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LITERATURE REVIEW

EVALUATING THE PROGRESS OF MID-PORTION ACHILLES TENDINOPATHY DURING REHABILITATION: A REVIEW OF OUTCOME MEASURES FOR SELF- REPORTED PAIN AND FUNCTION

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ABSTRACT

Introduction: Management of mid-portion Achilles tendinopathy is a challenge for both clinicians and researchers. Alteration in tendon structure, muscle performance and pain processing mechanisms have been suggested as mechanisms driving improvement in pain and function. However, few trials have used consistent outcome measures to track changes in pain and function.

***Objectives*:** 1) To identify all outcomes measures used in trials utilizing exercise-based interventions for mid-portion Achilles tendinopathy (AT) that assess self-reported pain and function and to report on the reliability and validity of the identified measures, and 2) Propose measures to optimally assess self-reported pain and function in patients with AT.

***Design*:** Literature Review

***Data Sources*:** Three major electronic databases were searched from inception until May 2016 for studies using isometric, eccentric or isotonic loading protocols for mid-portion AT.

***Eligibility Criteria*:** Randomized and non-randomized trials of isometric, eccentric or isotonic loading in people with mid-portion AT.

***Results*:** Forty-six studies were included and all outcome measures assessing self-reported pain and function were extracted. While a variety of outcome measures have been used, few have provided reliability data. There is evidence to suggest that the Victorian Institute of Sports Assessment- Achilles (VISA-A) is the only valid and reliable measure of self-reported pain and function for people with mid-portion AT. No other outcome measures have been validated in mid-portion AT.

***Conclusion*:** The VISA-A remains the gold standard for assessing pain and function in mid-portion AT. However, while the validity or reliability of the Numerical Rating Scale (NRS) of pain during a functional task has not been established it may be a better measure of immediate treatment effect.

***Level of evidence*:** 5

***Key words*:** Achilles; outcome measures; reliability; tendinopathy; validity

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INTRODUCTION

Achilles tendinopathy (AT) is one of the most common running-related injuries, with a prevalence of 6.2-9.5% in recreational runners[1] and 2-18.5% in ultra-marathon runners.[1] AT can present as either mid-portion or insertional tendinopathy. Mid-portion tendinopathy affects the mid-portion of the tendon approximately 2-4cm proximal to the insertion whereas insertional tendinopathy affects the tendon insertion onto the calcaneus.[2] AT is characterised clinically by pain and stiffness (either mid-portion of the tendon or at the insertion) and these symptoms affect athletic function, which is a key diagnostic feature of the condition.[3,4] Mid-portion and insertional Achilles tendinopathy are considered different clinical entities and thus are considered separately within the literature. Therefore, this review will purely focus on mid-portion Achilles tendinopathy.

Management of AT is a challenge for both clinicians and researchers. Exercise rehabilitation, specifically either eccentric or isotonic resistance training are effective interventions.[2,5] While loading programmes have demonstrated effectiveness, symptoms can persist up to 5 years following exercise rehabilitation with some participants not reaching complete resolution and some not responding to the intervention.[6] One potential explanation for this relates to our incomplete understanding of the mechanisms underpinning this therapy.[7] Several mechanisms have been alluded to in the literature including 1) alterations in tendon structure[8,9] 2) alterations in muscle performance[7] and 3) alterations in pain mechanisms.[10]

One challenge in understanding these mechanisms is the fact that few trials have used consistent outcome measures to track changes in pain and function. The chosen outcome measures also often lack sufficient psychometric properties. It is important that clinicians and researchers are familiar with the outcome measures that have been used in clinical trials including their validity and reliability, as poor choices in outcome measures can lead to results with questionable utility. However, while valid and reliable measures are important for researchers it is also important for clinicians to know which measures are accessible for everyday practice. This may in turn reduce barriers to implementation of these measures.[11]

The objectives of this review were: 1) To identify all outcomes measures that have been used in trials that involved exercise based interventions for mid-portion AT assessing self-reported pain and function, and to report on the reliability and validity of the identified measures; and 2) Recommend those measures that optimally assess self-reported pain and function in patients with AT.

METHODS

Criteria for considering studies for this review

Types of studies

Both non-randomized cohort studies and randomised controlled trials were included if a loading protocol was used to treat mid-portion AT. Case reports, clinical observations and systematic reviews were excluded.

