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Review

The Outcomes of Conservative Nonpharmacological Treatments for Achilles Tendinopathy: An Umbrella Review

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Abstract: Achilles tendinopathy (AT) is the most common injury of the Achilles tendon and represents 55–65% of all Achilles tendon clinical diagnoses. AT is characterized by pain, swelling, and impaired performance. ATs can be divided into two types, according to anatomical location—midportion AT (MAT) and insertional AT (IAT). MAT more often occurs in older, less active, and overweight populations, while IAT usually occurs in the more physically active population. Both types of AT can be treated by different treatments, such as surgery, conservative pharmacological treatments, and conservative nonpharmacological treatments. This umbrella review aims to assemble the evidence from all available systematic reviews and/or meta-analyses to determine which conservative nonpharmacological treatments are most commonly used and have the greatest effects. Three major electronic scientific databases (PubMed, Scopus, and Web of Science) were screened. The reference lists of several recent articles on AT were also searched. We found 50 articles that met the inclusion criteria. The methodological quality of the included articles was assessed using the AMSTAR 2 tool. Eccentric (ECC) exercise, isotonic (ISOT) exercise, and acupuncture treatment showed the greatest effects for treating MAT as a standalone therapy. Meanwhile, extracorporeal shockwave therapy and ECC exercise provided the best outcomes for treating IAT as individual treatments. However, an even greater pain decrease, greater function improvement, and greater patient satisfaction for treating either MAT or IAT were achieved with combined protocols of ECC exercise with extracorporeal shockwave therapy (in both cases), ECC exercise with cold air and high-energy laser therapy (in the case of IAT), or ECC exercise with ASTYM therapy (in the case of IAT).

Keywords: Achilles tendinopathy; insertional Achilles Tendinopathy; midportion Achilles Tendinopathy; conservative treatments; nonpharmacological treatments

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1. Introduction

The Achilles tendon is the largest [1,2], strongest, and thickest tendon in the human body [1–4]. It transforms energy from the leg to the foot and is essential for postural control and gait [3]. The most common pathology of the Achilles tendon is Achilles tendinopathy (AT), which represents 55–65% of all Achilles tendon clinical diagnoses [5]. AT is characterized by swelling, pain, and impaired performance of the Achilles tendon [6–8]. Tendinopathies are well known as overuse injuries [1,9] that are a consequence of a repetitive load acting on a tendon, which can no longer maintain tension and stress [9]. ATs can be divided into two groups based on the duration and possible inability to perform physical activity (acute and chronic AT) [5]. Moreover, AT may be divided according to anatomical location into insertional AT (IAT) and non-insertional or midportion AT (MAT) [10]. MAT is located in the middle of the Achilles tendon, 2–6 cm above the calcaneum (the heel bone) [11–13], and it occurs in older, less active, and overweight populations [13]. Meanwhile, IAT is located in the distal insertion point of the Achilles tendon to the calcaneal bone [14–16]. IAT tends to occur in the more physically active population [13].

Lagas et al. [17] found that AT affects 5.2% of runners on average, whereas it affects approximately 7.4% of runners who are registered for a marathon. On the other hand, Lysholm and Wiklander [18] claimed that AT affects 9% of recreational runners and causes up to 5% of professional athletes to end their careers. ATs also represent 6.1 running-related injuries per 1000 running hours [17] and 0.235 injuries per 100 adult injuries in the general population [19]. Although AT often occurs in the physically active population [20], the incidence of injury in the population with a sedentary lifestyle is around 30% [21,22]. The most common risk factors are a previous AT injury [1,17] and inadequate rehabilitation of previous AT [17], low plantar flexor strength [1,17], training during cold weather [1], decreased plantar flexor flexibility [13], an abnormal gait pattern, and an increased lateral foot roll over at the forefoot flat phase [1].

AT can be treated by conservative or operative treatments. Nonsurgical, conservative treatments show great efficacy for treating AT, but in about 25% of all cases, surgery is needed [23]. The most common non-surgical treatments are nonsteroidal anti-inflammatory drugs, corticosteroid injections, acupuncture, extracorporeal shockwave therapy (ESWT), cold air and high-energy laser therapy, ultrasound, thermotherapy, massage and physiotherapy, splints, braces and taping, wait-and-see treatment, stretching, and exercise (e.g., isometric (ISOM), isotonic (ISOT), eccentric (ECC), concentric (CON), vibration exercise, etc.) [24]. Rompe et al. [25] reported that conservative pharmacological treatments (such as nonsteroidal anti-inflammatory drugs and corticosteroid injections) did not have beneficial effects on pain decrease, function improvement, or patient satisfaction improvement as great as exercise treatments at short-term follow-up. However, the implementation of corticosteroid injections to an exercise protocol caused greater function improvement and Achilles tendon thickness than either an exercise protocol alone or a combined exercise protocol with placebo injections [26]. On the other hand, Li and Hua [20] claimed that modification of the training regimes and specific exercises is necessary. As the maximal load is placed on a tendon during the eccentric phase, tendon injuries are likely to occur during eccentric loading [27]. That is why ECC exercise is the most frequent exercise protocol for treating AT [28]. ECC exercise was found to be beneficial in early treatment [29,30] and also in chronic AT patients [27]. Several different types of ECC exercise for the rehabilitation of AT are known, among which Alfredson's heavy-load eccentric calf muscle training (HECT) is the most commonly used [27]. On the other hand, many physiotherapists use either ISOM exercise [31,32], ISOT exercise (i.e., heavy slow resistance (HSR) exercise, the Silbernagel combined protocol, and the Stanish and Curwin protocol) [33], CON exercise [34,35], or the combination of two or more of the mentioned protocols [33]. Similarly, great results for treating either IAT or MAT were found after executing acupuncture treatment [36,37], ESWT treatment [36,38], cold air and high-energy laser therapy [15,39], physiotherapy and massage treatment [39,40], etc.

Santacaterina et al. [41] and Gatz et al. [42] reported that the operative treatment of AT should be considered only when conservative management has failed. That is why this umbrella review aims to be the first manuscript to clearly and coherently combine all systematic reviews and/or meta-analyses, so that either physiotherapists, researchers, or the general population, who are not familiar with the outcomes of conservative non-pharmacological treatments for treating AT, can find out which standalone or combined conservative nonpharmacological treatment protocol caused the greatest treatment results in comparison to other conservative nonpharmacological treatments for treating each type of AT (i.e., IAT or MAT) separately or together (if the authors of the articles did not specify the type of studied AT), in order to further improve the effectiveness of the mentioned conservative treatment.

