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### Research Article

## Eccentric vs. Isometric Strengthening for Achilles Tendinopathy: A Randomized Controlled Trial

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### ABSTRACT

**Background:** Achilles tendinopathy is a common overuse injury characterized by pain and impaired function. Eccentric exercises (EE) are the cornerstone of treatment, but the efficacy of isometric exercises (ISO) remains unclear. **Objective:** To compare the effectiveness of EE and ISO in reducing pain and improving function in individuals with mid-portion Achilles tendinopathy. **Methods:** A randomized controlled trial was conducted with 46 participants (23 per group). Participants aged 18–50 years with ultrasound-confirmed mid-portion Achilles tendinopathy were randomized to either EE (Alfredson protocol) or ISO (45-second high-load isometric holds). Both interventions were supervised and conducted over 12 weeks. Pain intensity (VAS), functional capacity (VISA-A), and tendon elasticity (shear wave elastography) were assessed at baseline, 4, 8, and 12 weeks. Data were analyzed using repeated measures ANOVA, with  $p < 0.05$  considered significant. **Results:** EE led to greater pain reduction (VAS: baseline  $6.8 \pm 1.2$  vs. 12 weeks  $2.4 \pm 0.9$ ,  $p < 0.01$ ) compared to ISO (baseline  $6.9 \pm 1.3$  vs. 12 weeks  $3.8 \pm 1.0$ ,  $p < 0.01$ ). VISA-A scores improved significantly in EE (baseline  $45.7 \pm 8.5$  to  $74.6 \pm 5.4$ ,  $p < 0.01$ ) compared to ISO ( $46.3 \pm 9.1$  to  $67.9 \pm 6.5$ ,  $p < 0.01$ ). No significant differences were found in tendon elasticity ( $p > 0.05$ ). **Conclusion:** Eccentric exercises demonstrated superior outcomes in reducing pain and improving function compared to isometric exercises in managing mid-portion Achilles tendinopathy. Isometric exercises may be beneficial for early rehabilitation but are less effective overall.

**Keywords:** Achilles Tendinopathy, Eccentric Exercise, Isometric Exercise, Pain Management, Functional Outcomes, Shear Wave Elastography.

### INTRODUCTION

Achilles tendinopathy is a prevalent musculoskeletal condition, commonly affecting individuals engaged in physical activities or sports that involve repetitive loading of the Achilles tendon. Characterized by pain, stiffness, and impaired function, this condition significantly impacts the quality of life and physical performance of affected individuals. Despite its high prevalence, the optimal approach for managing Achilles tendinopathy remains a topic of ongoing debate within the medical and rehabilitation fields. Exercise-based interventions have long been considered the cornerstone of conservative management, with eccentric exercises (EE) emerging as the most extensively studied and clinically adopted modality. This approach has demonstrated efficacy in alleviating pain and improving function in individuals with Achilles tendinopathy (1, 2). However, recent investigations have explored alternative or adjunctive exercise regimens, including isometric exercises (ISO),

which have garnered attention for their potential role in modulating pain and tendon adaptations (3, 4).

Eccentric exercises, such as the Alfredson protocol, have traditionally been regarded as the gold standard for treating mid-portion Achilles tendinopathy. These exercises involve controlled lengthening contractions of the gastrocnemius-soleus complex under load, promoting tendon remodeling and pain reduction. Despite their efficacy, adherence to these protocols can be challenging due to the intensity and duration required, leading to a search for alternative approaches that may offer comparable benefits. Isometric exercises, which involve muscle contraction without a change in muscle length, have been proposed as a potential solution. These exercises are thought to reduce pain via central and peripheral mechanisms and may serve as a precursor to isotonic or eccentric strengthening programs. However, the evidence regarding their effectiveness in comparison to eccentric exercises remains inconclusive, with some studies reporting equivalent outcomes and others suggesting minimal additional benefits (5, 6).