Types of participants

Physically active and sedentary participants aged 18 years and over identified as having mid-portion AT for greater than three months were included. Studies including participants with insertional AT or other causes of pain (differential diagnoses) anywhere in the Achilles region were excluded from the review.

Types of interventions

Intervention studies using either isometric, eccentric, concentric or isotonic (eccentric and concentric) loading protocols were included. Studies that employed an isometric, eccentric, concentric or isotonic loading program in conjunction with a placebo therapy (for example sham laser treatment) were included.

Types of outcomes measures

Only studies that used a self-reported measure of pain and function in mid-portion AT were included.

Search methods for identification of studies

Electronic Searches

Searches using free text terms (Table 1) were used to identify published articles on the following electronic databases; PUBMED, CINAHL (Ovid) and CINAHL (EBSCO). Only peer reviewed, human, clinical trials and cohort studies were included.

Table 1. *Systematic Review Search Strategy*

Number	Combiners	Terms
1	Problem of Interest	Achilles tend*
2	Intervention	exercise OR eccentric OR isotonic OR resistance OR strength*
3		#1 AND #2
	Limitations	Peer reviewed, human, clinical trials written in English

Searching other Resources

Reference lists from reviews and retrieved articles were checked and citation searches on key articles performed. The list of included studies were evaluated by content experts to help identify any additional relevant studies.

Data collection and analysis

Selection of Studies

One review author (MM) independently searched and assessed the titles and abstracts of potential studies identified by the search strategy for their eligibility. Studies were exported to reference management software EndNote X8.0.2 (Clarivate Analytics, 2017) and duplicates were removed. If the eligibility of a study was unclear from the title and abstract the full paper was assessed. Studies that did not match the inclusion criteria for this review were excluded. Studies were not anonymised prior to assessment.

A PRISMA study flow diagram[12] was used to document the screening process as recommended in Part 2, Section 11.2.1 of the Cochrane Handbook for Systematic Reviews of Interventions.[13]

Data abstraction and management

One review author (MM) independently extracted data from all included studies using a standardised and piloted data extraction form on Microsoft Excel (Microsoft, 2016). The following information was recorded; primary author, year of publication, study design, study population (diagnosis), sample size, loading intervention (e.g. heavy eccentric calf training), outcome measures used, number of follow up points and time (weeks) at each follow up point.

Data synthesis

Reliability, validity, minimally clinically important difference (MCID) and the minimal detectable change (MDC) were reported if provided by the study using the outcome measure. If the study provided a reference to psychometric properties, the referenced study was used to extract the data.

RESULTS

Selection of Studies

A total of 46 studies were included and are presented in a Prisma Flow Chart (Figure 1).

Data Extraction

All studies using a loading intervention for mid-portion AT used a measure of self-reported pain and function. The characteristics of the included studies are presented in Appendix A.

Data Synthesis

The outcome measures used to assess pain and function in the interventional clinical trials are presented in Table 2. Most outcome measures in this domain did not report their reliability and have not been validated in mid-portion AT.

Victorian Institute of Sport- Achilles

The Victorian Institute of Sports Assessment-Achilles (VISA-A) has been used in 28 clinical trials and was the most frequently used outcome measure to assess pain and function. The VISA-A has excellent reliability (test-retest r = 0.93-0.98)[58] and is the only

