction in patients with chronic mid-portion achilles tendinopathy (AT). Six of the seven studies found significant clinical improvements following ET, and the one study comparing ET with HSRT found equally good improvements following HSRT. One study found no significant clinical improvements following ET despite following the same protocol as the rest of the studies.

Although six of the seven included studies found significant improvements in outcome scores following ET, the magnitude of these improvements differed greatly between studies. For example, the ET-group in the study by Alfredson and colleagues went from a mean baseline VAS-running score of 81,2 to a mean twelve week follow up score of 4,8, which represents the biggest improvement out of all the studies. Comparing this to the ET-group in the study by Kongsgaard and colleagues, which went from a mean baseline VAS-running score of 49 to a mean twelve week follow up score of 20, it is clear that the magnitude of improvement differs. Another important factor to consider when trying to determine the reliability of the studies is patient characteristics and the differences between studies.
Most of the studies included a population classified as recreational athletes, however one study investigated the effects on an athletic population and although they found statistically significant results, the reported standard deviation was the highest out of all the studies. This could indicate that eccentric training might not be as effective for athletes.

Characteristics regarding age, height, weight, symptom duration and number of participants could also contribute to explain the difference in clinical improvements between the studies. When combining these factors and looking at standard deviation and range, the study by Kongsgaard and colleagues comes out on top as the highest quality study. They reported the smallest standard deviation and the narrowest range on all results, which could possibly be explained by the fact that patients in this study, to a larger degree shared characteristics when compared to patients in the other studies. The study by Ram and colleagues did not find significant clinical improvements after ET, however these results could be explained by patient characteristics as well. When looking at body mass index (BMI), this study reported the highest mean out of all the studies, with the widest range as well. Because the ET protocol is based on bodyweight exercises it is possible that a higher body weight could influence the results by making the training too intense. In addition, this study reported no information regarding symptom duration beyond the requirement of at least three months of pain. One could theorize that the mean symptom duration in this study was significantly different compared to the other studies and that this could be a contributing factor to the lack of satisfying results achieved in this study. This is however not likely as most of the studies reported a wide range for their symptom duration. All together this study replicated other successful studies to a large extent and the poor results could simply be due to the fact that ET might be flawed as a treatment option for this injury.

Another important factor to consider is that some of the studies uses the VAS for different activities like running, heel-rises, and activities of daily living. This makes it harder to compare results between the studies as it is difficult to compare pain when performing low intensity activities to pain when performing high intensity activities. In addition, you might not see the same magnitude of improvement in VAS-scores for different kinds of activities. For instance, if the activity measured is a very low intensity activity, a low level of pain might be reported at baseline which leaves little room for improvement towards the follow up. This could result in what seems like a nonsignificant improvement. On the other hand, if the activity is a very high intensity activity with a lot of pain being reported at baseline, there will be much more room for improvement towards the follow up, which makes it more likely to result in a seemingly more impressive improvement. As seen in the study by Alfredson and colleagues, where VAS-running was used, patients started with very high baseline scores (mean: 81,2) and ended with very low follow up scores (mean: 4,8). Comparing this to the study by Ram and colleagues where VAS-activities of daily living was used, patients started with a very low baseline score (mean: 29,6) and ended with a mean follow up score of 25,37. The same magnitude of improvement was not possible in this study as their baseline scores were too low to begin with. One could also make the argument that it is harder to go from almost pain-free to completely pain-free, than it is to go from having a lot of pain to being almost pain-free.

One of the studies investigated the effects of ET compared to ET plus shock wave therapy (SWT) and found a significantly better improvement in the combination group than in the ET only group, meaning that ET by itself not necessarily results in the best improvement. This is interesting because it shows that alternative treatment methods might have a place in the rehabilitation of chronic mid-portion AT as well, which contradicts the idea that resistance training is supposed to be the only reliable treatment option. Since the ET only group also achieved significant improvements it seems as if the eccentric component might have been the most important, considering the positive results from other ET groups in this review as well.

The study by Kongsgaard and colleagues comparing HSRT to ET showed equally significant improvements in VISA-A and VAS-running/Heel rises scores from baseline to follow up in both the HSRT and ET group. This is interesting as it is the first study that manages to achieve equally good results with another form of resistance training compared to ET. In addition, patient satisfaction was significantly higher in the HSRT group, and the compliance rate was also higher although not significantly higher. Nonetheless this is still in favour of the HSRT group. A possible reason for the better compliance rate could be the amount of exercise prescribed in the different protocols. In HSRT the patients are required to perform three workouts a week, in contrast to the ET group which is required to perform two workouts a day, every day of the week. The number of total workouts is drastically different, which can make the likelihood of missing workouts greater in the ET group. On the other hand, the difference in number of workouts makes the impact on compliance rate different for the two groups. If a workout is missed in the HSRT group, it will account for a bigger part of the total workload percentage than if a workout in the ET group is missed. This can be a motivational factor for the participants for two reasons, firstly by making it seem more manageable to get through, and secondly by making it seem even more important to get every workout done. Patients following the ET protocol might not see it as a big problem to miss a workout, because there is another one scheduled later that day or the morning after. Compliance rate is extremely important to consider when designing training protocols as a training protocol has no value if no one can manage to stay compliant, even though the training protocol might be the best in theory. Following this logic one could speculate about what the results would have looked like if compliance rate in the ET group was as good as in the HSRT group.