2. Materials and Methods

2.1. Information Sources and Search Strategy

The search for articles was performed in April 2022. We screened 3 major electronic scientific databases: PubMed, Web of Science, and Scopus. The terms that were used in the electronic search were: *Achilles paratendinitis*, *Achilles peritendinitis*, *Achilles tendinitis*, *Achilles tendinopathy*, and *Achilles tendinosis*. The terms were combined into one string that was used for all databases: (Achilles paratendinitis OR Achilles peritendinitis OR Achilles tendinitis OR Achilles tendinopathy OR Achilles tendinosis). We carried out the search strategy in 3 stages: (1) assessing the eligibility of the papers based on the title; (2) assessing the eligibility of the papers based on the abstract; and (3) assessing the eligibility of the papers based on the full text. All 3 stages of the search strategy were carried out by two reviewers independently. Disagreements were resolved by additional discussion and consultation with a third reviewer. Our search included all found articles written in the English language, regardless of the year of publication. None of the authors of the included articles were contacted for additional data.

2.2. Eligibility Criteria

The inclusion criteria were structured according to the PICOS tool [43]:

- Population—Human population with IAT or MAT, regardless of age, physical activity status, and duration of symptoms.
- Intervention—Interventions that consisted of one or more different conservative nonpharmacological treatments (exercise (ISOM, isokinetic, ISOT, ECC, CON, etc.), stretching, ESWT, cold air and high-energy laser therapy, low-level laser therapy, microcurrent therapy, cryotherapy, ultrasound therapy, ultrasound, carbon dioxide laser, TECAR therapy, physiotherapy and massage (i.e., manual therapy, deep friction massage, soft tissue massage, ASTYM therapy, etc.), splint/brace, orthoses, tape, acupuncture, wait-and-see, etc.).
- Comparison—Comparison between the aforementioned different conservative nonpharmacological treatments.
- Outcome—Outcomes describing patient's pain, function, strength, power, endurance, work, functional performance (e.g., jumping performance, etc.), range of motion, tendon properties (e.g., tendon diameter, tendon volume, tendon thickness, tendon neovascularisation, tendon cross-sectional area, tendon length, tendon stiffness, etc.), nervous system sensitization, satisfaction, general health status, quality of life, the incidence of injury, the severity of injury, return-to-sports, and efficacy.
- Study design—Systematic reviews with or without meta-analyses were included, whereas narrative reviews, literature reviews, a protocol for systematic reviews and/or meta-analysis, topical reviews, and intervention reviews were excluded.

2.3. Data Extraction

The data extraction was performed by one reviewer, while other reviewers additionally helped by supervising and re-reviewing of the extracted data. Any dilemmas were resolved by consultation with other authors. From the included articles, we extracted and analysed: (A) the type of AT; (B) the number of studies included in a systematic review and meta-analysis that were connected to conservative nonpharmacological interventions for AT; (C) observed conservative nonpharmacological interventions for treating AT; (D) reported outcome variables for conservative nonpharmacological interventions for treating AT; and (E) summary of key findings.

2.4. Methodological Quality Assessment

The methodological quality of the included systematic reviews and/or meta-analyses was assessed by one reviewer with additional help from other reviewers. Dilemmas were solved by consultation with other reviewers. The assessment of methodological quality was executed by the Assessment of Multiple Systematic Reviews 2 tool (AMSTAR 2) [44,45]. The mentioned tool is a critical appraisal tool for systematic reviews and meta-analyses that include randomized and/or nonrandomized studies of healthcare interventions [45]. We used AMSTAR 2 guidance document as an additional help for item interpretation during the assessment process. The AMSTAR 2 tool consists of 16 items among which we determined 7 critical domains (7 out of 16 items). These 7 domains are selected according to the field of research and critically affect the rating of overall confidence [45]. We decided that the items number: 1, 3, 8, 9, 11, 14, and 15 were the most appropriate to be determined as critical domains for our field of research. If a meta-analysis was not conducted, the critical domain covering the appropriateness of the meta-analytical methods (i.e., item 11) or the critical domain covering the investigation of publication bias (i.e., item 15) did not apply to the formation of an overall confidence score [45]. The rating of overall confidence was categorized as, depending on fulfilled criteria [45]:

- High: no or one noncritical weakness;
- Moderate: more than one noncritical weakness, multiple noncritical weaknesses may diminish confidence in the review, and it may be appropriate to move the overall appraisal down from moderate to low confidence;
- Low: one critical flaw with or without noncritical weaknesses;
- Critically low: more than one critical flaw with or without noncritical weaknesses.

Risk of bias assessment of all included studies in our umbrella review was carried out by 2 authors (L.K. and Ž.K.) independently. Any disagreements between them were additionally discussed with a third author (N.Š.).

3. Results

3.1. Selection of Studies

The records from PubMed (n = 221), Scopus (n = 758), and Web of Science (n = 568), as well as the records identified through relevant reference lists (n = 8), were imported into Mendeley (version 1.19.8) (Mendeley, London, UK), upon which the duplicates were removed and the records were exported into Microsoft Excel software (Microsoft, Redmond, Washington, DC, USA) (n = 1182). Among 1182 articles, 1037 were excluded due to inappropriate content based on the title and/or abstract. The remaining 145 potential articles were read in a full text. Ninety-five articles of these 145 were excluded due to not meeting the eligibility criteria. Among the mentioned 95 articles, 49 were literature reviews, 9 were narrative reviews, 3 were protocols for systematic review, 1 was a topical review, 2 were intervention reviews, 1 included only tables (supplementary paper), 4 referred to surgical treatments, 2 referred to pharmacological treatment, 4 did not include AT, 8 were written in German, 3 were written in Spanish, 1 was written in Danish, and we were not able to obtain 8 articles for full-text assessment. Thus, a total of 50 systematic reviews and/or meta-analyses were included in the current umbrella review, among which the authors of 5 articles separately researched IAT and MAT, 4 articles researched only IAT, 16 articles researched only MAT, and the authors of 25 articles did not specify the researched type of AT. The flowchart of the study selection is shown in Figure 1.