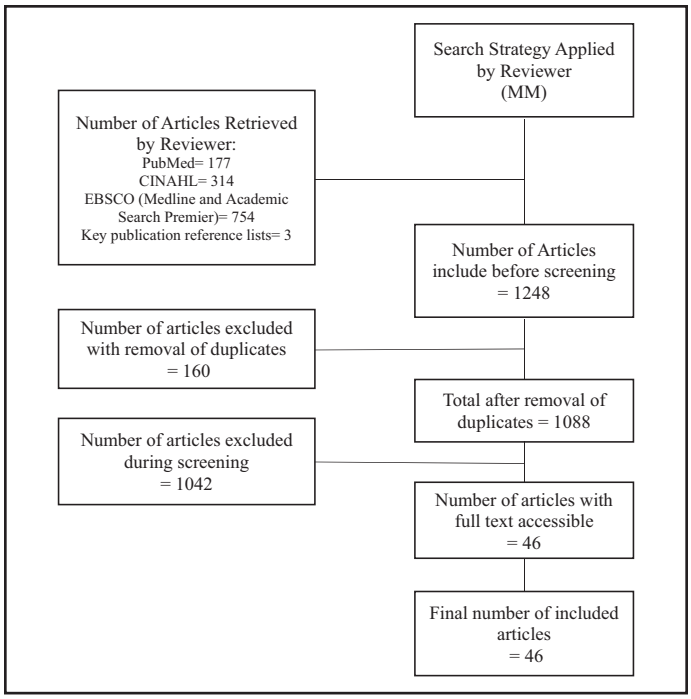

Figure 1. *Prisma Flow Chart.*

Table 2. *Outcome measures assessing self-reported pain and function*

Outcome Measure	Number of Times used in Clinical Trials	Follow up Times (weeks)	Validity	Reliability
Visual Analogue Scale of Pain at Rest	6[18, 24, 31, 45, 50, 55]	2, 3, 4, 6, 8, 12, 26	Assessed against the Numerical Rating Scale in Rheumatoid Disease: r= 0.62-0.91[56] Assessed against a Simple Descriptive Scale in Rheumatic Disease: r= 0.73-0.78[56]	Test Retest Reliability in Mid-portion Achilles Tendinopathy: r= 0.45[45]
Visual Analogue Scale of Pain with various functional tasks	11[5, 14, 15, 18, 24, 32, 34, 40, 45, 46, 49,	2, 4, 6, 8, 12, 26, 52	Not Reported	Test Retest Reliability in Mid-portion Achilles Tendinopathy with Jumping: r= 0.69[45] Test Retest Reliability in Mid-portion Achilles Tendinopathy with Heel Raise: r= 0.61[45]
100mm VAS of Pain with 1kg Squeeze of the Achilles Tendon	3[17, 29, 45]	2, 6, 12, 26	Not Reported	Not Reported
4 Point Scale of Pain with 1kg Squeeze of the Achilles Tendon	1[36]	1, 3, 6, 12, 39	Not Reported	Not Reported
Numerical Rating Scale of Pain at Rest	2[52, 53,	4, 12, 52	Assessed against the Visual Analogue Scale in Rheumatoid Disease: r= 0.61-0.91[56] Assessed against a Simple Descriptive Scale in Rheumatic Disease: r= 0.68-0.88[56]	Test Retest Reliability in Rheumatoid Arthritis: r= 0.95-0.96[57]
Numerical Rating Scale of Pain over time	5[41, 42, 52-54]	4, 12, 16, 26, 52	Not Reported	Not Reported
5 Point Likert Scale of Difficulty in Sport	1[43]	6, 12, 26, 52	Not Reported	Not Reported
Victorian Institute of Sport Assessment - Achilles	28[5, 6, 16, 17, 20-28, 30, 33, 35, 39, 41, 42, 44, 46-48, 50-54	2, 3, 4, 6, 8, 12, 16, 24, 26, 36, 52, 2.2 years	Assessed against the Percy and Conochie's grade of severity in Achilles Tendinopathy: p<0.01[58] Assessed against the Curwin and Stanish grade of severity in Achilles Tendinopathy: p<0.001[44] Assessment of severity in pre-surgical Achilles Tendinopathy, non-surgical Achilles Tendinopathy and two control groups: p<0.001[58]	Test Retest Reliability in Achilles Tendinopathy: r= 0.93-0.98[58] Intra-rater Reliability in Achilles Tendinopathy: r= 0.90[58] Inter-rater Reliability in Achilles Tendinopathy: r= 0.90-0.97[58]
Modified Curwin and Stanish Six Level Pain Scale	2[8, 9]	12, 60, 220	Not Reported	Not Reported
Functional Index of the Leg and Lower Limb (FILLA)	1[18]	2, 4, 6, 12	Not Reported	Not Reported
American Orthopedic Foot and Ankle Score (AOFAS) Hindfoot Scale	1[40]	6, 12	Assessed against the Foot Function Index in Rheumatoid Arthritis Hallux Pain: p<0.05[59]	Test Retest Reliability in Rheumatoid Arthritis Hallux Pain: ICC=0.95[59] Intra-Rater Reliability in Rheumatoid Arthritis: ICC= 0.95[60] Inter-Rater Reliability in Rheumatoid Arthritis: ICC= 0.91[60]
Short Form-36 (SF-36)	2[35, 40]	4, 6, 12, 26, 52	Assessed against the Visual Analogue Scale of Pain in Rheumatoid Arthritis: r= -0.48[61]	Test Retest Reliability in General Practice: α= 0.78[62]
EuroQoL	2[18, 30]	2, 4, 6, 12, 26	Assessed against the Western Ontario and McMaster Universities Osteoarthritis Index in Knee Osteoarthritis: Spearman's rho=0.20-0.60[63] Assessed against the SF-36 in Knee Osteoarthritis: Spearman's rho=0.20-0.60[63]	Test Retest Reliability in Knee Osteoarthritis: 0.70-0.73[63]
Foot and Ankle Outcome Score (FAOS)	3[31, 36, 43]	3, 6, 12, 39	Assessed against the Karlsson Score in Foot and Ankle Osteoarthritis: r=0.58-0.67[64]	Test Retest Reliability in Foot and Ankle Osteoarthritis: ICC= 0.70-0.92[64]
Numerical Scale of Physical Activity	1[43]	6, 12, 26, 52	Not Reported	Test Retest Reliability: "satisfactory"[65]
Numerical Scales of Improvement	8[9, 16, 29, 36, 41, 42, 47, 54	4, 12, 16, 26, 52	Not Reported	Not Reported
Treatment Satisfaction	7[20, 23, 24, 34, 37, 38, 50	3, 6, 12, 52, 112, 200	Not Reported	Not Reported
Patient Global Impression of Change (PGIC)	1[54]	12, 26, 52	Assessed against the Self-Assessment of Treatment Scale in Postherpic neuralgia: r=0.68-0.90[66]	Not Reported

