

## Exercise Therapy for Plantar Heel Pain: A Systematic Review

AMEER A. ALMUBARAK<sup>1,2</sup> and NADINE FOSTER<sup>2</sup>

<sup>1</sup>Ministry of Higher Education, Riyadh, Kingdom of Saudi Arabia; <sup>2</sup>Keele University, Staffordshire, United Kingdom

†Denotes graduate student author

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### ABSTRACT

*International Journal of Exercise Science* 5(3) : 276-295, 2012. This study aimed to review the evidence of exercise therapy in the treatment of Plantar Heel Pain. Comprehensive search strategy was conducted to identify randomized and quasi-randomized trials. The primary outcome was pain intensity; the secondary outcome was functional limitation. From an initial list of 2327 potentially relevant trials, seven trials were included. Most trials included short-term follow up only of pain and function outcomes. Narrative review revealed limited evidence that stretching exercise alone was superior to other conservative treatments; combining other conservative treatments with stretching was more effective than stretching exercise alone. Limited evidence showed that supervised clinical-based exercise is more effective than home-based self exercise. There is limited evidence that adding stretching exercise to the conservative treatment is more effective than control/ sham therapy. Future trials should investigate the effectiveness of long-term treatment of stretching and other forms of exercise therapy on larger sample size.

KEY WORDS: Heel pain, plantar fasciitis, exercise, stretch, systematic review

### INTRODUCTION

Plantar Heel Pain (PHP) has been defined as a broad term expressing unspecified symptoms and conditions affecting the medial plantar aspect of the heel (31), or in the insertion site of the plantar fascia in the medial tuberosity of the calcaneal bone (12). Health care professionals and researchers usually use the terms: heel pain, plantar fasciitis, plantar fasciodesis and calcaneal spur interchangeably without specifying the accurate underlying pathology. However, the term PHP was used recently rather than previous terms to generalize results of studies and cover all themes of

heel pain pathologies. PHP may exist for a short time (acute) either continuously or intermittently. If the pain lasts for more than six months it should be considered chronic PHP (11).

PHP is usually characterized by pain in the medial side of the heel during loading activities or during first-step activities (23). The nature of this pain is described as throbbing, searing or piercing ;The same pain can be felt after periods of inactivity or prolonged sitting (8). PHP significantly affects the quality of life in many patients. Irving *et al.* (25) found that those in middle age with high body mass index and chronic

PHP demonstrated a significant deterioration in foot health. Scores on questions like foot pain, foot function, footwear, physical activity, and social capacity were lower in those with chronic PHP.

The prevalence of PHP is relatively high. Hill *et al.* (22) reported point estimates of 3.6% in Australian population; 33.4% of those complain of chronic pain. Crawford (9) reported that approximately one in ten American individuals will develop chronic PHP and nearly two million Americans are affected yearly. In athletic populations in both UK and USA, the point estimate was approximately 8%, which is relatively higher than non-athletic people (28, 53).

There are different risk factors in those with PHP. Pigliardo *et al.* (37) suggested that multiple anatomical structures of plantar heel may be affected and involved in PHP and the risk factors may be different in each layer of the plantar heel. Thomas *et al.* (54) classified five main themes of PHP risk factors: (i) neurological; (ii) arthritic; (iii) mechanical; (v) traumatic; and (vi) other heel pain types. Although mechanical risk factors of PHP is the most common, PHP usually is multi-factorial disease and more than one of PHP risk factors may co-exist in same patient (37).

Conservative therapies have been adopted in the management of PHP. Shock-wave therapy, manual therapy, therapeutic ultrasound, myofascial trigger points and western dry needling have been frequently investigated in literature as suggested conservative treatments for those with PHP (54). However, the previous treatments are relatively expensive and need supervision

from a qualified health practitioner. In contrast, Exercise therapy (mainly unsupervised home-based exercise therapy) is a cost-effective and flexible conservative therapy. Up to date, no reviews investigated the effectiveness of exercise therapy in the treatment of PHP. Stuber and Kristmanson (51) reviewed randomized trials which investigated stretching exercises in patients with plantar fasciitis. However, they included only three studies from a chiropractic perspective without a specific focus on exercise therapy. The aim of this review is to summarize the evidence on the effectiveness of exercise therapy in the treatment of PHP. Using a systematic review approach, this study will compare exercise therapy in terms of reducing pain and functional limitation with (i) different settings of exercise therapy (ii) placebo, sham therapy, no treatment or waiting list controls; (iii) other conservative treatment options.

## METHODS

### *Search Strategy*

The following bibliographic databases were searched to identify potentially relevant trials: (i) MEDLINE from 1966 to November 2010; (ii) EMBASE from 1980 to November 2010; CINAHL from 1981 to November 2010 (iii) SPORTDiscus from 1985 to November 2010; (iv) PEDro From 1987 to November 2010; (v) Cochrane Central Register of Clinical Trials (CENTRAL).