The therapeutic rationale for exercise-based interventions in tendinopathy management extends beyond symptom relief. These interventions aim to address the underlying pathophysiology of the tendon, which is characterized by degenerative changes, altered tendon structure, and impaired mechanical properties. Recent

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advances in imaging modalities, such as shear wave elastography, have provided insights into the effects of different exercise modalities on tendon and muscle properties. These studies have shown that neither eccentric nor isometric exercises significantly alter the elastic properties of the symptomatic gastrocnemius muscles, highlighting the complexity of tendon adaptation and the potential role of other mechanisms in clinical improvement (7, 8). Moreover, modifications to traditional eccentric exercise protocols, such as "do-as-tolerated" approaches, have shown promise in improving adherence and short-term outcomes, suggesting that individualized treatment plans may optimize results (9).

While eccentric exercises remain a cornerstone of Achilles tendinopathy management, the growing body of evidence exploring the efficacy of isometric exercises, combination protocols, and alternative exercise strategies underscores the need for a nuanced and patient-centered approach. The heterogeneity in responses to these interventions suggests that no single exercise prescription is universally effective. Instead, clinical decision-making should integrate evidence-based guidelines, patient preferences, and functional goals. This review synthesizes the existing literature on eccentric and isometric strengthening programs, comparing their effects on pain, function, and tendon adaptation, to provide a comprehensive understanding of their roles in the management of Achilles tendinopathy.

## MATERIAL AND METHODS

The study was conducted as a randomized controlled trial (RCT) to compare the effects of eccentric and isometric strengthening exercises in the management of Achilles tendinopathy. Ethical approval for the study was obtained from the institutional ethics committee, and all procedures adhered to the principles outlined in the Declaration of Helsinki. Informed consent was obtained from all participants before enrollment, ensuring that they fully understood the study's purpose, procedures, and potential risks.

Participants were recruited from outpatient rehabilitation clinics and sports medicine centers. Inclusion criteria included adults aged 18–50 years with a clinical diagnosis of mid-portion Achilles tendinopathy confirmed by ultrasound imaging. Exclusion criteria included a history of systemic diseases affecting musculoskeletal health, prior Achilles tendon surgery, corticosteroid injections within the last six months, or involvement in other rehabilitation programs during the study period. The sample size was calculated to ensure adequate statistical power, with 23 participants allocated to each group using simple randomization.

After randomization, participants were assigned to either the eccentric exercise (EE) group or the isometric exercise (ISO) group.

Both interventions were implemented over a 12-week period under the supervision of qualified physiotherapists. The EE group followed the Alfredson protocol, which involved slow, progressive loading exercises performed twice daily. The ISO group engaged in high-load isometric contractions of the gastrocnemius-soleus complex, holding each contraction for 45 seconds, with a gradual increase in resistance over time. Participants were instructed to report any adverse events or discomfort during the intervention period.

Baseline assessments included demographic and clinical characteristics, pain intensity measured using the Visual Analog Scale (VAS), and functional impairment assessed with the Victorian Institute of Sports Assessment-Achilles (VISA-A) questionnaire. Tendon structure and elasticity were evaluated using ultrasound imaging and shear wave elastography. Assessments were repeated at 4, 8, and 12 weeks to monitor changes over time. The reliability of measurements was ensured by having the same trained assessor conduct all evaluations, blinded to group allocation.

Data were collected and securely stored in a de-identified format to maintain participant confidentiality. The primary outcomes were pain reduction and functional improvement, while secondary outcomes included changes in tendon structure and elasticity. Statistical analysis was performed using SPSS software (version 25.0, IBM Corporation, Armonk, NY). Continuous data were summarized using means and standard deviations, while categorical data were presented as frequencies and percentages. Between-group differences were analyzed using independent t-tests for continuous variables and chi-square tests for categorical variables. Repeated measures analysis of variance (ANOVA) was used to assess changes within groups over time. A p-value of <0.05 was considered statistically significant.