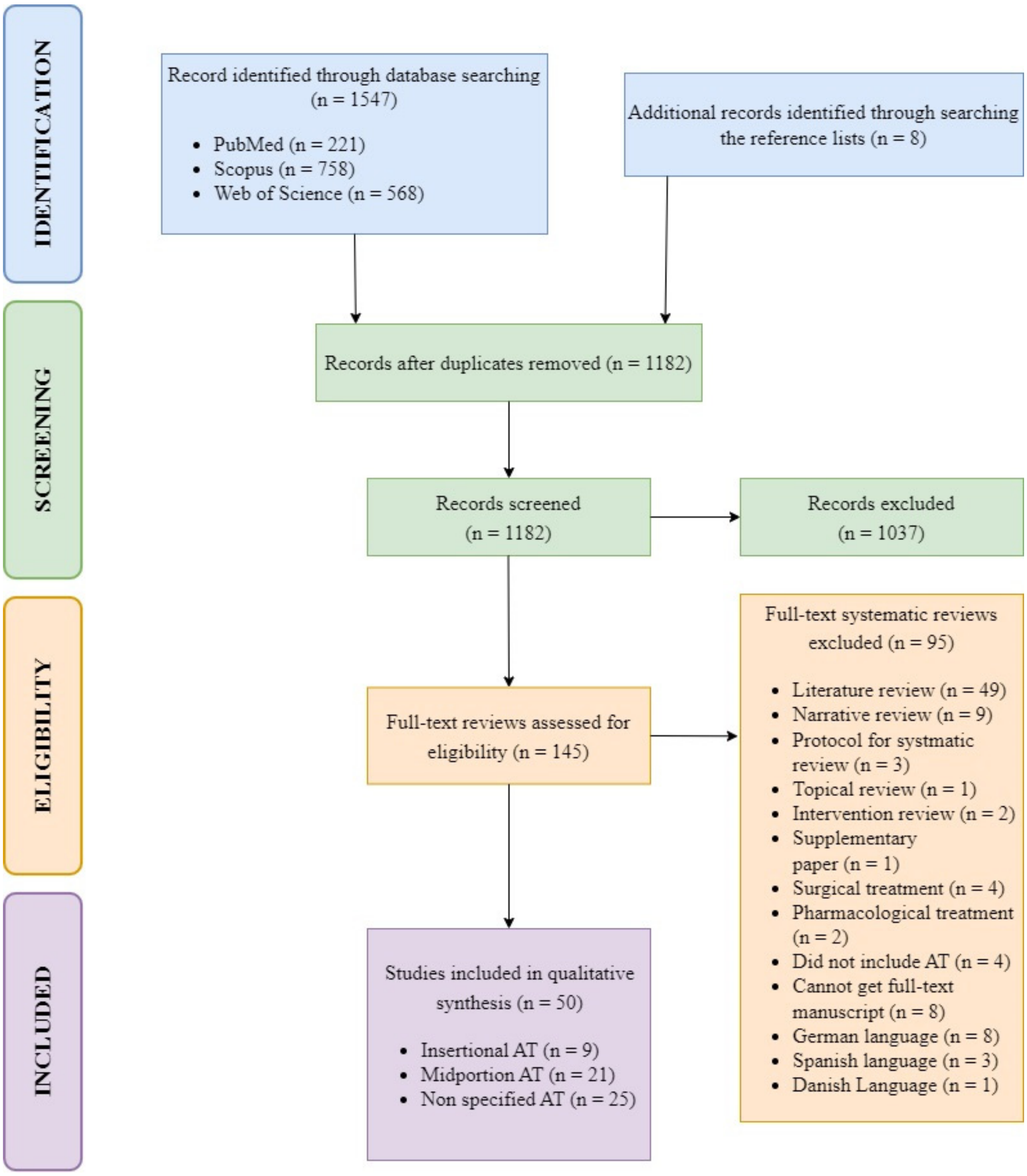

Figure 1. Flowchart of the study selection.

3.2. Methodological Quality Assessment of Studies

The results of methodological quality are presented as the rating of overall confidence in the range from critically low overall confidence to high overall confidence (Table S1). Twenty-seven articles had critically low overall confidence [14–16,28,31,32,34,35,38,40,46–61], 8 articles had low overall confidence [29,39,62–67], none of the included studies had moderate overall confidence, and 16 out of 50 articles had high overall confidence [11,12,30,33,36,37,68–77].

Among all the included studies, 26 of them defined the components of PICO in the research question and inclusion criteria, while the other 25 articles did not include these components. Forty-six articles consisted of randomized control trials and/or nonrandomized studies of intervention, whereas 4 studies did not include the types of intervention. The authors of the included articles described their studies in adequate detail or at least partially described them in 42 articles, while 8 authors did not do this. Twenty-seven studies used a satisfactory technique for assessing the risk of bias in their research that was included in the review, while an unsatisfactory technique for assessing the risk of biases was observed in 16 articles. Only 14 of the 50 included articles provided meta-analysis, out of which the authors of 11 studies used appropriate methods for the statistical combination of results. In 26 of the 50 studies, authors provided a satisfactory explanation for, and discussion of, any heterogeneity that was observed in the results of the review. Only two studies executed sufficient investigation and discussion about publication biases, while the other seven articles that obtained a "YES" included fewer than 10 studies, which is a minimum to perform a test for publication bias.

3.3. Key Findings

3.3.1. Midportion Achilles Tendinopathy

The authors of 21 out of the 50 studies were focused on the effects of conservative non-pharmacological treatments for treating MAT [11,12,29–34,40,51–53,55,56,58,66,68,70,73,76,77].

ECC exercise, characterized by lengthening of the muscle with a purpose to maintain a certain load or because external resistance/load becomes greater than the force produced by the muscle [78,79], was found to be effective as a rehabilitation protocol for treating MAT, as it caused a significant decrease in pain, an improvement in function [29,32,51,77], an improvement in tendon properties (e.g., increase in tendon volume, decrease in tendon cross-sectional area, decrease in free tendon diameter, reduced tendon post-capillary filling pressure and capillary blood flow, increase in type I collagen synthesis, and reduction in tendon neovascularization) [32,51,53,55], an increase in strength [34], and an improvement in ankle performance [55], and it caused an improvement in patient satisfaction compared to a baseline [29]. An increase in strength and improvement in function were found to have a relationship with a decrease in pain in the Achilles tendon after executing ECC exercise [32]. Whereas ECC exercise resulted in pain decrease, and function and tendon structure improvement in approximately 60% of patients with MAT [51], the proportion of patients who felt satisfied after executing ECC exercise ranged between 60 and 90% [29]. Meanwhile, Obst et al. [53] reported that a 12-week ECC exercise program that consisted of 3 sets of 15 ECC heel raise repetitions with an extra load of approximately 120% of individual body weight, caused a statistically significant decrease in free Achilles tendon diameter with a negative effect size between -0.72 and -3.53 compared to a baseline. The average free Achilles tendon diameter or Achilles tendon anterior–posterior diameter needs to be measured 8 cm above the most inferior part of the calcaneus [80], and it should be lower than 5.9 mm in the healthy female and 6.9 mm in the healthy male population [80–82]. AT leads to swelling of the Achilles tendon (with 9 ± 3 mm free tendon diameter measures) [83], and it can be decreased by executing ECC exercise protocols [53]. On the other hand, a 12-week ECC exercise program reduced Achilles tendon post-capillary filling pressure and capillary blood flow [34], which were increased at the point of pain [84,85], and increased type I collagen synthesis [34].