Both free-text and subject headings in previous databases were used to identify the eligible trials. Alerts were designed through an ISI Web of Knowledge database to deliver weekly updates of additional citations for the authors through to 30<sup>th</sup> of

November 2010. No language, date or document format restrictions were applied. Non-English trials were translated by a professional translator with medical background. The electronic search strategy presented in Appendix I. The authors of the included trials were contacted to identify further unknown trials, especially grey, unpublished, ongoing or in-press articles.

### *Inclusion and Exclusion Criteria*

Trials included in this review had to be randomized controlled trials (RCTs) or quasi-randomized trial (QRTs); RCTs are the trials which include at least one intervention and one comparison control group with random allocation for subjects with all groups. QRTs are the trials which include at least one intervention group which not randomly allocated. Trials which were published in peer-review journals were included. Measures of either pain or function or both had to be reported in included trials. Only Trials which used exercise therapy in at least one group or subgroup of PHP were included. Trials which used combined treatment with exercise therapy (e.g insoles) were included if combined treatment used also in comparison group. Participants in included trials needed to be 16 years or older suffering from PHP regardless of onset or duration. Although, acute and chronic PHP may be treated with different parameters of exercise therapy, a decision was made to include both because of limited number of PHP trials investigated the effectiveness of exercise therapy. For the purpose of this review, PHP was defined as pain localized to the medial plantar aspect of the heel, made worse by weight-bearing activities after prolonged periods of standing, sitting or rest (54). Trials included in this review

had to either describe the signs and symptoms of participants as being consistent with this definition, or state a diagnosis known primarily by these clinical features. Trials had to mention explicitly that the exercise therapy was designed mainly for PHP.

Studies which discussed specific pathological conditions (such as diabetes mellitus or rheumatoid arthritis), neurovascular abnormalities, and plantar fibromatosis were excluded. The previous pathological conditions were considered to relate to blood glucose level, immunity, genetic factors, etc rather than depending on PHP risk factors. These reasons may misinterpret the potential positive or harmful effects of exercise therapy. Studies which investigated any other conservative, surgical or medical treatment except exercise therapy combined with exercise therapy in the same group or sub-group were excluded too (e.g. using orthotic device(s) or braces to produce stretching or lengthening exercises). However, Trials used same conservative therapy in both treatment and comparison groups were included.

### *Outcomes*

The primary outcome for this review was PHP pain intensity. Secondary outcome was functional limitation (e.g. decreased ankle dorsiflexion in daily living activities). Outcome measures were grouped according to the length of the follow-up since the baseline measurement into short-term (less than three months), mid-term (three to twelve months) and long-term (more than one year). This classification was followed because it was used in most of included trials in this systematic review.

*Trials Selection and Data Extraction*

The potential relevant trials produced by the search strategy were examined by the author (AA) and the first independent reviewer (NF) for eligibility according to the inclusion and exclusion criteria. Titles and abstracts were examined to remove clearly irrelevant studies. Authors of included trials were contacted by e-mails to clarify exclusion and inclusion criteria of relevant trials with successful response from two authors. A pilot study was conducted before the main study on a number of different studies (relevant, irrelevant and possibly relevant) to test out the application of the inclusion and exclusion criteria.

Outcome data and information regarding the trial design, participants, settings of treatment, and summary of information about the interventions groups were extracted. Information about adherence and exposure to the intervention were collected where possible from the identified trials (21). Only outcomes regarding pain intensity and functional limitation were collected from the included trials. Adverse effects were collected for the same outcome measures.

*Quality Assessment of Included Trials*

The quality assessment tool used in this systematic review was the PEDro scale. PEDro is a scale with a good reliability (29), based on the Delphi list (55). The quality of included trials was reassessed regardless of the previous published PEDro rating score in the official PEDro website ([www.pedro.org.au](http://www.pedro.org.au)).

*Data Analysis*

In this review, narrative synthesis was followed according to the following three factors: (i) population characteristics; (ii) clinical diversity; (iii) statistical homogeneity. Decisions according to the previous three factors were made by the author (AA) and the first independent reviewer (NF). One important note regarding clinical diversity is the risk that the outcome event varies between studies; the baseline of a particular event may be viewed as an aggregate measure of case-mix factors such as age or disease severity (21). Therefore, narrative synthesis was followed in all comparison in this review.

Standardized effect size of exercise therapy versus comparison group (s) was calculated by Cohen's *d*, an approach described by Jacob Cohen (7). Cohen's *d* effect size was calculated for those trials which concluded that specific exercise therapy or treatment included exercise therapy was more effective than comparison or control treatment. The aim is to see to what extent the size of effect was large. According to Cohen (7), for Cohen's *d* an effect size of 0.2 to 0.3 might be a "small" effect, around 0.5 a "medium" effect and 0.8 to infinity, a "large" effect. The effect size calculated if the data of mean, standard deviation and sample size were available for both experimental and control group. The effect size calculation performed by StatsDirect (StatsDirect v. 2.7.2, Altrincham, UK).