This study adhered to rigorous methodological standards to ensure the reliability and validity of its findings. Randomization, blinding, and standardized protocols were employed to minimize bias, and adherence to ethical guidelines ensured the rights and welfare of participants were protected throughout the research process.

## RESULTS

A total of 46 participants were included in the final analysis, with 23 participants in each group (eccentric exercise [EE] and isometric exercise [ISO]). Baseline demographic and clinical characteristics were comparable between the groups, as summarized in Table 1. There were no significant differences in age, gender distribution, baseline pain (VAS), or functional scores (VISA-A) between the groups ( $p > 0.05$ ).

**Table 1: Baseline Characteristics of Participants**

Characteristic	EE Group (n=23)	ISO Group (n=23)	p-value
Age (years, mean ± SD)	35.6 ± 8.2	34.8 ± 7.9	0.72
Gender (M/F)	14/9	13/10	0.78
Baseline VAS (mean ± SD)	6.8 ± 1.2	6.9 ± 1.3	0.85
Baseline VISA-A (mean ± SD)	45.7 ± 8.5	46.3 ± 9.1	0.82

Both groups demonstrated significant improvements in pain intensity (VAS) and functional outcomes (VISA-A) over the 12-week intervention period. However, the EE group showed greater

reductions in pain and superior functional improvements compared to the ISO group, as detailed below.

**Table 2: Change in Pain Intensity (VAS Scores)**

Time Point	EE Group (mean ± SD)	ISO Group (mean ± SD)	p-value (between groups)
Baseline	6.8 ± 1.2	6.9 ± 1.3	0.85
4 weeks	5.2 ± 1.1	5.9 ± 1.2	0.04
8 weeks	3.8 ± 1.0	4.6 ± 1.1	0.02
12 weeks	2.4 ± 0.9	3.8 ± 1.0	<0.01

Pain intensity, measured by VAS, significantly decreased in both groups. By the end of the study, the EE group reported a mean reduction of 4.4 points, compared to a reduction of 3.1 points in the ISO group. Repeated measures ANOVA revealed a significant interaction between time and group ( $p < 0.01$ ), indicating that the

trajectory of pain improvement differed between the groups. The results are presented in Table . The VISA-A scores, representing functional outcomes, also improved significantly in both groups. The EE group exhibited a mean improvement of 28.9 points compared to 21.6 points in the ISO group by week 12. Post-hoc analyses



showed significant differences between groups at 8 weeks and 12 weeks. These findings are presented in Table 3. Tendon elasticity, assessed through shear wave elastography, did not show significant changes in either group throughout the intervention period. Both

groups demonstrated stable shear wave velocity values, with no meaningful differences between them at any time point. These results are summarized in Table

**Table 3: Change in Functional Outcomes (VISA-A Scores)**

Time Point	EE Group (mean ± SD)	ISO Group (mean ± SD)	p-value (between groups)
Baseline	45.7 ± 8.5	46.3 ± 9.1	0.82
4 weeks	56.3 ± 7.9	51.8 ± 8.7	0.05
8 weeks	65.1 ± 6.8	59.4 ± 7.2	0.01
12 weeks	74.6 ± 5.4	67.9 ± 6.5	<0.01

**Table 4: Tendon Elasticity (Shear Wave Velocity, m/s)**

Time Point	EE Group (mean ± SD)	ISO Group (mean ± SD)	p-value (between groups)
Baseline	3.8 ± 0.5	3.9 ± 0.6	0.72
4 weeks	3.9 ± 0.4	3.9 ± 0.5	0.85
8 weeks	4.0 ± 0.5	4.0 ± 0.4	0.93
12 weeks	4.1 ± 0.4	4.0 ± 0.5	0.67

Pain intensity (VAS) and functional outcomes (VISA-A) showed significant improvements in both groups, with the EE group demonstrating superior outcomes ( $p < 0.01$ ). No significant changes were observed in tendon elasticity in either group ( $p > 0.05$ ).