One of the biggest issues the studies in this systematic review have in common, is the large range of acceptable symptom duration. Going back to Cooks idea of a continuum of tendon pathology, where it is discussed that a person's placement in the continuum could heavily impact the reversibility of the condition. Symptom duration could be an important factor in determining this placement as someone with a long history of symptoms is likely to be placed further into the continuum. Cook also mentions that where one lies within the continuum could heavily impact how you go about reversing the condition, meaning that different training protocols might be suited for different stages. Since symptom duration and placement in the continuum of tendon pathology might be closely connected, the large range of symptom durations in the studies of this systematic review might explain the varied results. What works for a patient with a symptom duration of three months might not work for someone with a symptom duration of 20 years. For this reason, further research should be conducted on the effects of the different training protocols on more narrow ranges of symptom durations.

Previously most focus has been directed at ET in the rehabilitation of tendinopathies, however as shown by one high quality study in this review, HSRT is equally as effective on clinical outcomes and superior to eccentric training with regards to compliance and patient satisfaction. This indicates that the isolated eccentric component of the Alfredson protocol might not be the important factor. When comparing the two protocols against each other, several common factors are seen. Both protocols utilise a very slow tempo and the stretch shortening cycle (SSC), which is the rapid change from eccentric to concentric contraction, is eliminated in both protocols. The protocols also focus on progressive overload over time and aims to build up the tendons capacity to handle greater mechanical loads. The absence of a stretch reflex and a slow tempo is likely important because we know that increasing tempo and utilising the SSC places a higher demand on energy storage within the tendon. This will in return drastically increase the mechanical load placed upon the tendon, and thus impair recovery of the already injured tendon through continuing to exceed its capacity.

Progressive overload is perhaps the most important factor shared by the two protocols as this mechanism ensures that the tendon adapts and becomes stronger over time. There is however one problem with the protocols as they only aim to increase the tendons capacity to bear mechanical load in a very slow tempo with the absence of the SSC. This may do little to improve the tendons capacity for energy storage which is required in fast moving activities where the SSC is utilised. For this reason, a rehabilitation protocol might need several stages to cover different types of demands, as proposed by Mallaris and colleagues. In his four-stage model, Mallaris proposes that ET or HSRT is used in stage two after initially aiming to reduce symptoms through isometric training. After stage two is completed he suggests another stage where the aim is to develop capacity for energy storage, before the final stage includes gradually returning to sports or normal activity. ET or HSRT would only account for one of the four stages in this model. Whether the patient in question is an athlete or not, the rehabilitation plan should aim to develop capacity towards the demands placed upon the patient in everyday life. This could mean repetitive jumping for the athlete, or just being able to perform daily activities of living for the non-athlete. In the case of the achilles tendon, energy storage is extremely important as it is used in almost all everyday activities, and a rehabilitation protocol that fails to account for this is flawed and full recovery will be difficult to achieve. Therefore, more research is needed to develop a more comprehensive approach for treating chronic mid-portion AT.

A limitation in this systematic review is the use of subjective outcome measures to evaluate improvement. Pain as an assessment can be inconsistent since individuals could have vastly different experiences of pain. How different patients adapt to pain is also relevant as two patients with similar baseline scores could end up with completely different follow up scores based on how their pain-tolerance adapts during the intervention. It is a possibility that their difference in improvement is completely explained by how they adapt to pain, and how they rate it. This can be problematic as it might be difficult to determine if the training protocol works and improves the actual function of the tendon. On the other hand, this might not be a problem because the main aim of the training protocols is to reduce symptoms and if they manage to do that, then no one could argue they are ineffective. Patient satisfaction is also a subjective outcome measure and it is closely linked with an individual's expectations. An example of this is found in the study by Ram and colleagues where a patient deemed itself not satisfied, even though this patients VISA-A score was at 95 points and the VAS score was at 0 after twelve weeks. VAS and VISA-A both assumes that a patient's perception of function and pain can be standardized on a numerical or linear scale, and it also relies on a patient's ability to answer the forms accurately and truthfully. The methods used for measuring outcome in studies included in this systematic review are however considered the most reliable available.

Another limitation of this review is the limited number of studies researching the HSRT protocol. Even though the HSRT protocol produced good results in the study by Kongsgaard and colleagues, the fact that only one study using this approach exists makes it difficult to draw a conclusion. Further research should focus on validation of the HSRT protocol to establish if it in fact can yield reliable results.

A strength in our systematic review is the specific focus on two training protocols, one of which is known to be the most popular ET protocol. This makes it easier to compare the included studies and interpret the results. Other similar systematic reviews tend to include several different training protocols within each subcategory like ET, and by doing so their findings contribute little to the development of an optimal training protocol. This systematic review is also consistent with regards to tendinopathy location and only included studies whose main aim were to investigate the effects on mid-portion AT. This was considered important because inconsistency regarding location could potentially be a confounding factor.

Conclusion

We conclude that although most of the studies in this systematic review further backs up the use of ET in the treatment of chronic mid-portion AT, it does not provide any obvious advantages over HSRT. Data on HSRT is limited and it does not have the same support in the literature as ET. Because of this more research is needed to determine its effect compared to ET. Patient characteristics varied greatly between and within studies giving us a vague picture of how well the protocols work as well as who they work for. Future research should focus on narrowing down patient characteristics to be better able to determine who the protocols might or might not work for. This could be the key to optimizing a training protocol for the treatment of chronic mid-portion AT.

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