REVIEW

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Therapeutic Exercise in Plantar Fasciitis: A Systematic Review with Meta-Analysis

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SUMMARY

Purpose. Plantar fasciitis (PF) is a degeneration of the plantar fascia. There are different forms of treatment for PF. Conservative treatment stands out as the main method of choice. The aim was to review in the literature the effectiveness of therapeutic exercise (TE) on pain and functionality in PF.

Methods. The search was carried out in the databases: PubMed, Web of Science, Embase and Lilacs, and in the gray literature: Google Scholar, Open Grey, LIVIVO and Brazilian Library of Theses and Dissertations. A Cochrane tool was used to assess the quality of the studies. The primary outcome was pain, and the secondary outcomes were range of motion (ROM) and functionality. The assessments were performed by two reviewers and a third reviewer resolved conflicts. Randomized controlled trials using therapeutic exercise compared with placebo, no treatment, phototherapy, thermotherapy, and electrotherapy. There was no restriction on time or language.

Results. The references of 2,984 studies were identified, 2,832 from major databases and 152 from gray literature**.** A total of 10 articles were included in this review. Nine studies assessed pain, and all had positive results in decreasing pain levels. All 10 studies used to stretch exercises, but only one used strengthening exercises.

Conclusions. It is concluded that TE, mainly through plantar fascia and triceps sural stretching, is effective in reducing pain and functionality when associated with other therapies in PF.

Study registration. The study is registered with the International Prospective Register of Systematic Review (PROSPERO) under protocol CRD42021296710.

KEY WORDS

Muscle strength; muscle stretching exercises; calcaneus; fascia.

INTRODUCTION

Plantar fasciitis (PF), considered the most common cause of sub-calcaneal pain, was first described in 1812, related to painful sensation in the calcaneus, resulting from degeneration of the plantar fascia. Some reported cases are the result of biomechanical failure that provides tension along the plantar fascia (1). It is a common dysfunction in runners, due to the high loads they exert on the plantar fascia, but other risk factors are also worth mentioning, such as increased plantiflexion, high body mass and high body mass index (2).

There are different forms of PF treatments, in patients who do not respond adequately to conservative treatment after 6-12 months, surgical treatment is an option, with release of the plantar fascia, open, percutaneous, or endoscopic fasciotomy, neurectomy or neurolysis of the calcaneal nerve, and even calcaneal osteotomy (3). But conservative treatment stands out as the main method of choice, aiming to reduce the inflammatory process and pain (4, 5), as well as stimulating the remodeling of collagen tissue (6). The use of night splints (7), extracorporeal shock wave treatment (ESWT) (8), steroid injections and platelet-rich plasma (9) are all therapies that have been adopted, as well as modalities offered by physiotherapy, how manual therapy, electrostimulation, laser, ultrasound, cryotherapy, and kinesiotherapy. Kinesiotherapy,

based on the active stretching of the gastrocnemius muscle and plantar fascia, can improve painful symptoms. In addition, high-load strength training is performed to improve the foot functionality index, and thus patient satisfaction with kinesiotherapy (10).

However, although kinesiotherapy has been shown to be positive in the treatment of PF, there are a variety of resources that can be used within it to achieve the proposed objectives, and generally research is concerned with using this resource as a control and not as the main form of therapy. Therefore, the aim of this study was to review the literature on the effectiveness of exercise therapy on pain and disability in patients with PF.

MATERIALS AND METHODS

Protocol

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement.

Eligibility criteria

The acronym PICOS was used to formulate the question focused on this study:

- P: Population (individuals with chronic plantar fasciitis);
- I: Intervention (exercise therapy);
- C: Comparison (placebo, no treatment, phototherapy, thermotherapy, and electrotherapy);
- O: Outcome (pain and functionality);
- S: study design (randomized controlled trials).

Inclusion criteria included: individuals with chronic plantar fasciitis; humans; intervention using kinesiotherapy (stretching and strengthening, home and non-home) alone, compared to another conservative treatment such as phototherapy, thermotherapy and electrotherapy, or combination of more than one of these conservative treatments. Exclusion criteria were individuals who had undergone previous surgical treatment on the foot or lumbosacral spine; metabolic or connective tissue disorders; radiographic evidence of local pathology other than plantar fasciitis. Case studies, systematic reviews, case reports, cohort studies, literature reviews and editorials, as well as animal studies were also excluded.

Sources of information

The initial search was conducted using keywords in the PubMed database, with the Medical Subject Headings (MeSH) medical metadata system, descriptors defined in Health Sciences (DeCS), from the Virtual Health Library (VHL) website and free terms. Individual search strategies were developed for the databases: Pubmed, Embase, The Cochrane Library, Lilacs, Physiotherapy Evidence Database (PEDro) and Web of Science; and in the gray literature: Google scholar, Brazilian Catalog of Theses and Dissertations of CAPES and LIVIVO. In addition, citation searches were conducted. The reference manager software EndNote Web (Thomson Reuters) and Rayyan QCRI were used to collect references and exclude duplicates.

Study selection and data collection process

The study selection process was carried out by 2 reviewers in two phases. Articles were imported from the databases into the Endnote Web reference manager for duplicate removal, automatically and manually. They were then imported into Rayyan, and once again duplicates were removed manually by the first reviewer. In this way, the studies included in Phase 1 were defined for reading of titles and abstracts, according to the eligibility criteria by two blinded reviewers R1 (R.A.S) and R2 (B.T.). For studies with conflicts, a third blinded reviewer R3 (G.R.F.B.) performed the tiebreaker. Final selection, Phase 2 was based on the assessment of the full text of the studies by the two blinded reviewers.

Data collected

The main data collected were study characteristics (authors and year of publication), sample characteristics (sample size and mean age), intervention, outcomes and conclusion. The primary outcome was pain, and the secondary outcomes were functionality and range of motion (ROM).

Individual assessment of risk of bias in studies

Assessment of risk of bias was performed using the Cochrane tool, RoB 2, and carried out by the two blinded reviewers, and when necessary R3 was triggered. All included studies were assessed in the following domains: randomization process, timing of participant recruitment identification, deviations from intended interventions, lack of outcome data, outcome measurement, selection of reporting outcome, and overall bias. Each domain with an overall outcome: low risk, unclear or high risk.

Strategy for data synthesis

The results of clinically and statistically homogeneous studies were meta-analyzed using Review Manager (RevMan) software. Meta-analysis was performed using the inverse variance method for continuous outcomes. A random effects model was used.

Publication bias

To reduce the likelihood of publication bias, an exhaustive search was conducted without limitations on language, time period and with inclusion of gray literature (11). Therefore, the risk of publication bias could be mitigated but not eliminated.

RESULTS

This is followed by a narrative synthesis of the results of the included studies, structured around the reported outcomes. This is followed by a quantitative analysis.