Furthermore, 2–4 weeks were found to be enough for ECC exercise to cause a pain decrease and function improvement for patients with MAT, while the peak efficiency of ECC exercise was found at the end of the 12-week protocol [32]. Conversely, the tendon structure of the Achilles tendon with MAT stayed unchanged within the first few weeks of executing the ECC exercise, which is connected to the fact that the tendon structure has a poor relationship with a decrease in pain and improvement in function [32]. A decrease in pain, improvement in function, improvement in ankle performance, and reduction in tendon neovascularization were observed 6 or more months after the a 12-week ECC exercise protocol ended [55]. It was also found that both athletes and sedentary patients with MAT achieved similarly successful rates of outcome measures (such as pain decrease, function improvement, and strength increase) after executing ECC exercise [56].

The most frequently used ECC exercise protocol for treating MAT was HECT (heavy-load eccentric calf muscle training) or its modifications [33,77]. The HECT regimen is a 12-week program that was founded by Alfredson [27]. The HECT regimen consists of 3 series with 15 painful repetitions that need to be executed twice per day. The patient needs to stand on a higher base on the forefoot while the ankle joint is in plantar flexion The patient then eccentrically loads the injured leg by lowering the heel level with the knee straightened or bent, followed by concentrically loading the plantar flexors of both legs. The

HECT protocol can be aggravated by using extra loads (an extra-loaded backpack or machine). The HECT protocol is relatively easy to execute, even at home [27]. There are some modifications to the classic HECT protocol with customized pain (i.e., "do-as-tolerated" protocol) [14,16,33,75,77] that is achieved by limiting the range of motion (a patient eccentrically loads the plantar flexors of the ankle only to the floor level/obstacle) [14] or adjusting the number of sessions, series, or repetitions [33]. Both classic and "do-as-tolerated" HECT were found to significantly decrease pain, improve function, and cause a significant improvement in patient satisfaction compared to the baseline [33,77]. Modified HECT that was executed 3 x/week caused a greater pain decrease than classic HECT that was executed 2 x/day [33,77]. Similarly, the same duration, modified HECT protocol (with 3 sessions/week) caused greater function improvement than the classic HECT protocol, but the difference was statistically unsignificant [33]. On the other hand, Head et al. [33] did not report any difference between the mentioned protocols in the case of patient satisfaction improvement. The mean improvement in the VISA-A score between the pre- and post-test results, after finishing either a 12-week classic HECT or the same duration, modified HECT that gradually increased the number of series within a session, was around 74% [77]. Similarly, Head et al. [33] reported that the execution of a 12-week HECT protocol 3 x/week decreased pain by 35.6 points on a 100-point scale (when compared to the baseline), which was 11.7 points greater compared to classic HECT. Higher loading magnitudes caused greater tendon stiffness and a greater increase in tendon cross-sectional area compared to lower loading magnitudes [33]. ECC exercise with the gradually addition of an extra load additionally decreased pain compared to normal ECC exercise [51].

Unlike ECC contraction, ISOM contraction occurs when the muscle does not change its length during contraction [78]. A single session of ISOM exercise of the plantar flexor muscle that consisted of 10 repetitions with an intermediate break of 60 s largely decreased the Achilles tendon cross-sectional area (with standardized mean difference (SMD) of −1.01) and Achilles tendon volume (with SMD of −1.24) [31]. It caused small changes in Achilles tendon length (with SMD of 0.27) [31]. A single session of ECC exercise caused a small-to-moderate increase in the Achilles tendon volume (with SMD of 0.41) [31] and instant changes in cortical inhibition and tendon pain [34], while longer execution of the ECC exercise protocol resulted in a small-to-moderate decrease in Achilles tendon volume (with SMD of −0.46), which was observed as long as 4 years after the protocol for treating MAT ended (SMD = −0.15) [31].

ISOT contraction includes both ECC and CON contractions [78]. During the entire range of motion, the force produced by the muscle stays unchanged and is greater than the external resistance/load [78]. The most frequently used ISOT exercises for treating MAT were HSR (heavy slow resistance) exercise [55,70], the Stanish and Curwin protocol [33,34], and the combined ISOT and ECC exercise, called the Silbernagel combined protocol [33,34,56] (Table S2). Although ECC exercise (i.e., HECT) caused a greater pain decrease (especially while running or heel raising) and function improvement compared to wait-and-see or traditional physiotherapy, HECT caused a similar pain decrease and function improvement as HSR exercise did [55,70]. The biggest difference in results caused by either ECC exercise or HSR exercise was connected to the improvement in patient satisfaction [55]. Patients with MAT who executed ECC exercise were found to be highly satisfied at a 6-month follow-up, whereas the group that executed HSR exercise was found to be highly satisfied even at a 1-year follow-up [55]. While a 12-week ECC exercise caused up to 88% of patients to be satisfied, HSR exercise caused an even greater improvement that was up to 100% of patients at a 6-month follow-up [55]. Meanwhile, HSR exercise decreased tendon thickness and tendon neovascularization, which was observed at different follow-ups (at a 6-week and even a 6-month follow-up) [55]. The Silbernagel combined protocol increased the power and strength of the plantar and dorsal flexors of the ankle, decreased the range of motion of the dorsal flexors of the ankle, and increased the range of motion of the plantar flexors of the ankle [34]. This program caused a greater increase in the ankle plantar flexor's endurance and an improvement in jumping performance compared to either calf raises (i.e., HECT) or stretching [34]. There was no consensus on whether to engage in sports activities or not while rehabilitating MAT by the Silbernagel combined protocol [34]. The Silbernagel combined protocol also caused a significantly greater pain decrease at 3- and 6-month follow-ups compared to basic ISOT exercise alone [33]. While Rowe et al. (2012) reported that ECC exercise caused a slightly greater pain decrease compared to ISOT exercise, similar to the Silbernagel combined protocol, Malliaras et al. [34] objected and pointed out that the pain decrease and improvement in patient satisfaction were greater after executing the latter. Nevertheless, this program is more appropriate for patients with MAT with weak ankle plantar flexor muscles because it contains both CON and ECC exercises [34]. It was also reported that the Stanish and Curwin protocol resulted in a decrease in pain and a faster return to sports activity after 12 weeks, while Head et al. [33] reported just the positive effects of the Stanish and Curwin protocol on pain decrease for patients with MAT.

As opposed to ECC contraction, CON contraction creates force, greater than the external resistance/load, by shortening the muscle [78]. The isolated CON exercise protocol was found to be less effective than the same duration isolated ECC exercise protocol for decreasing pain [29,33,56], increasing muscle strength, improving muscle properties (i.e., improving muscle hypertrophy), improving patient satisfaction, and causing a faster return to a preinjury level of activity [34], but CON exercise decreased pain and caused other positive effects (to a lesser extent) [56]. The increase in muscle strength and muscle hypertrophy (especially type II fibers) was greater in ECC exercise than CON exercise, but only when the patients who executed the ECC exercise protocol used greater loads than the CON exercise group did [34]. On the other hand, CON exercise was found to be especially effective when individuals with MAT were too weak to execute ECC exercise [56]. Symptomatic patients with MAT who executed either ECC or CON heel raise exercises, increased their Achilles tendon volume to a greater level compared to asymptomatic patients [53].