outcome measure used in clinical trials that has been validated for AT; it was validated against two tendon pain rating scales, the Percy and Conochie's grade of severity (Spearmans r = 0.58, p = < 0.01)[58] and that of Curwin and Stanish (Spearmans r = -0.57, p = < 0.001).[58] No MDC has been reported.

The MCID of an outcome measure is important both for study design (e.g. power calculations), as well as measuring whether or not an intervention reflects a meaningful improvement for the patient.[67] The majority of outcome measures reported in the literature to assess pain and function have not yet had

Table 3. *Frequency of the MCID reported for the VISA-A in mid-portion Achilles Tendinopathy in clinical trials using loading protocols*

MCID	Frequency
10	6[5, 16, 35, 44, 46, 47]
12	4[21, 25, 27, 30]
15	2[42, 50]
16	3[51-53]
17	1[39]
20	1[54]

the MCID calculated for mid-portion AT. The VISA-A has had the MCID reported for insertional AT with an improvement of 6.5 points reflecting a meaningful improvement for the patient.[68] The MCID of the VISA-A in mid-portion AT has only once been reported in one pilot study, with an MCID of 16 points.[68] However, this study did not provide any information on how the MCID was calculated and it is unlikely using the study design they would have been able to complete calculations required for determining a MCID.[67] However, most clinical trials reviewed here used other scores, with 10 points[5,16,35,44,46,47] being the most common MCID reported (Table 3).

In addition to the MCID another psychometric property commonly used is the minimal detectable change. However, none of the papers included in this review which used the VISA-A made any reference to this.

Visual Analogue Scale and Numerical Rating Scale

Variations of the Visual Analogue Scale (VAS) (Table Two) and Numerical Rating Scale (NRS) using average pain, worst pain, pain at rest or during functional tasks have been used in sixteen and five clinical trials, respectively. The VAS has been shown to have poor test-reliability at rest in AT ($r = 0.45$)[45] however this is marginally better when used to assess pain during functional tasks ($r = 0.61\text{-}0.69$).[45] Whilst the VAS has been shown to be valid when tested against a variety of pain rating scales in other conditions, such as rheumatoid disease, total knee replacement and acute abdominal pain,[56,69,70] it has yet to be validated in AT.

The NRS has been shown to be highly reliable in other musculoskeletal pain conditions, such as rheumatoid arthritis,[57] but it has yet to be determined in patients with AT. While the NRS has been shown to be valid when tested against a variety of pain rating scales in other conditions (e.g. rheumatoid disease, chronic low back pain, osteoarthritis)[56,71,72] it has yet to be validated in AT.