Selection of studies

The references of 2,984 studies were identified, 2,832 from major databases and 152 from gray literature. All searches were conducted on a single day, November 22, 2021 (**appendix 1**) and were updated on August 12, 2023. After removing duplicates, 1,775 articles were left for Phase 1 (reading titles and abstracts) according to the eligibility criteria, and for Phase 2, 19 articles for reading the full texts. The articles included in Phase 2 that did not fit the eligibility criteria were then excluded due to: study design and interventions without isolated kinesiotherapy group. Ultimately, 10 studies were included in this review. **Figure 1** summarizes the full selection process, and the summarization of studies is described in **table I**.

Characteristics of the studies

Ten randomized controlled trials (12-21) were included in this review, with publication date between 2009 and 2020.

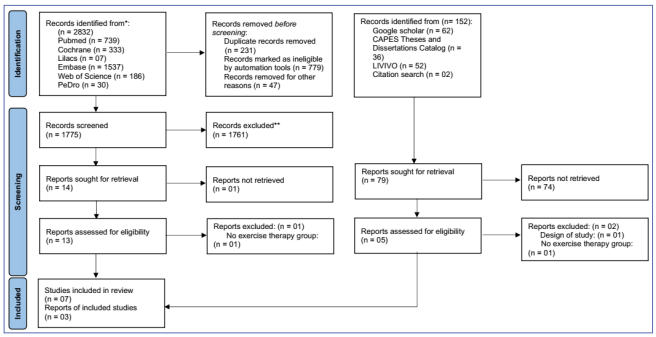

Figure 1. Flowchart of literature search and selection criteria, based on PRISMA 2020.

Risk of bias analysis

In the individual assessment of risk of bias, it was observed that the high risks of bias were in the domains of outcome measurement (12, 13, 17, 21) and report outcome selection (13, 14, 17-19).

Only three studies had overall bias at low risk (15, 16, 20). All others had high risk of overall bias (12-14, 17-19, 21) (**figures 2,3**).

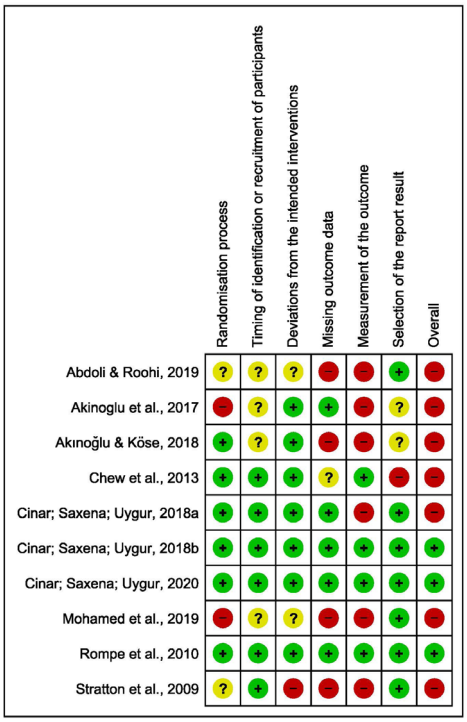

Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

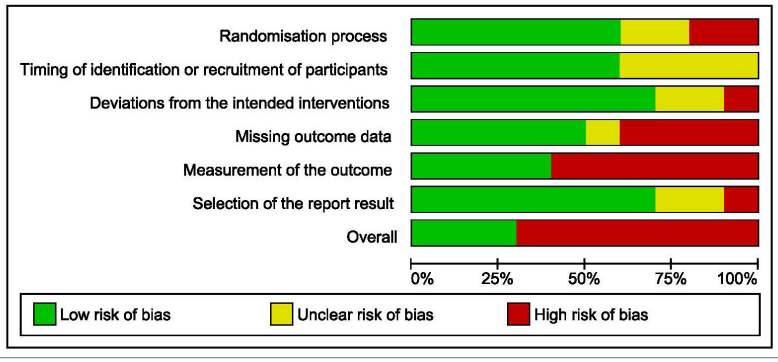

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Collection instruments

The following instruments were used to measure the main outcome (pain): visual analog scale (VAS), pain subscale-Foot Function Index (pain-FFI) and Numerical Rating Scale for pain (NRS-p) (12-21).

The American Orthopedic Foot and Ankle Society Score (AOFAS) and the Activities of Daily Living subscale of the Foot and Ankle Ability Measure (ADL/FAAM) (7-11, 13-15) were used as secondary outcomes for functionality and ROM (13-17,19-21).

Primary outcome: pain

A total of 9 included studies assessed pain level, all of which found results of decreased pain levels. The studies by Akinoglu *et al.* (17), Cinar *et al.* (15, 16), Chew *et al.* (19) and Mohamed *et al.* (12) found significant differences between the groups. Despite also reporting positive results on pain, Abdoli and Roohi (13), Akınoğlu and Köse (18), Stratton *et al.* (21) and Rompe *et al.* (20) found no statistical differences in the intergroup analysis.

ESWT was used in 7 studies (12-14, 17-20) to evaluate its effects on pain compared to a stretching protocol (SP). The application of ESWT can be radial (ESWTr) or focal (ESWTf), the studies that used ESWTr were Akinoglu *et al.* (17), Akinoglu and Bose (18), Mohamed *et al.* (12) and Rompe *et al.* (20). ESWT therapy, regardless of the form of application, was shown to be effective in reducing pain in patients with PF, but did not provide an additional benefit beyond the benefits promoted by SP. In addition, Rompe *et al.* (20) and Mohamed *et al.* (12) compared the effects of ESWT and TE alone and in this case, TE was more effective in reducing pain than ESWT.

The use of low-level laser therapy (LLLT) was investigated in the study by Cinar *et al.* (16), and they observed that the association of LLLT with ET, the results in pain reduction were potentiated. In the case of Cinar *et al.* (15), it was also shown that the group receiving LLLT and SP had greater pain reduction compared to the groups of ESWT and SP, and SP alone. Regarding the use of low-frequency electrical stimulation (LFES), Stratton *et al.* (21) found no difference between the groups that associated SP with electrostimulation and those that were limited to SP alone.

Secondary outcomes: functionality and ROM

In the study by Abdoli & Roohi (13) both ESWT and SP were effective in improving ROM, although no significant differences were found between the groups. Additionally. Chew *et al.* (19) compared ESWTr combined with SP and SP alone and concluded that ESWTr associated with SP show superior functional improvement compared to home exercises alone.

Cinar *et al.* (16) found no differences between the LLLT groups associated with SP and SP alone in the outcome of functionality. Similarly, Cinar *et al.* (14) found no additional benefit in functionality to the groups that received ESWT treatment in addition to SP. Finally, Stratton *et al.* (21) used LFES, also with the aim of assessing functionality, and both groups showed improvement, with no differences between them.