Magnussen et al. [29] reported that even though ECC exercise decreased pain and improved function for patients with MAT at 3- and 12-month follow-ups, the improvement was not significant compared to the stretching protocol. On the other hand, Rowe et al. [56] reported that calf stretching of the plantar flexor muscle was not found to be as important as executing either ECC or CON exercise for treating MAT. That is why ECC exercise was found to be superior in improving function at 3- to 12-month follow-ups compared to the combined protocol, which consisted of stretching, ultrasound, and deep friction massage [30].

ESWT caused similar or lower function improvement [30,52] and pain decrease for patients with MAT as ECC exercise did [29,52]. A greater pain decrease, greater function improvement, and greater and faster self-perceived recovery were found after executing ESWT treatment compared to wait-and-see [29,68], the sham ESWT treatment [52,68], footwear modification, or calf stretching [52]. ESWT improved the American Orthopaedic Foot and Ankle Society score (AOFAS for pain, function, and alignment) by 18 points on a 100-point AOFAS scale, while the sham ESWT group improved the AOFAS score by 8 points on the same scale [52]. Korakakis et al. [68] reported that the most efficient protocol for treating MAT was radial ESWT, which delivers 2000 impulses at 3 bars (with an energy flux density of 0.1 mJ/mm^2) at 8 Hz for 3 sessions per week.

ESWT treatments can be divided into two types according to the energy level of the ESWT—low-energy ESWT and high-energy ESWT [56,58,68]. Korakakis et al. [68] found that a 12-week high-energy ESWT treatment improved function and decreased pain for patients with MAT, while a low-energy ESWT treatment did not. However, Rowe et al. [56] pointed out that there was no difference between combined ECC exercise with low-energy ESWT and high-energy ESWT in terms of pain decrease at a 12-month follow-up.

The combining of ECC exercise and ESWT protocols caused additional beneficial effects on pain [52,56,68], function [11,52,56,68], and sped up the self-perceived recovery [52,68]. The difference between the combined HECT + ESWT treatment and HECT alone was statistically significant in the case of function improvement (with an MD of 13.9 points on a 100-point

VISA-A scale) [52,68,73], but not in the case of pain decrease (with an MD of 1.5 points on a 10-point VAS scale) [52,68].

It was found that both low-level laser therapy and placebo low-level laser therapy, which were applied on three standardized points on both sides of the Achilles tendon for 30 s, 3 x/week for 4 weeks, decreased the pain and improved function in acute MAT in the short term (<4 weeks), medium term (4–12 weeks), and long term (at a 52-week follow-up) [66]. Rowe et al. [56] agreed and suggested low-level laser therapy is useful for treating the reactive state of AT, while the degenerative state needs to be treated with other interventions. They [56] also added that the implementation of low-level laser therapy to the ECC exercise protocol shortened the recovery time for treating recreational athletes with MAT.

A 12-week HECT was more effective for decreasing pain than the same duration night splint treatment [29,31] or AirHeel brace [12]. Immediately post-intervention, HECT was found to be significantly more effective than wearing an AirHeel brace in improving general health status, improving foot and ankle function, and improving quality of life [12]. The implementation of a night splint (which was worn during the night) or AirHeel brace (which was worn during the daytime) to the HECT program did not cause any additional pain decrease [29,73], nor did it achieve any greater general health level compared to HECT alone for patients with MAT at a 12-week follow-up [73].

Additionally, acupuncture has regularly been compared to ECC exercise [11,12]. Rhim et al. [11] pointed out that acupuncture caused greater function improvement and severity of injury reduction than ECC exercise with an SMD of −1.23 points on a 100-point VISA-A scale, while Woitzk et al. [12] reported that the MD was 19.50 points on a 100-point scale in favour of acupuncture treatment. ECC exercise alone did not improve function or reduce the severity of injury as much as a combined protocol of ECC exercise with acupuncture [11]. While acupuncture caused a greater short-term pain decrease, function improvement, and severity of injury reduction for patients with MAT, the ECC exercise resulted in greater long-term treatment effects in populations with the same pathology [12,66].

Meanwhile, the combined physiotherapy treatment (i.e., 10-times 30 min deep friction massage treatment combined with ultrasound treatment, ice sensory motor training, which consisted of 3 sets of 15 repetitions of balance exercises on a stability pad with ECC exercise) caused a significant decrease in pain and an improvement in function compared to the baseline [56]. A single exercise program was found to be as effective as the usual physiotherapy treatment in terms of pain decrease and function improvement [51]. Multimodal physiotherapy was found to be more effective in reducing symptoms and improving function compared to any type of orthoses (i.e., custom-fitted semi-rigid insoles) or wait-and-see interventions [56]. Executing a 6-week soft tissue mobilization treatment (6 times, once per week) was found to be effective for as long as 24 months after treatment ended [56]. Meanwhile, 10 treatments of ASTYM therapy in 5 weeks (2 x/week) were found to be useful for decreasing pain for patients with MAT, so they were pain-free and were able to participate in their normal life activities [40]. The combined treatment of ASTYM therapy and stretching was also used in the case of a girl with cerebral palsy who suffered from MAT [40]. After 11 sessions of combined treatment, the girl increased the range of motion of ankle dorsiflexion and plantarflexion by 5° compared to the baseline [40]. Table S3 contains an overview of the included reviews that researched the effects of conservative nonpharmacological interventions for treating MAT.

3.3.2. Insertional Achilles Tendinopathy

IAT was investigated in 9 of 50 included studies [14–16,39,40,52,58,68,76].

Executing the ECC exercise protocol for plantar and dorsal flexors of the ankle was found to be extremely effective for improving foot and ankle function [15,16] with a mean improvement of 58.05 points on the 100-point VISA-A scale in patients with IAT [15]. ECC exercise also caused a greater pain decrease [15,16,39] and patient satisfaction compared to the baseline [14,15,39]. It was found that 67% of the patients with IAT were able to return to normal sports activity after finishing a 12-week ECC exercise program [15]. Different authors [14,16] reported different outcomes after executing a 12-week classic HECT or modified HECT (modified in the case of the progression of repetitions and loads, or modified in the case of a limited range of motion). Kearney and Costa [16] reported that both HECT and modified HECT (with the progression of repetitions and loads) caused similar improvements in function and decreases in pain for patients with IAT after executing a 12-week program. They [16] also claimed that both protocols (i.e., HECT or modified HECT with the progression of repetitions and loads) resulted in a decrease in pain in around 67% of patients with IAT. Meanwhile, Wiegerinck et al. [14] reported that modified HECT (with limited range of motion) caused a slightly lower pain decrease compared to classic HECT (with an MD of 0.7 points on a 10-point VAS scale in favour of classic HECT), but it was not the case in terms of patient satisfaction where 70% of patients with IAT who finished a 12-week HECT were neither extremely satisfied nor satisfied with the treatment, whereas 33% of patients with IAT who finished a 12-week modified HECT reported the same level of satisfaction. It was found that modified HECT with the progression of repetitions and loads, was more efficient for treating IAT than Alfredson's classic HECT [16].