A variety of other self-reported pain and improvement scales have been used in clinical trials however none of these scales have been validated in AT (Table 2).

None of the papers included in this review which used the NRS or VAS made any reference to either the MCID or MDC for these measures in mid-portion AT pain.

DISCUSSION

Pain and function have been measured with VISA-A and pain scales including NRS and VAS. However, the timing and instructions of implementing the VAS and NRS differs vastly between trials; for example worst pain today, current resting pain or pain during loading task such as hopping. It is unclear in both a research and clinical setting when these pain and function outcome measures should be used.

The results of this review indicate that the VISA-A is the only validated and reliable measure of pain and function for mid-portion AT. It is therefore recommended as currently being the best primary outcome measure to assess these clinical domains. However, problems do remain when considering utilisation of the VISA-A in clinical practice; firstly, completion of the VISA-A may not be practical for assessing immediate response to treatment. Furthermore, the process used to develop and validate the VISA-A does not conform to current recommendations in developing a self-reported outcome measure and is missing components suggested to be vital in developing a self-reported outcome measure.[73] Given that the VAS and NRS of pain are easily applied and have been validated[56, 69-72] for musculoskeletal pain in other conditions, they may be more appropriate for assessing immediate treatment effect; however, further research is of course required to establish reliability and validity. Specifically, given that the NRS of pain has been shown to be more reliable, valid and responsive than the VAS of pain in other musculoskeletal pain conditions[57,74] it may be the preferred choice. Immediate treatment effects have been measured in patellar tendinopathy by comparing the NRS of pain during a provocative functional test (single leg decline squat) before and

immediately after a loading program.[75,76] By mirroring this investigational methodology in AT, further information on the immediate effect of loading on tendon pain can be gathered. However, caution must be taken given that the validity and reliability of the NRS of pain in AT remains unknown.

Improvements have been observed in VISA-A scores in as early as two weeks following commencement of a loading protocol.[17] For both clinicians and researchers, completing a VISA-A at multiple time points during the intervention may help determine the rate of change, and provide insight into the mechanisms relating to improvements based on the temporal response.

While the MCID of the VISA-A has been reported in insertional AT it has not been formally reported in mid-portion AT. No clear consensus exists with the only study which has reported an MCID not providing any information on how the MCID was calculated. Without clear information on how the MCID was calculated we cannot be confident in the results. Currently the authors would suggest that two different methods can be utilized for choosing the MCID for sample size calculations when using the VISA-A as the primary outcome measure in a clinical trial; 1) using the MCID of insertional AT (6.5 points);[68] or 2) using the most commonly reported MCID in clinical trials (10 points).[5,16,35,44,46,47] Either of these methods of selecting a MCID for power calculations to estimate sample sizes are appropriate, however they are potential sources of error given the true MCID for mid-portion AT has not been calculated.

The quality of the studies using an exercise intervention for mid-portion AT was very low. A mix of randomized and non-randomized studies existed, each containing small sample sizes. Only four out of 46 studies identified in this paper have a sample size of greater than 50 participants. When considering that the quality of evidence is low, and that 18 out of 46 studies failed to use a reliable or validated measure of self-reported pain and function clinicians must be wary when drawing conclusions based on study efficacy from this body of work.

CONCLUSION

Many different outcome measures have been used to assess pain and function in clinical trials that study the treatment of mid-portion AT with exercise rehabilitation. To assess pain and function the VISA-A appears to be the most valid and reliable tool. However, the NRS of pain during a functional task is possibly a simpler tool to assess immediate effect post-treatment or short-term effects of interventions as it may be more responsive to change. It is important for clinicians and researchers to be aware of the outcome measures that have been used as well as the reliability and validity of these measures. By identifying the best measures, rehabilitation professionals can optimize clinical assessment and improve clinical trials, as well as identify areas that require further research.