Meta-analysis

Therapeutic exercise vs ET + other therapy - VAS (pain)

Short term - 3 to 4 weeks

The studies by Akınoğlu and Köse (18), Cinar *et al.* (16) and Stratton *et al.* (21) were included in the meta-analysis of the VAS pain endpoint, comparing ET with ET + other therapy in the short term (3 and 4 weeks) (**figure 4**), with a total sample of one hundred and eighty-five (n = 185) subjects (MD = 1.62; 95%CI

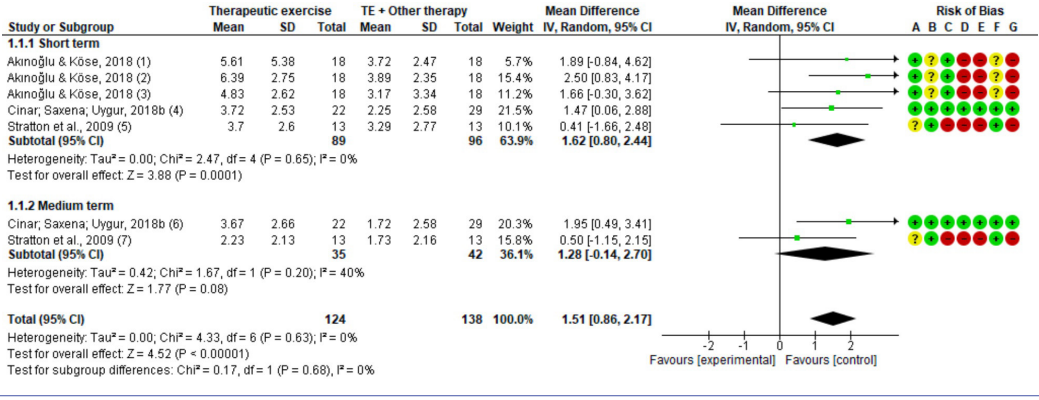

Figure 4. Forest plot of comparison therapeutic exercise *vs* TE + other therapy (short and medium term).

Outcome: VAS (pain). (1) VAS - Morning pain (4 weeks) – US; (2) VAS - Pain before bedtime (4 weeks) – US; (3) VAS - Pain after 6MWT (4 weeks) – US; (4) VAS - Pain after experiment (3 weeks) – LLLTI; (5) VAS - Pain after experiment (4 weeks) – EEBF; (6) VAS - Pain after experiment (3 months) – LLLTI; (7) VAS - Pain after experiment (3 months) – EEBF.

0.80-2.44; p = 0.0001). The study by Akınoğlu and Köse (18) used as comparator TE + US in 4 weeks and at three different times, pain in the morning, pain before bedtime and pain after the 6-minute walk test. Cinar *et al.* (16) used as comparator TE + LLLT in 3 weeks. And Stratton *et al.* (21) used as comparator TE + EEBF in 4 weeks.

Medium term - 2 to 3 months
The studies by Cinar *et al.* (16) and Stratton *et al.* (21) were included in the meta-analysis of the VAS pain endpoint, comparing TE with TE + other therapy at mid-term (3 months) (**figure 4**), with a sample size of 77 subjects (MD = 1.28; 95%CI -0.14 to 2.70); p = 0.08).
The pooled effect estimates between the short- and medium-term studies (MD = 1.51; 95%CI 0.86-2.17); p < 0.00001) showed that TE *versus* TE combined with other therapy (US, LLLT and LFES) had a large effect (1.51) in decreasing pain in plantar fasciitis. Thus, being favorable to the TE group. When heterogeneity was analyzed by the degree of inconsistency between the results of the studies (I^2 = 0%), heterogeneity was not important (22, 23).

TE vs TE + ESWT - short term - VAS (pain)
The studies of Akınoğlu and Köse (18) and Mohamed *et al.* (12) were included in the meta-analysis of VAS-measured pain outcome comparing therapeutic exercise with TE + ESWT at short term (3 and 4 weeks) (**figure 5**), with a total sample of 138 subjects, pain was measured at different time points: morning pain, pain before bedtime, pain after 6MWT and pain after experiment.
The pooled estimate of effect across studies (MD = 1.62; 95% CI -0.17 to 3.41; p = 0.08) demonstrated that TE *versus* TE + ESWT had no advantageous effect on pain reduction. When heterogeneity was analyzed by the degree of inconsistency between study results (I^2 = 75%), heterogeneity was considerable (22, 23).

TE vs TE + Other therapy - FFI (pain) - short and medium term
The studies of Akınoğlu *et al.* (17), Cinar *et al.* (15) and Rompe *et al.* (20) were included in the meta-analysis of the pain outcome measured by FFI, comparing TE with TE + other therapy (ESWT, US or LLLT) in the short term (3 days to 3 weeks) and medium term (2 to 5 months), with a total sample of 544 subjects (**figure 6**).
Pooling the effect estimate across studies (MD = -3.20; 95% CI -8.97 to 2.56; p = 0.29) showed no advantage for TE *vs* TE + other therapy.

TE vs TE + other therapy - Functionality - short term
The studies by Akınoğlu *et al.* (17) and Cinar *et al.* (15, 16) were included in the meta-analysis of the functional endpoint comparing ET *vs* ET + other therapy in the short term (3 days and 3 weeks) (**figure 7**), with a total sample 129 subjects.
Pooling the effect estimate across studies (MD = -3.81; 95%CI -10.48 to 2.86); p = 0.26), showed that ET *vs* ET + other short-term therapy had a small effect (-3.81) on functionality in PF. When heterogeneity was analyzed by the degree of inconsistency between study results (I^2 =87%), heterogeneity was considerable (22, 23).

TE vs TE + other therapy - Functionality - medium term
The studies by Cinar *et al.* (14, 16) were included in the meta-analysis of the functionality endpoint, comparing TE *vs* TE + other therapy at mid-term (3 months), with a total sample of 93 subjects (**figure 8**).
The pooled effect estimate (MD = -2.02; 95%CI -4.08 to 0.04); p = 0.06) showed that TE *vs* TE + other therapy in the medium term had a small effect (-2.02) on functionality in plantar fasciitis. When heterogeneity was analyzed by the degree of inconsistency (I^2 = 0%), heterogeneity was not important (22, 23).

DISCUSSION

The initial hypothesis of this work was that kinesiotherapy, in the form of TE, is effective in the treatment of PF, and that different forms of application can promote relief of pain symptoms and disability. From this, the aim was to review the effectiveness of exercise therapy in plantar fasciitis showing some relevant results for clinical practice. All studies included in this review included stretching programs for plantar fascia and triceps suralis (12-21), however, only Mohamed *et al.* (12) used strengthening of intrinsic foot musculature in addition to the stretching program.
Individuals with PF usually present with a history of progressive inferior and medial heel pain, but this may radiate proximally in more severe cases. Pain tends to be accentuated on passive dorsiflexion of the toes, and is worse when patients stand up after rest, usually in the early morning (18). In addition, pain may be exacerbated in activities requiring prolonged orthostasis (5, 24, 25).
Plantar fasciitis can be a benign disease, but if not treated properly it can become disabling (5, 24, 25), which explains the choice of the secondary outcomes of this review, functionality, and ROM. It is known that the plantar fascia has the function of stabilizing the longitudinal arch, a passive mechanism that generates the ligament and bone stability of the foot. Most cases of PF are the result of a biomechanical failure that results in tension along the plantar fascia (26). Thus, it is believed that by strengthening the intrinsic musculature there may be a reduction in

Table I. Summary description of the clinical trials included in this review (n = 10).