As mentioned, ESWT treatment can be divided into two types, according to the energy level of the ESWT [15,39,58]. The low-energy ESWT (with shockwave energy lower than 0.28 mJ/mm^2) consists of 3–4 applications, while the use of anaesthesia is not required [15,39]. Meanwhile high-energy ESWT (with shockwave energy higher than 0.60 mJ/mm^2) consists of one application, while the extra use of anaesthesia is also needed [15,39]. Both protocols greatly decreased pain and improved the function of the Achilles tendon [15,39,58]. Nevertheless, high-energy ESWT caused a greater pain decrease compared to low-energy ESWT, with an MD of 5.10 points on a 10-point VAS scale in the case of high-energy ESWT and an MD of 4.40 points on a 10-point VAS scale in the case of low-energy ESWT [39]. However, the efficacy of ESWT might differ from population to population, while greater improvements in function and decreases in pain at a 5-year follow-up were observed in a younger, active population [15]. Jarin et al. [15] reported that cold air and high-energy laser therapy treatment most likely caused faster recovery than ESWT, but the decrease in pain and improvement in function were similar between protocols at a 6-month follow-up.

When comparing ECC exercise (i.e., HECT) with other conservative nonpharmacological treatments such as ESWT, ECC exercise was found to be slightly less effective for decreasing pain [14–16,39,52,58,76] and improving function in patients with IAT compared to ESWT [15,16,39,52,76]. Regardless of the fact that both HECT and ESWT treatment caused a great decrease in pain [14,16,39,68] and improvement in function [16,39,68], this was statistically significant just in the case of ESWT treatment [16,68]. The decrease in pain for a group that executed three sessions of ESWT treatment at a 4-month follow-up was up to 5.1 points on a 10-point VAS scale [14]. However, Wiegerinck et al. [14] pointed out that HECT as a monotherapy caused similar or even greater patient satisfaction compared to ESWT. While 64% of patients with IAT who executed ESWT treatment were satisfied, the percentage of satisfied patients who executed HECT increased by an additional 18% [14]. Based on the claim from Korakakis et al. [68], the most efficient monotherapy protocol for treating IAT was by using radial ESWT, which delivered 2000 impulses at 2.5 bars (with an energy flux density of 0.12 mJ/mm^2) at 8 Hz for 3 sessions per week. The effects of ESWT treatment were found to be less effective when patients with IAT used a local anaesthetic before the treatment [52].

Even greater effects were observed after combining HECT and ESWT treatment [15,39]. The combination of ESWT and ECC exercise showed a greater decrease in pain and improvement in function [15,39] compared to ECC exercise alone [39]. The likelihood of a successful outcome after executing the combined protocol was up to 6.5-times greater than in the case of ECC exercise as a monotherapy [15]. As high as 74.3% of patients with IAT who executed ECC exercise with the ESWT protocol reported good-to-excellent patient satisfaction, while just 45.6% of patients were similarly satisfied after finishing just the ECC exercise protocol [39].

Similarly, as an implementation of ESWT to ECC exercise, the implementation of cold air and high-energy laser therapy to ECC exercise caused faster and greater pain decrease and greater patient satisfaction compared to each treatment as a mono intervention [39].

On the other hand, Chughtai et al. [40] and Zhi et al. [39] reported that the implementation of ASTYM therapy to either HECT or modified HECT (with a lowered number of repetitions, series, or sessions) also caused an additional decrease in pain and improvement in function compared to exercise treatment alone. It was found that all participants who executed the combined ECC exercise and ASTYM therapy protocol had decreased pain and improved function, whereas just 50% of patients who executed the ECC exercise-only protocol were found to be similarly successful at a 12-week follow-up [40]. Statistically significant differences between both groups were observed in the short term and as long as 26 to 52 weeks after treatment ended [15,39,40].

Nevertheless, each of the treatments, cryoultrasound therapy, carbon dioxide laser, or TECAR therapy, decreased the pain of all patients with IAT who were treated that way, which was seen at an 8-month follow-up (55, 61). The cryoultrasound therapy was found to be significantly better than carbon dioxide laser or TECAR therapy, whereas there was no significant difference between the latter two (55, 61). Table S4 contains an overview of the included reviews that researched the effects of conservative nonpharmacological interventions for treating IAT.

3.3.3. Non Specified Achilles Tendinopathy

The authors of the other 26 studies did not specifically write which type of AT they investigated [28,35–38,46–48,50,54,57,59–65,67,69,71,72,74,75,86].

After patients with AT executed the ECC exercise program, the results showed a significant decrease in pain [28,35,36,46,47,59,63,71,72], and an improvement in function [35,36,47,63,71,72] and patient satisfaction [36,46,47,63,71,72], which was able to be observed up to 4 years after the intervention ended [35]. It was found that, most likely as a consequence of ECC exercise, neither the decrease in pain nor the improvement in function or greater patient satisfaction were associated with a decrease in tendon diameter, a decrease in tendon neovascularisation, [47] or a decrease in tendon thickness [48]. On the other hand, the decrease in pain or improvement in function, caused by ECC exercise, were associated with a decrease in tendon volume in the short term, while it was not the case in the long term [47]. The ECC exercise treatment facilitated tendon remodelling by promoting collagen fibre cross-link formation within the tendon [28]. ECC exercise was also found to enhance healthy tissue tolerance and caused positive changes in nervous system sensitization rather than causing dysfunctional tissue or degeneration [28], but it did not reduce the incidence of injury for patients with AT [54].

The pain-free HECT protocol for treating AT was found to be similar or superior in terms of function improvement, pain decrease [62,71,75], and jumping performance improvement compared to the classic, painful HECT protocol [71]. Meanwhile, the authors [46,71] reported contradictory data about the importance of specified intensity. While Wilson et al. [71] reported that a similar pain decrease and function improvement were observed regardless of intensity and frequency (either low or high) of ECC exercise, Burton and McCormack [46] claimed that a minimum intensity above 79% of the maximum is required to cause adaptations in tendon properties, and material, mechanical, and morphological tendon changes. Intensity probably needs to be greater than 79% of the maximum, while a greater increase in the intensity (up to 100%) does not cause greater improvements. A greater improvement in function for patients with AT was found after daily execution of a home-based exercise program compared to the results obtained after supervised training twice per week [62]. Gradually increasing the load used in the ECC exercise program also caused a superior pain decrease and function improvement compared to predetermined ECC exercise loads [75]. Regardless of the great effects caused by ECC exercise, 45% of patients with AT were not found to have decreased pain or improved function after executing that kind of rehabilitation protocol [46].