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Appendix A. *Individual Study Characteristics*

Study Name	Study Design	Cohort Size (n)	Loading Intervention in Exercise Arm of Study
Alfredson et al. (1998)[14]	Cohort	15	Heavy Eccentric Calf Training
Alfredson & Lorentzon. (2003)[15]	Cohort	6	Heavy Eccentric Calf Training
Bell et al. (2013)[16]	RCT	27	Heavy Eccentric Calf Training
Beyer et al. (2015)[5]	RCT	25	Heavy Eccentric Calf Training
		22	Heavy Slow Resistance Training
Brown et al. (2006)[17]	RCT	18	Heavy Eccentric Calf Training
Chester et al. (2008)[18]	RCT	8	Heavy Eccentric Calf Training
Crill et al. (2014)[19]	Cohort	25	Heavy Eccentric Calf Training
De Jonge et al. (2010)[20]*	Cohort	32	Heavy Eccentric Calf Training
De Jonge et al. (2011)[21]*	RCT	27	Heavy Eccentric Calf Training
De Jonge et al. (2015)[22]*	RCT	54	Heavy Eccentric Calf Training
De Vos et al. (2007)[23]	RCT	32	Heavy Eccentric Calf Training
De Vos et al. (2007)[24]*	Cohort	58	Heavy Eccentric Calf Training
De Vos et al. (2010)[25]*	RCT	27	Heavy Eccentric Calf Training
De Vos et al. (2011)[26]*	RCT	27	Heavy Eccentric Calf Training
De Vos et al. (2012)[27]*	Cohort	24	Heavy Eccentric Calf Training
Gardin et al. (2010)[8]*	Cohort	24	Heavy Eccentric Calf Training
Herrington et al. (2007)[28]	RCT	13	Heavy Eccentric Calf Training
Horstmann et al. (2013)[29]	RCT	19	Heavy Eccentric Calf Training
Kearney et al. (2013)[30]	RCT	10	Heavy Eccentric Calf Training
Knobloch et al. (2008)[31]	RCT	59	Heavy Eccentric Calf Training
Langberg et al. (2007)[32]	Cohort	6	Heavy Eccentric Calf Training
Maffuli et al. (2008)[33]	Cohort	45	Heavy Eccentric Calf Training
Mafi et al. (2001)[34]	RCT	22	Heavy Eccentric Calf Training
		22	Concentric Calf Training
Munteneau et al. (2015)[35]	RCT	54	Heavy Eccentric Calf Training
Norregaard et al. (2007)[36]	RCT	21	Heavy Eccentric Calf Training
Ohberg & Alfedson (2004)[37]	Cohort	30	Heavy Eccentric Calf Training
Ohberg et al. (2004)[38]	Cohort	25	Heavy Eccentric Calf Training
Pearson et al. (2012)[39]	RCT	18	Heavy Eccentric Calf Training
Peterson et al. (2007)[40]	RCT	37	Modified Heavy Eccentric Calf Training
Rompe et al. (2007)[41]	RCT	23	Heavy Eccentric Calf Training
Rompe et al. (2009)[42]	RCT	30	Heavy Eccentric Calf Training
Roos et al. (2004)[43]	RCT	16	Modified Heavy Eccentric Calf Training
Sayana & Maffuli (2007)[44]	Cohort	34	Heavy Eccentric Calf Training
Shalabi et al. (2004)[9]	Cohort	25	Heavy Eccentric Calf Training
Silbernagel et al. (2001)[45]	RCT	22	Eccentric Overload
Silbernagel et al. (2007)[46]	RCT	26	Eccentric Overload with Active Rest
		24	Eccentric Overload
Silbernagel et al. (2011)[47]*	Cohort	34	Eccentric Overload
Stasinopoulos & Manias (2013)[48]	RCT	20	Heavy Eccentric Calf Training
		21	Stanish Protocol
Stergioulas et al. (2008)[49]	RCT	20	Heavy Eccentric Calf Training
Stevens & Tan (2014)[50]	RCT	14	Heavy Eccentric Calf Training
		12	Modified Heavy Eccentric Calf Training
Tumilty et al. (2008)[51]	RCT	10	Heavy Eccentric Calf Training
Tumilty et al. (2012)[52]	RCT	17	Heavy Eccentric Calf Training
Tumilty et al. (2016)[53]	RCT	13	Heavy Eccentric Calf Training
		19	Modified Heavy Eccentric Calf Training
Van der Plas et al. (2012)[6]*	Cohort	46	Heavy Eccentric Calf Training
Yelland et al. (2011)[54]	RCT	15	Heavy Eccentric Calf Training
Yu et al. (2013)[55]	RCT	16	Heavy Eccentric Calf Training
		16	Concentric Calf Training

** The results of this study are a follow up of an included study or present different components of data from another included study.*