**RESULTS***Outcome of Search Strategy*

The electronic search of MEDLINE, CINAHL, SPORTDiscus, CENTRAL, EMBASE, AMED and PEDro databases resulted in 2,327 potentially relevant trials.

Forty of these trials were deemed potentially eligible after reading the titles and abstracts but follow-up reading the full texts, 33 of these trials were excluded for various reasons (Table 1). Thus, seven trials were appropriate for inclusion in this review. Citation tracking and alerts which were established through the ISI web of knowledge suggested two additional trials. One of these was subsequently deemed ineligible and the other was already included (45). A flow chart of the progress of search strategy is presented in Figure 1.

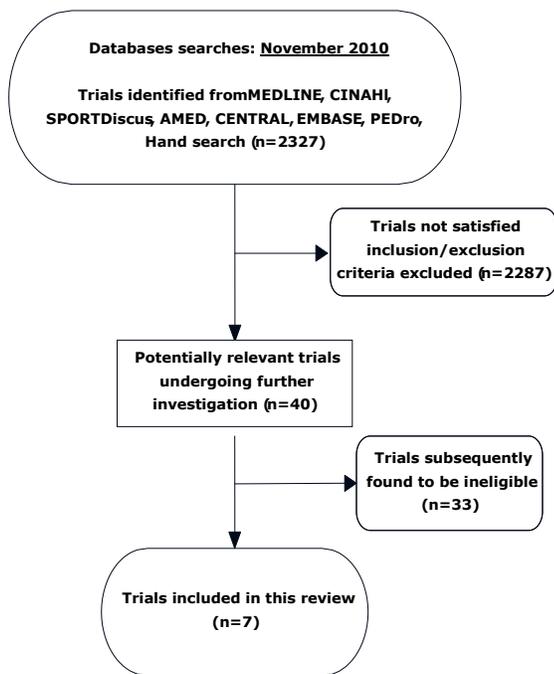


Figure 1: Outcome of comprehensive search strategy.

#### *Characteristics of Included Trials*

In most of the included trials, the effect size of exercise therapy classified as small effect size according to Cohen's *d*. Unfortunately, pooling effect size data from some studies were impossible because these studies did not report either standard deviation or mean in exercise therapy and control

groups (36, 13). Table 2 gives a summary of the included trials. In general, home-base stretching exercise of calf muscles, plantar-fascia, flexors of big toe or achilles tendon was used in the included trials (13, 36, 38, 41, 45, 52). The weight-bearing exercise was followed in two included trial (38, 41). One included trial compared weight-bearing versus non weight-bearing exercise (13). Two included trial used both weight-bearing and non weight-bearing exercise together in exercise therapy group (36, 52). Clinical-based, supervised, delivered by practitioner exercise were followed in one included trial only (24). Table 3 gives summary about characteristics of exercise therapy in included trials. Evaluating the quality of included trials with the PEDro tool showed a median score of 5 (range of 4-9) out of 10. The detailed scores of the PEDro scale for the included trials are presented in Table 4.

#### *Exercise Therapy Versus Sham/ Control Therapy*

Two trials compared the effectiveness of exercise therapy with other control/sham therapy (24, 41). One prospective randomized controlled trial (41), with a sample size of 92 middle aged chronic PHP patients, PEDro score of 9 and a short-term follow up (2 weeks), concluded that weight-bearing calf stretching was not effective in reducing first step pain, general foot pain, foot function or general foot health compared with the control group. The other prospective randomized controlled trial (24), with a sample size of 41 middle aged chronic PHP patients, PEDro score of 5 and a short-term follow-up (1 week), concluded that supervised stretching of toe-extensors with plantar fascia stretching and calf stretching statistically decreased pain and