ECC exercise was found to be superior in decreasing pain [28,35,36,46,59,63,71,72], improving function [28,36,46,72], and causing greater patient satisfaction compared to CON exercise for patients with AT [46,63,71]. Neither CON exercise as a monotherapy nor the combined CON exercise and ultrasound therapy protocol caused a successful pain decrease and function improvement compared with ECC exercise alone [72]. A significantly greater decrease in pain after executing ECC exercise compared to CON exercise was observed at each of the 4-, 8-, and 12-week follow-ups [59,71]. After executing a 12-week ECC exercise protocol, the physiotherapists' observed a mean decrease in pain in patients with an AT population of 60%, while the mean decrease in pain after executing a 12-week CON exercise was approximately 33% [67]. ECC exercise also greatly stimulated collagen synthesis compared to CON exercise, but there was no difference between both protocols in the rate of collagen degradation and increase in strength [63]. Nevertheless, patients that had executed CON exercises were able to jump higher compared to patients that executed a 6-week ECC exercise program [63].

Both ECC exercise (especially HECT) and HSR exercise interventions caused similar pain decreases and function improvements [36,71], while the latter caused greater patient satisfaction at a 12-week follow-up [36]. However, there was no difference in patient satisfaction between these two exercise protocols during a 52-week follow-up [36]. Similarly, no difference between protocols was observed in terms of pain decrease and function improvement at a 52-week follow-up [71]. An even greater achieved level of patient satisfaction was observed when the physiotherapist adjusted the HSR exercise to an individual (i.e., stage-based criteria that include percent of 1 RM of every single individual) compared to the predetermined HSR exercise [28] or pain-based adaptations of either HSR exercise or HECT [75]. On the other hand, the Silbernagel combined protocol was found to be as effective as ECC exercise in terms of function improvement and pain decrease [36], and achieved a great level of patient satisfaction [49] with no significant difference between the protocols [36].

The implementation of ISOM exercise with HECT [36,46] or the ISOT exercise program did not cause any additional benefit for pain decrease, function improvement, or greater patient satisfaction compared to either ECC exercise or ISOT exercise as monotherapy [74]. Meanwhile, Wilson et al. [71] reported that stretching similarly improved quality of life and decreased pain for patients with AT compared to strengthening exercise. Burton and McCormack [46] claimed that the latter caused a greater improvement in function and a greater decrease in pain compared to stretching. According to the reports of Peters et al. [54], stretching, just like the ECC exercise, was not found to be useful in reducing the incidence of AT. ECC exercise caused a greater pain decrease and function improvement for patients with AT compared to vibration exercise [46].

HECT caused a significantly greater pain decrease and function improvement compared to either wait-and-see treatment (with SMD of −1.26) or cryotherapy control intervention (with SMD of −1.67) [59]. HECT also caused a greater pain decrease and function improvement than deep friction massage, nonthermal US, and splinting [63]. Similarly, greater results of pain decrease and function improvement were observed after executing HECT compared to wait-and-see treatment, any placebo treatment, or resting treatment [71].

Furthermore, acupuncture caused a significantly greater pain decrease and greater functional improvement than the ECC exercise approach after an 8-week treatment [36,75]. Greater results were confirmed by Cox et al. [37], who added that there were statistically and clinically significant differences in AT function improvement in favour of traditional needle acupuncture over ECC exercise combined with stretching at the end of an 8-week intervention with 3 sessions per week (with a mean difference of 19.5 points on the 100 points VISA-A scale), and after that, at a 16-week follow-up (with a mean difference of 15.8 points on the 100 points VISA-A scale). Similarly, a statistically significant difference was observed as long as 24 weeks post-intervention, but the results were not clinically important [37]. Although acupuncture treatment was found to be superior compared to ECC exercise in improving function, van der Vlist et al. [61] reported that it was not superior compared to the ECC exercise protocol with ESWT (with an MD of 1 point on a 100-point scale) at a 3-month follow-up.

The extra implementation of dorsiflexion night splints to the ECC exercise rehabilitation protocol did not cause any additional pain decrease or function improvement since no significant difference in results was found after executing the ECC exercise intervention or the combined intervention of ECC exercise and night splints [28,57,71], even at 1- to 5-year follow-ups [71]. Thus, the implementation of a night splint or brace did not have any influence on pain decrease, function improvement, or quality of life improvement [36,46,61]. However, there were some contradictory data about the efficiency of the implementation of a brace to the ECC exercise protocol [46,57]. Whereas Burton and McCormack [46] reported that the brace did not have beneficial effects for function improvement, quality of life improvement, or pain decrease, Scott et al. [57] reported that at a 1-year follow-up, AirHeel brace treatment was found to be as successful as ECC exercise in terms of pain decrease and function improvement for treating MAT (with a reported improvement of 10%).

The data about the efficacy of orthoses were also contradictory. While Wilson et al. [71] claimed that orthoses did not improve function or decrease pain in MAT and were found to be as useful as a placebo or the wait-and-see treatment, Scott et al. [57] reported that customized foot orthoses had similar effects on the pain decrease and function improvement of AT as physiotherapy (with SMD of −0.04) [57]. However, they also reported that much better effects compared to each intervention alone were observed when the therapist combined both foot orthoses and physiotherapy.

Hence, using Kinesio tape did not influence the jumping performance of patients with AT [65]. These patients did not achieve as long jumping distances as healthy individuals did [65]. Meanwhile, no significant difference was found either in pain decrease (VAS) scores by the application of Kinesio tape or during the hop test without and with tape ($p = 0.74$) [57,65], but it improved function, especially for patients with AT, which was observed in a study that included badminton players [57]. Conversely, the combination of foot orthoses with taping was found to be effective even for decreasing the pain of football players compared to the baseline [57].