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Abdoli and Roohi, 2019	ECR	n = 30; G1: ESWT (n = 15); G2: TE (n = 15); Male athletes with PF. Average age 25 years.	ESWT: frequency 12 Hz to 15 Hz and 2500 pulses in 2 to 3 bar (once a week for 5 weeks). TE: stretching of the plantar fascia, Achilles tendon and triceps suralis (3 times a day, 10 stretches of 20 seconds each, for 5 weeks).	T0: baseline T1: 5 weeks	VAS (0-10)	T0: VAS = 6.37 T1: VAS =2.77 P-value between groups >0.05	It was concluded that both treatment by ESWT and TE are suitable methods to improve symptoms in PF, with no significant difference between them.
					ROM	T0: ROM = 37.86 T1: ROM =40 P-value between groups >0.05	
Akinoglu *et al*., 2017	ECR	n = 54; G1: r-ESWT + TE (n = 18); G2: US + TE; (n = 18); G3: TE (n = 18); Women with unilateral PF. Mean age 48.44 years.	r-ESWT: 500 pulses. 3Hz. 0.2mJ/mm² in the heel area. and a dose of 1.500 pulses. 8Hz. 0.3mJ/mm² in the palpated tender point (1/week/for 3 weeks/total 3). US: technique with longitudinal movements through the plantar fascia. 3.0 MHz frequency. 1W/cm² intensity and ¼ pulsed wave duty cycle (2x/week/total 07 sessions). TE: stretches for triceps sural. plantar fascia and Achilles tendon (4 times per week. 10 times in the morning and 10 in the evening. 30 seconds each). All groups performed TE.	T0: baseline T1a: 1 week after r-ESWT treatment for the r-ESWT group. T1b: 3 days after US treatment for the US group. T1c: 4 weeks after onset in the TE group.	Pain-FFI (0-100)	T0 (mean±SD, p- value): r-ESWT + TE= 62.94 ± 9.0 US + TE = 59.06 ± 11.86 TE = 54.61 ± 13.17 T1: (r-ESWT + TE = 43.28 ±18.52 (0.001) US + TE = 28.56 ± 12.44 (0.001 TE = 38.89 ± 16.52 (0.004)	All interventions tested led to a decrease in symptoms, with US resulting in the greatest contribution.
					Disability-FFI (0-90)	T0: r-ESWT + TE = 75.61 ± 19.05 US + TE = 74.61 ± 18.78 TE = 63.06 ± 17.64 T1: r-ESWT + TE = 47.67 ± 23.72 (0.001) US + TE = 30.78 ± 15.01 (0.001) TE = 46.78 ± 21.05 (TE 0.023)	
					Activity limitation – FFI (0-50)	T0: r-ESWT + TE = 20.61 ± 6.48 US + TE = 16.22 ± 9.52 TE = 17.28 ± 8.57 T1: r-ESWT + TE = 8.83 ± 7.02 (0.001) US + TE = 4.28 ± 4.53 (0.001) TE = 11.89 ± 8.61 (0.049)	
					AOFAS (0-100) Backfoot score	T0: r-ESWT + TE = 30.11 ± 12.49 (12.49) US + TE = 33.94 ± 14.02 TE = 37.50 ± 15.88 T1: r-ESWT + TE = 74.72 ± 13.55 (0.001) US + TE = 68.39 ± 12.91 (0.001) TE = 59.50 ± 9.34 (0.001)	

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Akınoğlu and Köse, 2018	ECR	n = 54; G1: r-ESWT + TE (n = 18); G2: US + TE (n = 18); G3 = TE (n = 18); Women with unilateral PF. Mean age 48.44 years.	r-ESWT: 1,500 pulses on the 5 most painful points, 0.3 mJ/mm², 8 Hz of 300 pulses were applied on the whole heel (3 times a week for one week). US: 3.0 MHz frequency and with 20% intermittently with 1 W/cm² power for 8 minute (7 sessions, 2 days per week). TE: stretching of Achilles tendon, sural triceps and plantar fascia. TE was applied in the 3 groups.	T0: baseline T1: 4 weeks	VAS - morning pain (0-10)	T0 (mean±SD, p- value): r-ESWT + TE =9.33 ± 1.41 US + TE = 9.50 ± 1.29 TE = 8.50 ± 2.55 T1: r-ESWT + TE = 4.94 ± 4.12 (0.001) US + TE = 3.72 ± 2.47 (0.001) TE = 5.61 ± 5.38 (0.004)	It concluded that r-ESWT, US and TE are effective in reducing pain in patients with PF with no statistical difference between them.
					VAS – before bedtime (0-10)	T0: r-ESWT + TE = 9.00 ± 1.75 US + TE = 8.83 ± 1.86 TE = 9.06 ± 1.80 T1: r-ESWT + TE = 5.94 ± 3.64 (0.005) US + TE = 3.89 ± 2.35 (0.001) TE = 6.39 ± 2.75 (0.005)	
					VAS – after 6MWT (0-10)	T0: r-ESWT + TE = 3.78 ± 3.44 US + TE = 8.17 ± 2.18 TE = 7.39 ± 1.97 T1: r-ESWT + TE = 3.78 ± 3.44 (0.001) US + TE = 3.17 ± 3.37 (0.001) TE = 4.83 ± 2.62 (0.002)	

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Cinar; Saxena; Uygur, 2018a	ECR	n = 66; G1: ESWT + TE (n = 25); G2: LLLT + TE (n = 24); G3: TE (n = 17); Women (n = 56). Men (n = 19) Mean age 45.3 years.	ESWT: total pulse dose 1000mJ/mm² per attempt applied to the area of sensitivity, and 1000mJ/mm² over the plantar fascia (once a week, for 3 weeks). LLLT: 830nm with continuous output of 70mW, with dose from 0 to 56J/cm², each single exposure lasting 50 seconds was applied over the plantar fascia and at the points of sensitivity. (3 times per week totaling 10 sessions). TE: stretching of the gastrocnemius muscle and plantar fascia (3 times a day. for 30 seconds each. for 3 weeks. at home) and use of silicone insoles for 3 months. All groups performed TE.	T0: baseline T1: 3 weeks T2: 3 weeks	Pain-FFI (0-50)	T0 (mean / CI): ESWT + TE = 41.8/ 39.8 – 44.1 LLLT + TE = 38.3/ 35.5 – 41.0 TE = 38.2/ 35.1 – 41.5 T1: ESWT + TE = 33.2 / 28.0 – 38.3 LLLT + TE = 22.0 / 18.2 – 25.7 TE = 23.2 / 19.0 – 3.6 T2: ESWT + TE =25.1 / 18.9 – 31.3 LLLT + TE = 15.4 / 9.4 – 21.5 TE = 21.8 / 14.5 – 29 P-value between groups (0.002)	When LLLT and ESWT were combined with TE, LLLT was more effective than ESWT in reducing PF pain.
					NRS-p (0-10)	T0: ESWT + TE = 6.7 / 5.6 – 7.8 LLLT + TE = 6.3 / 5.7 – 6.9 TE = 6.2 / 5.1 – 7.3 T1: ESWT + TE = 5.0 / 3.9 – 6.2 LLLT + TE = 2.5 / 1.6 – 3.5 TE = 4.2 / 2.6 – 5.7 T2: ESWT + TE = 4.5 / 3.1 – 6.0 LLLT + TE = 1.9 / 0.9 – 2.9 TE = 3.5 / 1.9 – 5.1 P-value between groups (0.002)	