## EXERCISE THERAPY FOR PLANTAR HEEL PAIN

Table 1: trials excluded from the review

Reason for exclusion	Trial
Impossible to conclude Effectiveness of exercise therapy because of different treatments in allocated intervention and comparison groups	Abbott <i>et al.</i> (1), Ayotte <i>et al.</i> (3), Cleland <i>et al.</i> (6), Davis <i>et al.</i> (11), Dimou <i>et al.</i> (15), Donley <i>et al.</i> (16), Filippou <i>et al.</i> (17), Greve <i>et al.</i> (19), Gudeman <i>et al.</i> (20), Melegati <i>et al.</i> (32), Osborne & Allison(33), Ozdemir <i>et al.</i> (34), Powell <i>et al.</i> (39), Probe <i>et al.</i> (40), Ryan <i>et al.</i> (46), Saxena & Fullem(47), Sharma & Loudon(48), Stratton <i>et al.</i> (50), Wolgin <i>et al.</i> (57).
Retrospective trial and used different stages of combined treatments	Barry <i>et al.</i> (4)
Patients in exercise group who did not improve shifted to receive comparison group treatment	Batt <i>et al.</i> (5)
PHP differential diagnosis and symptoms were not defined	Marabha <i>et al.</i> (30)
Case trial or case series design	Patla <i>et al.</i> (35), White <i>et al.</i> (56), Young <i>et al.</i> (59)
Diagnostic or theoretical studies	Allen <i>et al.</i> (2), Creighton & Olson(10), Filippou <i>et al.</i> (17), Kwong <i>et al.</i> (49)
Relevant trial published already, one group received comparison treatment	DiGiovanni <i>et al.</i> (14)
Trial investigated other treatments	Kavros(26), Sheridan <i>et al.</i> (49), Wynne <i>et al.</i> (58)

## EXERCISE THERAPY FOR PLANTAR HEEL PAIN

Table 2: Summary of included studies.

Trial	Design	Participants characteristics		Interventions (I: intervention (n=), C: control (n=))	Measurement outcomes (Adverse events)	Foll ow- up (w)	Loss to follow- up (drop out) (%)	Author's conclusion
		average age, source (participant number)	duration of complaint , BMI (day standing hours)					
Radford et al. (41)	RCT	Mean=50, local community advertisement (92)	One month or more, 31.8 (7.5)	I: sham ultrasound + calf muscle stretch (n=46). C: sham ultrasound only (n=46).	Primary: First step pain foot pain, foot function footwear and foot health-questionnaire Secondary: Ankle ROM, foot posture (stretching pain, calf pain, increase heel pressure).	2	0	Short term calf stretching was not effective in reducing pain and functional limitation comparing with control group.
DiGiovanni et al. (13)	RCT	Mean=46, educational college (101)	More than 10 months, 28.3 (5.75)	I: soft insole, NSAIDs, educational video, plantar fascia stretching (n=46). C: soft insole, NSAIDc, educational video, Achilles tendon stretching (n=36)	Primary: Pain subscale of FFI, first step pain, function and satisfaction with treatment (stopping stretching exercise for unknown reasons).	8	20	Plantar fascia specific stretching was superior to traditional weight-bearing Achilles tendon stretch for pain and functional limitation.
Hyland et al. (24)	RCT	Mean=40, local gymnastics and physicians offices (41)	? , 25 (?)	I: ankle plantar flexors, and plantar fascia and big toe flexors stretching (n=10) C1: control (n=10) C2: calcaneal taping (n=11) C3: sham taping (n=10)	Primary: Pain VAS, functional limitation PFPS.	1	2	Calcaneal taping was more effective than stretching. Stretching was more effective than sham taping and control.
Pfeffer et al. (36)	RCT	Median=48, various orthopaedic foot and ankle centres (236)	6 months or more in majorit y, 28(?)	I: Achilles and plantar fascia stretching (n=46) C1: Achilles and plantar fascia stretching+ silicone heel pad(n=51) C2: Achilles and plantar fascia stretching+ felt insert (n=47) C3: Achilles and plantar fascia stretching+rubber heel cup (n=50) C4: Achilles and plantar fascia stretching+ custom- made polypropylene neutral orthotics (n=42)	Primary: Pain subscale of FFI questionnaire, Secondary: Time to start of improvement, change in pain under various specific circumferences and change in activity.	8	I: 15.2 C1: 17.7 C2: 10.6 C3: 14 C4: 19.1	Prefabricated inserts with stretching groups were more effective in reduction of symptoms than stretching only group

## EXERCISE THERAPY FOR PLANTAR HEEL PAIN

Porter et al. (38)	RCT	Mean=46, Sport medicine clinic (94patients)	Half of participants more than 6, 28.5 (?)	I: sustained achilles stretching (n=54) C: intermittent achilles stretching (n=40)	Primary: pain from LLFA questionnaire, Ankle dorsiflexion ROM, Achilles tendon flexibility (medical problems).	16	I: 26 C:3 5	Both intermittent and sustained Achilles stretching increased flexibility, reduced pain. no statistical significantly difference between two stretching group
Rompe et al. (45)	RCT	Mean=52, outpatient clinics (102)	6 months or less, 27.5 (6.5)	I: plantar-fascia specific stretching program and heel pad (n=54) C: radial shock-wave therapy and heel pad (n=48)	Primry: Pain Subscale FFI, SWT (I: pain related to exercise, stopping plantar-fascia exercise; C: transient redding)	65	I: 22 C: 17	Manual specific plantar fascia stretching was superior to repetitive-low energy shock-wave therapy in reducing pain
Szabo et al. (52)	QRT	Mean=52, orthopaedic hospital (37 patients, 41 limbs)	20 months or more, 31(?)	I: Plantar-fascia specific stretching (n=10 limbs) C1: Iontophoresis (n=14 limbs) C2: Plantar-fascia specific stretching + Iontophoresis (n=17 limbs)	Primary: MTP extension, ankle extension, foot & ankle VAS	0, 6	0	Stretching exercise showed significant effectiveness comparing with iontophoresis in reducing pain, stretching and iontophoresis was slightly more effective than stretching group in reducing pain