Meanwhile, combining either deep friction massage, ultrasound, and calf stretching [59] or manual therapy alone with HECT [46] caused a beneficial improvement in function and a decrease in pain compared to any included protocol as monotherapy [46,59]. Meanwhile, a lot of authors [28,36,59,61] reported that a combination of ESWT and ECC exercise caused a greater pain decrease and function improvement than any one alone. However, the combination of cold air and high-energy laser therapy with ECC exercise caused an even faster and greater pain decrease and function improvement than ESWT with ECC exercise did [36]. On the other hand, the implementation of low-level laser therapy to ECC exercise accelerated clinical recovery (function improvement and pain decrease) for patients with AT [36]. Martimbianco et al. [69] observed the mean difference of pain decrease on a 10-point VAS scale between ECC exercise with low-level laser therapy and ECC exercise with sham low-level laser therapy, at more time points. Only at a 2-month follow-up was the MD 2.55 points in favour of the combined ECC exercise and low-level laser therapy treatment, while in all other cases (at 1- and 3-month follow-ups), the mean differences between the same protocols were lower than or equal to 0.61 points on the 10-point VAS scale in favour of ECC exercise with low-level laser therapy [69]. Similarly, a greater improvement in function was observed after executing combined ECC exercise with low-level laser therapy protocol compared to ECC exercise with sham low-level laser therapy protocol at a 1-month follow-up (with an MD of 9.19 points on a 100-point scale) and a 3-month follow-up (with an MD of 3.39 points on a 100-point scale) [69]. In comparison to all other implemented therapies with the ECC exercise protocol, the implementation of microcurrent therapy did not cause any additional improvement in function or decrease in pain at 12-, 26-, and 52-week follow-ups [59].

The low-energy ESWT (with 1500–2500 impulses per session administered at a flux density of 0.1 to 0.5 mJ/mm^2) produced an analgesic effect by altering the permeability of neuron cell membranes within at least 3 months, by increasing blood flow and causing the increase in inflammation in chronic AT, which improved the symptoms [38,64]. The low-energy ESWT that consisted of at least three sessions with an interval of 1 week between sessions was found to decrease pain and improve function for patients with AT compared to the baseline [38]. However, some evidence was found that low-energy ESWT is not as suitable for older adults with advanced tendinosis as it is for younger patients with the same pathology because ESWT could possibly cause tendon rupture in the older adult population [38]. Meanwhile, high-level ESWT was found to be able to cause the destruction of neovessels, while it could cause a big tissue damage risk [38].

The execution of ESWT treatment resulted in a decrease in pain, improvement in function, improvement in patient satisfaction, and a reduction in the severity of injury [28,36,38,48]. ESWT treatment and ECC exercise caused similar aforementioned outcomes [28,36,38,48]. This is also evidenced by the fact that there was no difference in pain decrease between ESWT treatment (4 sessions in 4 weeks) and combined ECC exercise with stretching for patients with AT [38]. Extra implementation of ultrasound therapy to ESWT treatment did not cause major beneficial effects compared to ESWT treatment alone [28].

ESWT treatment for AT was found to be inferior compared to cold air and high-energy laser therapy treatment (the difference between the efficacy of ESWT and cold air and high-energy laser therapy was −2.1% in favour of cold air and high-energy laser therapy) [64]. The latter caused a faster and more efficacious pain decrease and greater patient satisfaction compared to ESWT treatment [64]. Table S5 gives an overview of the included reviews that researched the effects of conservative nonpharmacological interventions for treating non-specified AT (the authors of the articles that did not specify which type of AT they were researching).

4. Limitations

A few limitations of this review must be acknowledged. First, we used only three electronic scientific databases (PubMed, Scopus, and Web of Science) and obtained reference lists to search for systematic reviews and/or meta-analyses, whereas we did not search any other electronic or nonelectronic databases. Second, only four studies were specifically investigating the outcomes after executing conservative nonpharmacological treatments for treating IAT. Third, only 25 articles included all the components of PICO so the authors were able to report the difference between the experimental and control group(-s). Fourth, the risk of biases of the included studies in peaked articles was not assessed in 16 articles, while it was just partially assessed in 7 out of 50 reviews. Fifth, meta-analysis was conducted in just 14 out of 50 included articles. Sixth, when the authors of the included articles did not conduct a meta-analysis, we had to overlook two out of seven critical domains (item 11 and item 15) when measuring the methodological quality of the included studies (that happened in 36 out of 50 articles). Seventh, publication biases were sufficiently investigated and discussed in just three included articles, while when assessing the methodological quality of the other 11 articles with meta-analysis, 7 of them had fewer than 10 included studies in the meta-analysis, which is the minimum to perform the test for publication biases, so the articles were positively assessed when the authors investigated and discussed the publication biases. Finally, because of the lack of similar research with the same outcome measures, and due to different exercises or exercise protocols, we could not carry out the meta-analysis to find out the heterogeneity of the results with which we would conclusively confirm the obtained data.

5. Conclusions

It was found that AT was regularly treated with conservative nonpharmacological treatments. The most effective treatments variate from MAT to IAT. As a conservative nonpharmacological monotherapy, acupuncture had the greatest effects on pain decrease, function improvement, and the severity of injury reduction for MAT in the short term (<3 months), while ECC exercise (i.e., HECT) and ISOT exercise (i.e., especially HSR exercise) were found to cause the greatest pain decrease and function improvement, and the greatest and longest-lasting patient satisfaction improvement. ECC exercise caused similar improvements in the case of pain decrease and function improvement to those of HSR exercise, while the latter caused greater patient satisfaction. However, the improvements caused by combined protocols, such as the combined ECC exercise with ESWT caused an even greater pain decrease and function improvement, and faster self-perceived recovery for patients with MAT. Meanwhile, among the patients with IAT, ECC exercise as a mono intervention caused significant pain decrease, function improvement, and patient satisfaction, but the pain decrease and function improvement were greater after executing ESWT. Hence, there were some contradictory data about which treatment, ECC exercise or ESWT, caused greater patient satisfaction at the end of the treatment for patients with IAT. Even greater results in terms of pain decrease and function improvement, compared to each treatment alone, were found after combining either ECC exercise with ESWT, ECC exercise with cold air and high-energy laser therapy, or ECC exercise with ASTYM therapy. Among the mentioned combined protocols, ECC exercise with cold air and high-energy laser therapy was found to have the greatest effects, but additional studies are required because the combined protocol is not as researched as the combined protocol that consists of ECC exercise and ESWT.

Given the findings and limitations of our study, we conclude that more studies and further research is needed on the outcomes of conservative nonpharmacological treatments, especially for IAT. Moreover, further research and umbrella reviews are needed in both the area of conservative pharmacological treatments for AT, and the comparison between conservative pharmacological or nonpharmacological treatments and surgical treatments for AT.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app122312132/s1, Table S1: Methodological quality assessment of studies with AMSTAR 2 tool; Table S2: Characteristics of HECT, Stanish and Curwin, Silbernagel and HSR exercise programs; Table S3: Overview of included reviews that researched the effects of conservative nonpharmacological interventions for treating MAT; Table S4: Overview of included reviews that researched the effects of conservative nonpharmacological interventions for treating IAT; Table S5: Overview of included reviews that researched the effects of conservative nonpharmacological interventions for treating non-specified AT.

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