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Cinar; Saxena; Uygur, 2018b	ECR	n = 51; G1: LLLT + TE (n = 27); G2: TE (n = 22); Women (n = 41); Men (n = 9) Mean age 45.3 years.	LLLT: 850nm with continuous output of 100mW, with a dose of 5.6J/cm² at 3 points, each exposure lasting 80 seconds was applied at the origin of the plantar fascia (3 times per week totaling 10 sessions). TE: stretching of the gastrocnemius muscle and plantar fascia (3 times a day, 10 repetitions, for 30 seconds each, for 3 months) and use of silicone insoles for 3 months. Both groups performed TE.	T0: baseline T1: 3 weeks T2: 3 months	AOFAS – function subscale (0-50)	T0 (mean / CI): LLLT+ TE = 44.16 / 42.58 – 45.4 TE = 44.55 / 43.75 – 47.34 T1: (mean / CI): LLLT + TE = 48.15 / 46.87 – 49.42 TE = 48.32 / 46.87 – 49.77 T2: (mean / CI): LLLT + TE = 49.95 / 48.45 – 51.45 TE = 47.78 / 46.07 – 49.49 P-value between groups = 0.76 VAS (0-10) T0 (mean / CI): LLLT+ TE = 6.13 / 5.41 – 6.85 TE = 5.49 / 4.67 – 6.31 T1 (mean / CI): LLLT+ TE = 2.25 / 1.31 – 3.18 TE = 3.72 / 2.66 – 4.79 T2 (mean / CI): LLLT + TE = 1.72 / 0.78 – 2.67 TE = média 3.67 / 2.56 – 4.77 P-value between groups = 0.07	The use of LLLT combined with TE and TE alone provides positive results on pain and functionality in patients with PF.
Cinar; Saxena; Uygur, 2020	ECR	n = 44; G1: ESWT + TE (n = 23); G2: TE (n = 21); Women (n = 40); Men (n = 4), with PF. Average age 45.	ESWT: 1000-1500 pulse was applied over the pain area and 1000 pulses over the plantar fascia (1 time per week, for 3 weeks). TE: stretching of the gastrocnemius muscle and plantar fascia (3 times a day, 10, repetitions, for 30 seconds each, during3 weeks) and use of silicone insoles for 3 months. Both groups performed the TE.	T0: baseline T1: 3 weeks T2: 3 months	AOFAS – function subscale (0-50)	T0 (mean / CI): ESWT + TE = 42.91 / 39.48 – 45.81 TE = 43.57 / 40.47 – 46.66 T1 (mean / CI): ESWT + TE = 45.82 / 42.89 – 48.85 TE = 46.26 / 43.10 – 49.42 T2 (mean / CI): ESWT + TE = 47.28 / 44.08 – 50.48 TE = 45.88 / 42.55 – 49.22 P-value between groups = 0.95	The results revealed that ESWT did not have an added benefit over usual care for improving foot function and gait performance in patients with PF.

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Chew *et al.*, 2013	ECR	n = 54; G1: ACP + TE (n = 19); G2: ESWT + TE (n = 19); G3: TE (n = 16); Women (n = 25) Men (n = 29) Unilateral PF. Mean age: 46.1 years.	ACP: 3ml of conditioned autologous plasma (extracted from the patient and injected into the thickening of the plantar fascia). ESWT: 2 sessions of 2000 pulses with energy levels progressing from 0.02 mJ/mm³ to 0.42 mJ/mm³ (duration 10 min, 2 sessions 1 week apart). TE: 1-2 sessions to learn triceps sural and plantar fascia stretching program (3 times per day, 3 times each stretch, for 30 seconds each). Guided to perform every day, including after study termination.	T0: baseline T1:1 month T2: 3 months T3: 6 months	AOFAS (0-100)	T0 (mean / amplitude): ACP + TE = 65 / 38 – 77 ESWT + TE = 62 / 44 – 79 TE = 72 / 51 – 77 T1 (mean / amplitude): ACP + TE = 75 / 35 – 84 ESWT + TE = 73 / 52 - 92 TE = 75/ 55 – 82 P-value between groups 0.045 T2 (mean / amplitude): ACP + TE = 86 / 67 – 100 ESWT + TE = 85 / 72 – 100 TE = 80 / 73 – 100 P-value between groups 0.04 T3 (mean / amplitude): ACP + TE = 90 / 4.6 – 7.9 ESWT + TE = 90 / 72 – 100 TE = 87 / 73 – 100 p - value between groups 0.061	Treatment of PF with ESWT + TE resulted in improved pain and functional outcomes compared to TE alone.
					VAS (0-10)	T0 (mean / amplitude): ACP + TE = 7 / 4 – 10 ESWT + TE = 7 / 5 – 8.5 TE = 6 / 3 – 8 T1 (mean / amplitude): ACP + TE = 4 / 1 – 10 ESWT + TE = 5 / 0 – 7 TE = 5 / 3 – 8 P-value between groups 0.036 T2 (mean / amplitude): ACP + TE = 4 / 0 – 8 ESWT + TE = 4 / 0 – 7 TE = 4 / 1 – 9 P-value between groups 0.053 T3 (mean / amplitude): ACP + TE = 2 / 0 – 6 ESWT + TE = 3 / 0 – 8 TE = 3 / 0 – 7 P-value between groups 0.090	