w= follow up times since baseline measurement in weeks; n= sample size; %= percentage of drop out; ?= not reported; C1= comparison group1; C2=comparison group 2; C3= comparison group 3; C4= comparison group4; FFI= Foot Function Index; NSAIDs= Non-Steroidal Anti-inflammatory Drugs; ROM= Range of Motion; VAS= Visual Analogue Scale; PFPS= functional limitation; LLFA= American academy of orthopaedic surgeons lower limb; Foot & ankle core module; SWT= shock wave therapy; MTP= metatarsophalangeal joint; QRT= Quasi-randomized trial; RCT: Randomized controlled trial.

# EXERCISE THERAPY FOR PLANTAR HEEL PAIN

Table 3. Summary of Exercise therapy characteristics.

Trial	Combined treatment with exercise (I: intervention group, C: comparison group)	Duration of exercise therapy (weeks)	Sessions per week (No.)	Length of session (Min.)	Advice Yes (y) No (n)	Type of exercise *				Progressed (y=yes, n=no)	Grouped (g), individual (i)	Supervised (s), unsupervised (u)	Exercise setting facility (f), home (h)	Delivered by practitioner (y: yes, n=no)
						Intervention (i)	Comparison (c)	PF stretch.	Ach. Stretch					
Radford et al. (41)	I:Sham US	2	≥7	≥5	y		I C			n	i	u	h	n
DiGiovanni et al. (13)	I: soft insole, celecoxib, educational video C: soft insole, celecoxib, educational video	≥8	21	1 minute and 40 seconds	y	I	C			n	i	u	h	n
Hyland et al. (24)	-	1	3	1.5	n	I	I	I		n	i	s	f	y
Pfeffer et al. (36)	C1: silicone heel pad C2: felt insert C3: rubber heel cup C4:polypropylene orthosis	Majority less than 52	14 (all groups)	10 (all groups)	y	C1 C2 C3 C4	C1 C2 C3 C4			n	i	u	h	n

## EXERCISE THERAPY FOR PLANTAR HEEL PAIN

Porter et al. (38)	-	16	I:21 C:14	I: 3 C: 1 minute 40 second s	y		I (sustained) C (intermittent)		n	i	u	h	n
Rompe et al. (45)	Heel pad	8	I:21	1 minute 40 second s	y	I			n	i	u	h	n
Szabo et al. (52)	Heel pad, NSAIDs	6	I: 35 C:	?	y		I C2	I C2	y	i	u	h	n

PF = plantar fascia stretching; Ach=achilles tendon stretching; Calf= calf muscles stretching; NSAIDs= non-steroidal anti-inflammatory drugs; ? = not reported; I= intervention; C= comparison; C1= comparison group 1; C2= comparison group 2; C3= comparison group 3; C4= comparison group 4; No.= number; Min.= time in minutes.

## EXERCISE THERAPY FOR PLANTAR HEEL PAIN

Table 4. PEDro criteria to evaluate quality of included trials.

Trial	Criterion 1: Source of subject and criteria list*	Criterion 2: Random allocation	Criterion 3: Concealed allocation	Criterion 4: More than one variable Key outcomes	Criterion 5: Subject blinding	Criterion 6: Therapist blinding	Criterion 7: Assessor blinding	Criterion 8: Adequate follow-up	Criterion 9: Intention to treat analysis	Criterion 10: Between-group statistical comparison	Criterion 11: Point measure	Overall score
Radford et al. (41)	<b>Yes</b>	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9
DiGiovanni et al. (13)	<b>Yes</b>	Yes	Yes	No	No	No	No	Yes	No	Yes	Yes	5
Hyland et al. (24)	<b>Yes</b>	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5
Pfeffer et al. (36)	<b>Yes</b>	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Porter et al. (38)	<b>Yes</b>	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5
Rompe et al. (45)	<b>Yes</b>	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	5
Szabo et al. (52)	<b>Yes</b>	No	No	Yes	No	No	No	No	Yes	Yes	Yes	4

\*: Not included in overall score, Yes= study satisfied specific criterion, No= study doesn't satisfied specific criterion.

self functional limitation compared with both the control and sham taping groups.