These results suggest that while both eccentric and isometric exercises are effective for managing Achilles tendinopathy, eccentric exercises provide greater benefits in reducing pain and improving function over a 12-week period. The lack of significant changes in tendon elasticity highlights the complexity of tendon adaptation and the need for further research to elucidate the mechanisms underlying clinical improvements.

## DISCUSSION

This study aimed to compare the effectiveness of eccentric and isometric strengthening exercises in the management of Achilles tendinopathy, with findings demonstrating that both modalities resulted in significant improvements in pain and functional outcomes over 12 weeks. However, eccentric exercises provided superior benefits in reducing pain intensity and improving functional capacity, as measured by VAS and VISA-A scores, respectively. These results align with the established literature that recognizes eccentric loading as the cornerstone of conservative management for mid-portion Achilles tendinopathy (1, 2).

The superiority of eccentric exercises may be attributed to their ability to induce tendon remodeling and promote adaptations in tendon structure, although the specific mechanisms remain incompletely understood. While improvements in clinical outcomes were evident, this study did not observe significant changes in tendon elasticity as assessed by shear wave elastography. These findings are consistent with previous research suggesting that clinical improvements are not necessarily accompanied by measurable changes in tendon structure, highlighting the complexity of the pathophysiological processes in tendinopathy (7, 8). This underscores the need to reconsider the reliance on structural parameters as the sole indicators of treatment efficacy.

In contrast, isometric exercises, although effective in reducing pain and improving function, did not provide comparable outcomes to eccentric exercises. Previous studies have reported mixed findings on the effectiveness of isometric exercises, with some suggesting immediate pain relief and others reporting no significant benefits over isotonic or eccentric loading (3, 5). In this study, isometric exercises were unable to match the progressive loading effects of eccentric exercises, which are thought to be critical for tendon adaptation and functional restoration. Nevertheless, the role of isometric exercises in early-stage rehabilitation or for patients unable to tolerate eccentric loading should not be dismissed, as they may offer an alternative pathway to engage the tendon without exacerbating symptoms.

The strengths of this study include its randomized controlled design, which minimized bias, and the inclusion of a homogenous sample

with a standardized intervention protocol. The use of validated outcome measures such as VAS and VISA-A ensured reliable assessment of pain and functional improvements, while shear wave elastography provided insights into tendon properties. However, the study also had limitations. The sample size, while adequate for detecting between-group differences, limited the ability to explore subgroup effects or stratify outcomes based on patient characteristics. Additionally, the study duration of 12 weeks may have been insufficient to capture long-term structural adaptations or relapse rates, which are critical in chronic tendinopathy management.

Another limitation was the reliance on supervised exercise sessions without accounting for variations in adherence, which could influence treatment outcomes. Future research should incorporate methods to objectively track adherence and explore the use of adjunctive therapies, such as shockwave therapy or platelet-rich plasma, in combination with exercise-based interventions. Furthermore, while shear wave elastography provided valuable data on tendon properties, the clinical relevance of these findings remains uncertain, warranting further investigation into their relationship with functional outcomes and patient-reported measures.

## CONCLUSION

The results of this study have important clinical implications. Eccentric exercises should continue to be recommended as the primary intervention for Achilles tendinopathy due to their demonstrated efficacy in reducing pain and enhancing function. However, clinicians should consider incorporating isometric exercises in early-stage rehabilitation or as part of a multimodal approach tailored to individual patient needs. Personalized exercise protocols that consider patient preferences, functional goals, and tolerance levels may further optimize outcomes. Future studies should focus on long-term follow-ups, exploring mechanisms underlying clinical improvements, and investigating the potential of individualized dosing strategies to enhance adherence and efficacy. By addressing these gaps, the management of Achilles tendinopathy can be further refined to provide comprehensive and effective care for patients.

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