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Mohamed *et al.*, 2019	ECR	n = 45; G1: r-ESWT (n = 15); G2: TE (n = 15); G3: r-ESWT + TE (n = 15); Women (n = 29) Men (n = 16) Unilateral PCF. Mean age 45.22 years.	r-ESWT: 2000 pulses, 3 bar energy. 15mm depth per session (for 3 weeks with one week break). TE = calf stretching 5 sets of 20 seconds; plantar fascia stretching 10 sets of 10 seconds + strengthening of intrinsic muscles of the feet; dorsiflexion with isometric contraction of the plantiflexors for 5 seconds 100 repetitions. (5 days/week. for 3 weeks).	T0: baseline T1: 3 weeks	VAS (0-10)	T0 (mean±SD): r-ESWT = 8.98 ± 0.8 TE = 8.79 ± 1.05 r-ESWT + TE = 9.05 ± 0.85 T1 (mean±SD): r-ESWT = 3.34 ± 1.3 (P-value 0.001) TE = 5.16 ± 1.2 (P-value 0.001) r-ESWT + TE = 1.82 ± 0.69 (P-value 0.001)	Therapy by r-ESWT alone or combined with TE is more effective than TE alone in improving pain in PF.
Stratton *et al.*, 2009	ECR	n = 26; G1: LFES + TE (N = 13); G2: TE (N = 13); Individuals with PF. Average age 41 years.	LFES = low frequency electrical stimulation, in intensity until a moderate contraction is felt (10 pulses per second, for 20 min, for 4 weeks). TE = DiGiovanni fascia stretching protocol (10 times each stretch, for 10 sec, 3 times a day, for 4 weeks). Both groups wore a pair of prefabricated foot orthoses for a minimum of 1 month. Both groups performed TE.	T0: baseline T1: 4 weeks T2: 3 months	Daily Living Subscale of the Foot and Ankle Ability (ADL/ FAAM) (0-100)	T0 (mean±SD): LFES + TE = 52.2 ± 13.8 TE = 52.3 ± 17.1 T1 (mean±SD): LFES + TE = 34.4 ± 13.3 TE = 37.3 ± 12.1 T2 (mean±SD): LFES + TE = 32.3 ± 13.4 TE = 32.3 ± 14.4	Based on these results, the efficacy of the use of low frequency electrical stimulation in the management of patients with PF is questioned.
					VAS (0-100)	T0 (mean±SD): LFES + TE = 54.0 ± 23.4 TE = 48.6 ± 25.6 T1 (mean±SD): LFES + TE = 32.9 ± 27.7 TE = 37.0 ± 26.0 T2 (mean±SD): LFES + TE = 17.3 ± 21.6 TE = 22.3 ± 21.3	

Eligible studies	Type of study	Sample description	Intervention protocol	Period of assessment	Measurement instruments and outcomes	Results	Conclusions
Rompe *et al.,* 2010	ECR	n = 102; G1: TE: (n = 54) G2: r-ESWT: (n = 48) Women (n = 66) Men (n = 36) Unilateral PF Mean age 51.45 years.	TE = plantar fascia stretches (3 times a day, 10 times each exercise, for 10 sec each, for 8 weeks). r-ESWT: 2000 pulses with energy of 320 mJ/mm², 8 pulses per minute, applied at the site of pain (3 sessions, one week apart each).	T0: baseline T1: 2 months T2: 4 months T3: 5 months	Pain subscale scores (PS- FFI) (0-50)	T1 (mean / CI): TE = -21.4 ± 10.6 / -24.3 a -18.5 r-ESWT = -6.6 ± 1.2 / -9.1 a -4.1 P-value between groups (< 0.001) T2 ((mean / CI): TE = -24.9 ± 13.0 / -28.5 a -21.4 r-ESWT = -15.5 ± 10.1 / -18.4 a -12.6 P-value between groups (0.001) T3 (mean / CI): TE = -29.1 ± 12.8 / -32.6 a -25.6 r-ESWT = 28.9 ± 12.3 / -32.5 a -25.3 P-value between groups (0.95)	TE for the plantar fascia is superior to repetitive r-ESWT therapy for the treatment of acute PF symptoms.

TE: therapeutic exercise; ROM: range of motion; ADL/FAAM: Activities of Daily Living subscale of the Foot and Ankle Ability Measure; AOFAS: American Orthopedic Foot and Ankle Society Score; VAS: visual analogue scale; FFI: Foot Function Index; PF: plantar fasciitis; EG: experimental group; CI: confidence interval; LLLT: low intensity laser; NRS-p: Numerical Rating Scale for pain; ESWT: extracorporeal shockwaves; ACP: conditioned autologous plasma; US: ultrasound; 6MWT: six minute walk test; r-ESWT: extracorporeal radial shockwaves; LFES: Low Frequency Electrical Stimulation.

the load imposed on the fascia and thereby improvement in symptoms (27).

Kaur and Koley (28) compared the effectiveness of calf and Achilles tendon stretching on foot pain and functional disability in 50 patients with PF over four weeks. They observed better results in VAS and FFI, for individuals who received stretching in the Achilles tendon. However, calf and plantar fascia stretching also have possible effects on reducing pain and disability in individuals with PF (29).

Ryan *et al.* (30) analyzed the efficacy of a program of stretching exercises, plantar fascia exercises, and balance training, compared with dexamethasone injection, in individuals with chronic PF. The sample consisted of 56 workers, who were orthostatic for more than 5 hours a day. Both groups had significant improvement in VAS pain score, as well as reductions in foot and ankle disability index compared to baseline scores. They mention that taking into account the side effects of corticosteroids, physiotherapy stands out in the choice of treatment for patients with PF. Muscle stretching has been used with advantages both in pain reduction and functional gains, for cases of subacromial impingement syndrome (31), knee osteoarthritis (32), chronic low back pain (33) and neck pain (34), aiming at improving dynamic balance (35), and even aiming at raising the pain threshold and muscle relaxation by stimulating the Golgi tendon organs (36).

In the present review, of the 10 studies included, only Mohamed *et al.* (12) associated strengthening in the home exercise program. A recent study of Gökçe *et al.* (37) compared a low-level laser therapy (LLLT) protocol associated with exercises, which included strengthening and stretching, with exercises alone, observing advantages when LLLT was used, but also positive effects of TE in individuals with plantar fasciitis, however, since it was a retrospective study, with no indication of randomization, it was not included in this review. Thong-On *et al.* (38) compared the effects of eight-week strengthening and stretching exercise programs on pain outcome in 84 patients with PF randomized to the strengthening or stretching exercise groups. As a result, both exercise programs were able to significantly

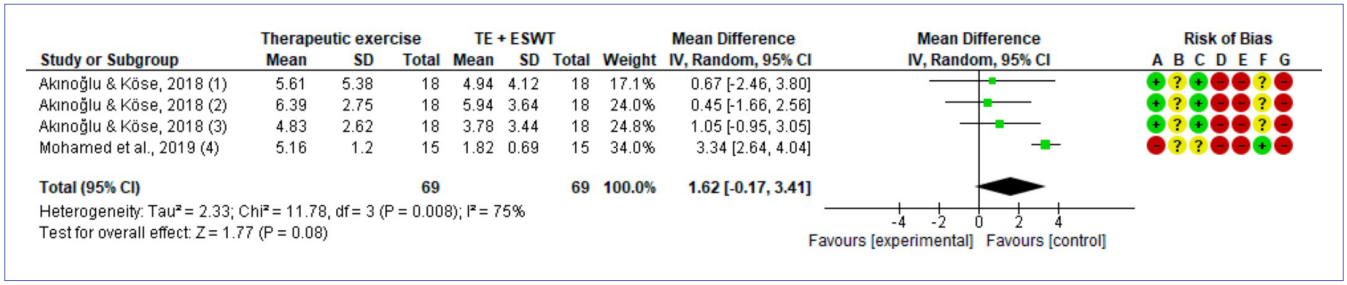

Figure 5. Forest plot of comparison: therapeutic exercise *vs* TE + ESWT.