### *Exercise Therapy Versus Combination of Customised Orthotic Device and Exercise*

One multi-centre prospective randomized trial (36), with a sample size of 236 middle aged chronic PHP patients, PEDro score of 6 and a short-term follow-up (8 weeks), compared the effectiveness of home-based exercise therapy with a combination of the same exercise therapy and a customized orthotic device. The trial concluded that both exercise therapy and combination of exercise with a customized orthotic device reduced the overall foot pain when compared with baseline results. However, the exercise therapy alone group was more effective in reducing overall pain than the combination group in those who stood for 8 hours or more daily. The patients who stood for less than 8 hours daily in the combination group showed more effectiveness than the exercise therapy alone group.

### *Exercise Therapy Versus Other Form of Exercise Therapy*

Two trials compared the effectiveness of one form of unsupervised, home-based exercise therapy with another form of home-based, unsupervised exercise therapy (13, 38). One prospective randomized trial (38), with a sample size of 92 middle aged PHP patients, PEDro score of 5 and intermediate follow-up (16 weeks), concluded that both sustained and intermittent Achilles tendon stretching increased the flexibility of the Achilles tendon, decreased foot and ankle pain, and increased foot and ankle function (ankle dorsiflexion). However, there was no significant difference in the previous

outcome between the two forms of exercise therapy (sustained and intermittent tendon Achilles stretching). The other prospective randomized trial (13), with a sample size of 101 middle aged chronic PHP patients, PEDro score of 5 and a short-term follow-up (8 weeks), also tested unsupervised home exercise therapy and concluded that plantar fascia specific stretching is superior to traditional weight-bearing Achilles tendon stretching in terms of reduction of PHP first-step pain, pain at its most severe, overall pain, increased function, and overall satisfaction compared with those treated with traditional weight-bearing Achilles tendon stretching.

### *Exercise Therapy Versus Repetitive Low-Energy Shock-Wave Therapy*

One prospective randomized trial (Rompe, Cacchio et al. 2010), with a sample size of 102 middle aged acute PHP patients, PEDro score of 6 and a long-term follow-up (65 weeks), compared the effectiveness of exercise therapy in the form of repetitive specific plantar fascia stretching versus repetitive low energy radial shock wave therapy. The trial concluded that both manual specific plantar fascia stretching and radial shock wave therapy reduced pain at its worst, first step pain, and overall pain. However, repetitive specific plantar fascia stretching was superior to repetitive low-energy shock-wave therapy in those with acute plantar heel pain.

### *Exercise Therapy Versus Combination of Exercise Therapy and Foot Insoles*

One multi-centre prospective randomized trial (36), with a sample size of 236 middle aged chronic PHP patients, PEDro score of 6 and a short-term follow-up (8 weeks), compared the effectiveness of

unsupervised, home exercise therapy with various forms of prefabricated foot inserts. Exercise therapy consisted of plantar fascia and Achilles stretching in all groups. The trial concluded that both the independent exercise therapy alone group and the exercise with prefabricated foot inserts group reduced the overall foot pain when compared with baseline results. However, the conclusion of both the prefabricated foot inserts and exercise was more effective in reducing overall pain than the exercise therapy group.

### *Exercise Therapy Versus Calcaneal Taping*

One prospective randomized controlled trial (24), with a sample size of 41 middle aged chronic PHP patients, PEDro score of 5 and a short-term follow-up (1 week), concluded that both calcaneal taping and supervised stretching of toe-extensors with plantar fascia stretching reduced pain and functional limitation. However, calcaneal taping was more effective than the stretching of toe-extensors with plantar fascia stretching and calf stretching in terms of decreasing first-step pain and functional limitation. After summarizing the effectiveness of exercise therapy versus calcaneal taping in key outcomes.

### *Exercise Therapy Versus Iontophoresis*

One quasi-randomized trial (52) with a sample size of 37 middle aged chronic PHP patients, PEDro score of 4 and a short-term follow-up (6 weeks), concluded that both iontophoresis (NSAIDs) and a combination of plantar fascia stretching and Achilles tendon stretching reduced overall pain. However, a combination of plantar fascia stretching and Achilles tendon stretching was more effective than iontophoresis alone.

### *Exercise Therapy Versus a Combination of Exercise Therapy and Iontophoresis*

One quasi-randomized trial (52), with a sample size of 37 middle age chronic PHP patients, PEDro score of 4 and a short-term follow-up (6 weeks), concluded that both exercise therapy consisted of plantar fascia stretching and Achilles stretching and a combination of the same exercise therapy and iontophoresis (NSAIDs) reduced overall pain. However, a combination of exercise therapy protocol with iontophoresis was more effective in reducing overall pain than exercise therapy alone.

## DISCUSSION

The aim of this systematic review was to summarize the evidence on the effectiveness of exercise therapy in the treatment of PHP. This systematic review compared exercise therapy in terms of reducing pain and functional limitation with (i) different settings of exercise therapy (ii) placebo, sham therapy, no treatment or waiting list controls, (iii) other conservative treatment options.