Outcome: VAS (pain). (1) VAS - Morning pain (4 weeks); (2) VAS - Pain before bedtime (4 weeks); (3) VAS - Pain after 6 MWT (4 weeks); (4) VAS - Pain after experiment (3 weeks).

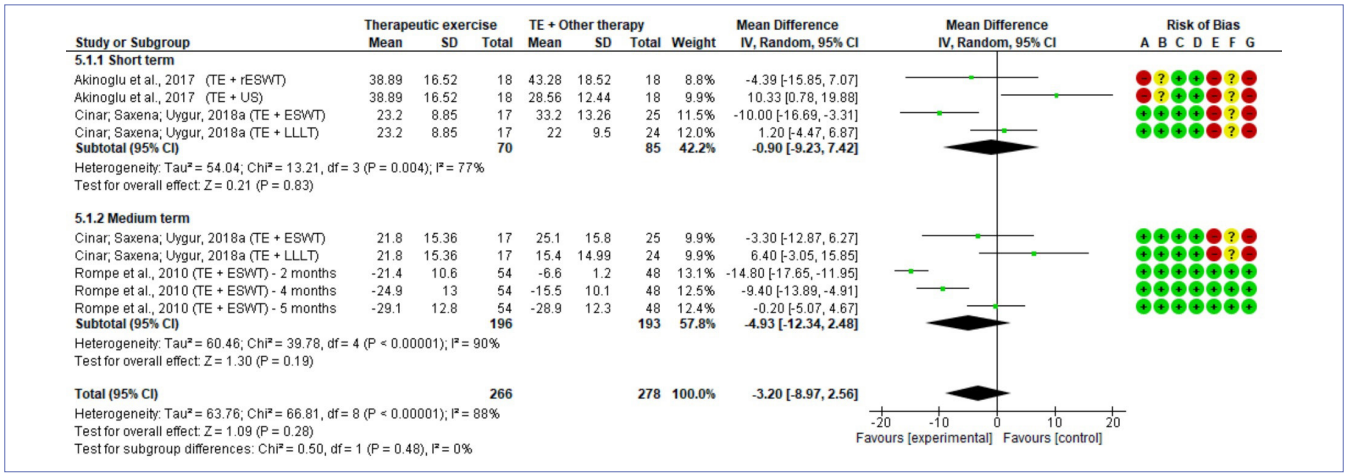

Figure 6. Forest plot of comparison: therapeutic exercise *vs* TE + other therapy.

Outcome: FFI (pain).

reduce VAS scores, although no superiority of one of the techniques was demonstrated.

Another widely used resource is ESWT, which is a therapeutic resource is a therapeutic resource that uses high-energy sound waves, which cause an inflammatory response in the tissue and cause the body to respond to this condition with increased blood flow and metabolism (39, 40). In the study by Mohamed *et al.* (12) ESWT alone or associated with a TE program was more effective than performing TE alone. In addition, Greve *et al.* (41) pointed out that ESWT may be more effective for the treatment of PF pain than conventional physiotherapy. However, this therapy is still controversial, because in the study by Carlisi *et al.* (8), the volunteers had a high number of trigger points in the triceps sural, and when ESWT was performed on these points, despite being safe, there was no improvement in symptoms. US is interesting for its thermal and non-thermal effects. It is characterized by kinetic oscillations produced by a vibrating transducer, which when applied to the skin, penetrates the body, and promotes therapeutic responses. Its mechanism is due to the agitation of the electrolytic medium of interstitial fluids, accelerating the inflammatory process and tissue repair, reducing pain and edema, assisting in tissue proliferation and protein synthesis, reducing joint stiffness and contractures, increasing the level of cellular activity and microcirculation (42, 43). In the studies of Akinoglu *et al.* (17) and Akınoğlu and Köse (18) found reduction in pain level from this intervention, and in the first study US proved to be more effective than ESWT and TE.

Cinar *et al.* (16) concluded that LLLT associated with TE was more effective than ESWT + TE in reducing pain. In this sense, the systematic review and meta-analysis by Wang *et al.* (44) aimed to investigate the clinical effectiveness of LLLT therapy in PF. In total, 6 randomized controlled trials were included, and the authors conclude that compared to the control group the VAS score decreased significantly at the end of treatment of patients treated with LLLT, an improvement that persisted for up to 3 months. Limitations of the present study include the absence of comparisons of the use of TE with placebo, but there are ethical implications that make this difficult.

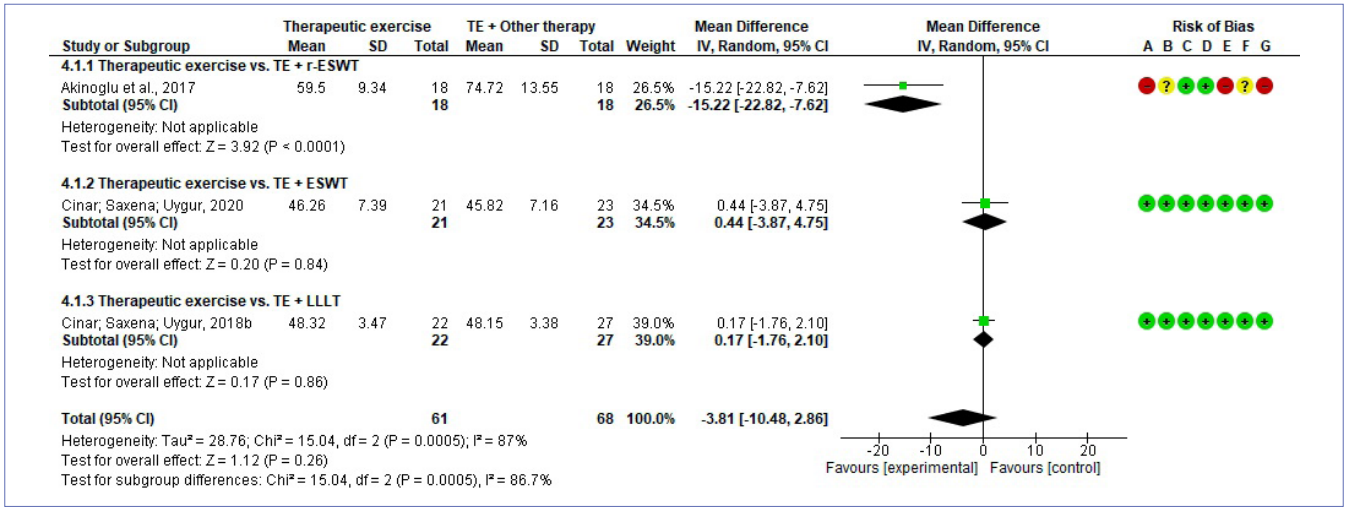

Figure 7. Forest plot of comparison: therapeutic exercise *vs* TE + other therapy.
Outcome: functionality - short term.

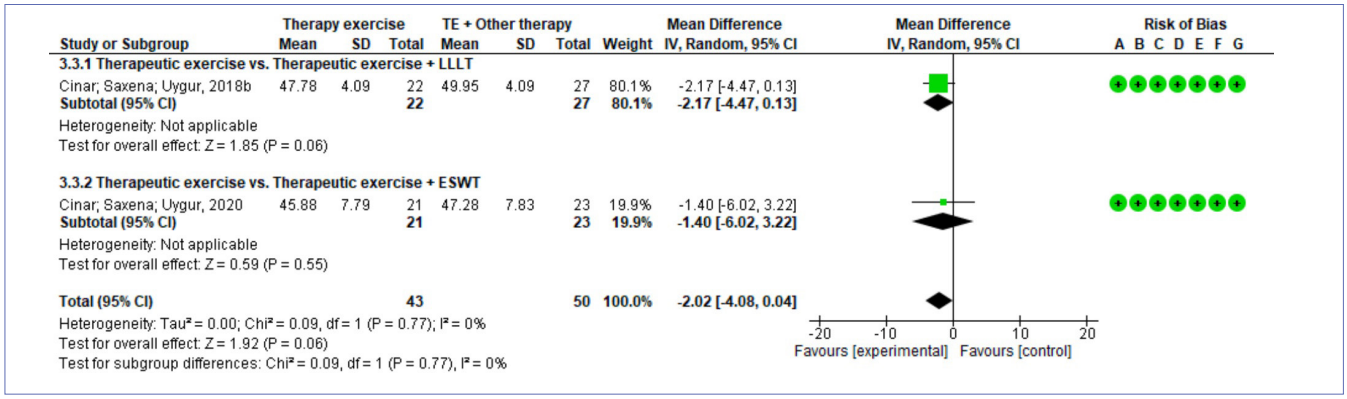

Figure 8. Forest plot of comparison: TE *vs* TE + other therapy.
Outcome: functionality - medium term.

CONCLUSIONS

It is concluded that TE, mainly through plantar fascia and triceps sural stretching, is effective in reducing pain and functionality alone, or combined with other therapies, such as ESWT, LLLT and US in PF, especially for the last two forms of association. In addition, new studies are suggested, with low risk of bias, which analyze the use of TE in the form of strengthening, because with the improvement of stabilization it is believed that functional improvement may follow.

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DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUITIONS

RAS, BT, FFC: research project, literature research, writing – original draft. DFL, CBD, GRFB: research project, literature research, critical review of the manuscripts. MRB: research project, literature research, critical review of the manuscript, coordination. FFC, DFL, CBD, GRFB, MRB: writing - review & editing.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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ONLINE SUPPLEMENTS

Appendix 1. Database searches.

Database	Search	References found
PubMed	((“fasciitis. plantar”(MeSH) OR “fasciitis. plantar”) OR (“fasciitis. plantar”(Title/Abstract)) OR (“fasciitis plantar” OR “Policeman’s Heel” OR “Policeman’s Heel” OR “Heel Spur Syndrome” OR “Chronic Plantar Fasciitis”)) AND ((“exercise therapy”(Mesh) OR “exercise therapy”) OR (“exercise therapy”(Title/Abstract)) OR (“exercise” OR “stretchs” OR “strengths” OR “therapy” OR “exercise” OR “stretching” OR “muscle stretching exercises”(Mesh) OR “muscle stretching exercises” OR “strength” OR “strengthening” OR “resistance training” OR “intrinsic foot muscle” OR “static stretching” OR “passive stretching” OR “static passive stretching” OR “isometric stretching” OR “active stretching” OR “static active stretching” OR “ballistic stretching” OR “dynamic stretching”))	739
Web of Science	(“fasciitis plantar” OR “Policeman’s Heel” OR “Policeman’s Heel” OR “Heel Spur Syndrome” OR “Chronic Plantar Fasciitis”) (Tópico) and (“exercise therapy” OR exercise OR stretches OR strengths OR therapy OR exercise OR stretching OR “muscle stretching exercises” OR strength OR strengthening OR “resistance training” OR “intrinsic foot muscle” OR “static stretching” OR “passive stretching” OR “static passive stretching” OR “isometric stretching” OR “active stretching” OR “static active stretching” OR “ballistic stretching” OR “dynamic stretching”)	186
Embase	(‘fasciitis plantar’/exp OR ‘fasciitis plantar’ OR ‘heel spur syndrome’/exp OR ‘heel spur syndrome’ OR ‘chronic plantar fasciitis’/exp OR ‘chronic plantar fasciitis’) AND (‘exercise therapy’/exp OR ‘exercise therapy’ OR stretchs OR strengths OR ‘therapy’/exp OR therapy OR ‘exercise’/exp OR exercise OR ‘stretching’/exp OR stretching OR ‘muscle stretching exercises’/exp OR ‘muscle stretching exercises’ OR ‘strength’/exp OR strength OR strengthening OR ‘resistance training’/exp OR ‘resistance training’ OR ‘intrinsic foot muscle’ OR ‘static stretching’/exp OR ‘static stretching’ OR ‘passive stretching’/exp OR ‘passive stretching’ OR ‘static passive stretching’ OR ‘isometric stretching’ OR ‘active stretching’ OR ‘static active stretching’ OR ‘ballistic stretching’ OR ‘dynamic stretching’)	1,537
Lilacs	((“fasciitis. plantar” OR “fasciitis plantar” OR “Policeman’s Heel” OR “Policeman’s Heel” OR “Policeman Heel” OR “Policemans Heel” OR “Heel Spur Syndrome” OR “Chronic Plantar Fasciitis” OR “Plantar Fasciitis” OR “Fasciíte Plantar” OR “Fascitis Plantar”)) AND ((“Exercise Therapy” OR “Terapia por Ejercicio” OR “Terapia por Exercício” OR exercise OR “Exercise Movement Techniques” OR ejercicio OR “Técnicas de Ejercicio con Movimientos” OR exercício OR “Técnicas de Exercício e de Movimento”)) AND (db:(“LILACS”))	7
Cochrane	(“fasciitis plantar” OR “Policeman’s Heel” OR “Policeman’s Heel” OR “Heel Spur Syndrome” OR “Chronic Plantar Fasciitis”) in Title Abstract Keyword AND (“exercise therapy” OR exercise OR stretchs OR strengths OR therapy OR exercise OR stretching OR “muscle stretching exercises” OR strength OR strengthening OR “resistance training” OR “intrinsic foot muscle” OR “static stretching” OR “passive stretching” OR “static passive stretching” OR “isometric stretching” OR “active stretching” OR “static active stretching” OR “ballistic stretching” OR “dynamic stretching”) in Title Abstract Keyword - (Word variations have been searched)	333
PEDro	“fasciitis plantar” AND “exercise”	30
LIVIVO	fasciitis plantar AND exercise therapy	52
Google scholar	(“fasciitis plantar”) AND (“exercise therapy”)	62
Brazilian catalog of theses and dissertations CAPES	(“fasciitis plantar”) AND (“exercise therapy”)	36
Citation search		2
Total		2,984