The findings of this review support the use of exercise therapy following acute and chronic PHP over control/sham therapy, repetitive shock wave therapy, NSAIDs and orthotic devices. However, this support based on a weak to moderate evidence and mainly in trials used non-weight bearing progressive stretching exercise. Exercise therapy, in a combination with other conservative treatments, such as foot inserts or NSAIDs, provided short term benefits. However, this effectiveness was combined with a small standardized effect size and

low methodological quality in the majority of included trials.

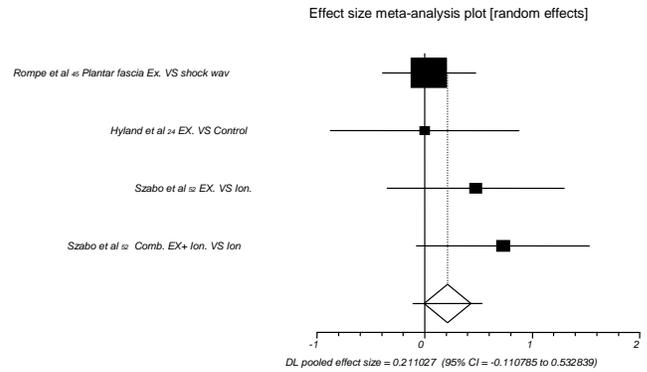
While every attempt was made to identify trials through various methods in the comprehensive search strategy, it is possible that other trials exist that were not included in this review. However, this review remains the first systematic review focused only on exercise therapy for PHP to date. The success of the search strategy used is indicated by a previous review published in 2006 by Stuber and Kristmanson(51). This narrative review for literature regarding conservative therapy for plantar fasciitis was limited to MEDLINE, CINAHL, MANTIS, the index to chiropractic literature and Cochrane databases, was date limited (1980-2005). Although the review identified three trials published before 2006, the exclusion of non-English-language trials would prevent such a review from including trials like Szabo *et al.* (52). The non-English-language trials identified in the literature search were professionally translated to allow full inclusion and to prevent the introduction of language bias. The non-English trial identified in this review (52) demonstrated a higher effective size of exercise therapy than most of the included English-language trials and compared the effectiveness of exercise therapy versus NSAIDs, which were not followed in the English-language trials. This supports the decision to include non-English trials in the search strategy used in this dissertation. There were no obvious major problems with the data extraction processes used in this review. Two spreadsheets were developed for exclusive use in this review. The first spreadsheet was used to summarize the included trials. The second spreadsheet was

used to summarize the characteristics of the exercise therapy employed in the included trials. The author (AA) and the second independent reviewers (JA) worked separately to extract data from the included trials to the spreadsheets. Later, the spreadsheets were reviewed by the first independent reviewer (NF). Using spreadsheets and independent reviewing were effective in reducing the data extraction time while ensuring efficient data extraction. The independent reviewers (NF and JA) showed high percentage agreement (97 %) with each other and high agreements when using Cohen's kappa regarding both trial selections. Following trial selection and quality assessment, the author (AA) and both independent reviewers (NF and JA) were in full agreement for all items for all trials.

Most of the participants in the included trials were middle-aged and over-weight. These baseline characteristics in exercise therapy trials are consistent with findings of other studies. Riddle *et al.* (Riddle, Pulisic et al. 2003) found that patients who are overweight (BMI ranged from 25-30) are more likely to get PHP. Rano *et al.* (42) found that those who are middle-aged or older are also more likely to get PHP. One included trial (Pfeffer, Bacchetti et al. 1999) found that the duration of complaint and the number of standing hours was correlated with drop-out percentage from the trial. Those with either long duration of pain or long standing hours ( $\geq 7$  hours daily) may tend to drop out more readily than others. Although we don't have specific proven mechanism for explaining drop-out of this specific patients sub-group; we hypothesize that this may due to two reasons (i) exercise therapy effectiveness is

affected significantly by fatigue caused by a long duration of standing and/or (ii) those who experience PHP for long durations may not respond well to exercise therapy because of fasciodesis resulting from microtrauma, which affects tissue regeneration, and permanent dysfunction in soft foot tissues cannot be ruled out after the prescribed exercise therapy.

All of the trials included in this review used stretching exercise therapy only (13, 24, 36, 38, 41, 45, 52). However, the outcome of stretching exercise as regards pain and/or functional limitation varied according to the parameters of the exercise therapy. Trials that used either clinical-based or home-based non weight-bearing exercise (13, 24, 45) showed significant improvement in outcomes in terms in reducing first-step and overall pain. However, the trials that used non weight-bearing exercise (13, 38, 41) showed that weight-bearing stretching exercise was either less effective or not effective at all. This may be related to the loading, weight-bearing position triggers pain and other symptoms of PHP which overcome the potential benefits of the exercise. In addition, the weight-bearing exercise was focused on stretching either the Achilles tendon or calf muscles, but not the plantar fascia. This may also indicate that stretching of these tissues is not effective or less effective for PHP treatment because of the existence damage in the other heel tissues, such as the plantar fascia. One trial (38) also showed that other treatment parameters, such as time of exercise, using sustained or intermittent modes of weight-bearing exercise did not affect the outcome of PHP pain.



\*Ex= Exercise therapy group; Vs= versus; shock wav= repetitive shock wave therapy group; Ion=Iontophoresis (NSAIDs group); EX + Ion=combination of exercise therapy and iontophoresis group; Control= control group.

Figure 2. Forest plot of standardized effect sizes (Cohen's *d*) with confidence intervals for first-step pain and/or overall pain and results of test for heterogeneity in some of included trials.

The included trials that used non weight-bearing exercise in the form of specific plantar fascia stretching showed short-term benefits (13, 24), and also long-term benefits (45) regarding PHP pain and functional limitation. The plantar fascia stretching treatment parameters were home-based in two of the non weight-bearing trials (13, 45) and clinical-based in one included trial (24). The stretching exercise was progressed (number of exercise session and durations increased gradually) in one trial only (41). The clinical-based exercise showed faster improvement in first-step pain and functional limitation than the home-based exercise. This may be due to the fact that the clinical-based exercise which usually therapist-delivered exercise produced more stretching in the targeted tissues, performed exactly on targeted tissues, included more tissues in the stretching than the home-based stretching exercises or may be resulted from other confounding factors

such as the placebo effect. Number of exercise therapy sessions in itself was not necessarily affected the pain and functional outcomes. One included trials used three session only per week (13). However, this trial showed positive pain and functional outcomes compared to sham therapy.

Exercise therapy was more effective in reducing pain level and functional outcomes compared with shock wave therapy in one long-term follow-up trial (45). This support one of our aims before conducting this systematic review that home-based exercise therapy mainly is a cost-effective treatment. Replacing a high-cost clinical-based device such as shock wave therapy with the unsupervised home base exercise therapy should be taken in consideration. It is also important to investigate in future whether exercise therapy can replace other less effective and costly conservative or surgical treatments.

The effect size of exercise therapy was small in most of the included trials (Figure 2) Although some trials, like Rompe *et al.*(45), reported that they used large effective size regarding the pain subscale of the foot function index, only the first and second item from the pain subscale of the foot function index presents PHP patient symptoms (pain at its worst and first-step pain). The effect size of most of the included trials, including Rompe *et al.*(45), were small in first step pain and pain at its worst; it is important to calculate statistical power according to the first and second items of the foot function index rather than using the overall score. One trial only (41) showed large effect size; this trial used progressed stretching exercise which may affects positively on the effectiveness of

stretching exercise therapy. Therefore, it is crucial for future trials to use a progressive exercise therapy rather than applying same exercise parameters along the treatment duration. In addition, it is crucial for new trials aim to investigate the effectiveness of exercise therapy for those with PHP to follow specific steps. These steps may include (i) make an effort to combine both clinical-based supervised exercises with home-based unsupervised exercise. One trial in this review (24) manifested a significant rapid improvement in those who received short-term supervised, therapist-delivered exercise. Although daily, or even weekly, supervised clinical-based exercise is not practical in long-term follow up studies, inviting patients to do clinical-based supervised exercise on a regular basis, such as monthly or every two weeks, can enhance the outcome of exercise therapy. (ii) It is important to explore the effectiveness of other forms of exercise therapy rather than simply stretching the surrounding heel tissue, this may include strengthening exercises for the intrinsic foot muscles and specific low load exercises for the deep foot muscles. (iii) It is important to combine other successful conservative therapy treatments, such as acupuncture, neurodynamics, manual therapy and electrotherapy to exercise therapy. Some studies in this review investigated the efficacy of adding orthoses or foot inserts to exercise therapy, which showed varied degrees of improvement. However, it is also important to combine other forms of successful conservative treatment with exercise therapy.

Limitations of this review which affect the conclusion include small effect size, lack of long-term follow-up in most of included

trials, and the heterogeneity in terms of interventions delivered and follow-up time points of the trials. In addition, the small number of included trials (7 trials) affected the conclusion of this systematic review.

There is limited evidence from two trials that exercise therapy is more effective than control/ sham therapy for short-term follow-up outcomes in the treatment of PHP. Limited evidence, from two trials only, suggests that a combination of exercise therapy and either foot inserts or iontophoresis is more effective than exercise therapy alone. Mild evidence from one other trial suggests that long-term exercise therapy is more effective than extracorporeal shock wave therapy. Most of the included trials recruited over weight middle-age subjects. High quality randomized trials of exercise therapy for patients with PHP, with sufficiently large sample sizes and long-term follow-up are needed to guide clinical practice in this area. It is also important to investigate whether exercise therapy is beneficial for other age-group.

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