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COMPARATIVE EFFECTS OF ACCELERATED REHABILITATION AND ECCENTRIC STRENGTHENING EXERCISES IN PATIENTS WITH ACHILLES TENDINOPATHY

Original Research

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ABSTRACT

Background: Achilles tendinopathy is a degenerative condition of the tendon characterized by pain, swelling, and functional impairment, particularly among active individuals. It commonly affects the Achilles tendon, which connects the gastrocnemius and soleus muscles to the calcaneus. With prevalence rates reaching up to 18% in runners and athletes, its management remains a clinical challenge. Traditional approaches focus on eccentric strengthening, while newer accelerated rehabilitation programs emphasize progressive loading, yet evidence comparing their relative efficacy is limited.

Objective: The aim of this study was to compare the effectiveness of an accelerated rehabilitation protocol and eccentric strengthening exercises in reducing pain and improving quality of life among patients with Achilles tendinopathy.

Methods: A single-blinded randomized controlled trial was conducted on 34 patients clinically diagnosed with Achilles tendinopathy. Participants were randomly allocated into two groups: Group A received an accelerated rehabilitation protocol, while Group B underwent eccentric strengthening exercises. Both interventions were delivered over 12 weeks, following standardized baseline therapy. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), and quality of life was measured using the WHOQOL-BREF at baseline and after intervention. Data were analyzed using the Mann–Whitney U test, with $p \leq 0.05$ considered statistically significant.

Results: At baseline, both groups reported comparable pain levels (Pre-NPRS median 9.00, $U = 144.5$, $p = 1.000$, $r = 0.000$). Post-treatment, Group B achieved greater improvements, with NPRS significantly reduced to a median of 2.00 compared to 6.00 in Group A ($U = 0.000$, $p < 0.001$, $r = 0.868$). Quality of life scores also improved more in Group B, rising from a median of 67.00 to 82.00, compared to Group A's increase from 53.00 to 61.00 ($U = 0.000$, $p < 0.001$, $r = 0.859$).

Conclusion: Both interventions were effective, but eccentric strengthening produced superior reductions in pain and greater improvements in quality of life compared to accelerated rehabilitation. These findings support the preferential use of eccentric exercises as a primary treatment for Achilles tendinopathy.

Keywords: Achilles Tendinopathy, Exercise Therapy, Pain Measurement, Physical Therapy Modalities, Quality of Life, Randomized Controlled Trial, Rehabilitation

INTRODUCTION

Achilles tendinopathy is a common musculoskeletal condition characterized by pain, structural degeneration, and impaired function of the Achilles tendon, which connects the gastrocnemius and soleus muscles to the calcaneus (1,2). Its burden is notable among physically active individuals, with an incidence of 2.35 per 1000 persons between 21 and 60 years of age (3). Prevalence estimates suggest that it affects 7–9% of professional athletes and 6–18% of recreational runners (4). Furthermore, Achilles tendon rupture, a severe consequence, occurs at a rate of 18 per 100,000 individuals annually, making this disorder a growing clinical concern (5). Global epidemiological data indicate a prevalence of 2.16 per 1000 person-years, with higher rates among those exposed to repetitive loading, such as athletes and runners (6). Although initially regarded as an inflammatory process, current understanding recognizes Achilles tendinopathy as a degenerative disorder marked by disruption of type I collagen fibers. Repeated microtrauma and defective repair mechanisms lead to disorganized, fragmented, and weakened collagen alignment, compromising the tendon's ability to withstand mechanical stress (7,8). Treatment approaches have evolved based on the biomechanical principle that progressive mechanical loading enhances tendon healing through mechano-transduction. This process stimulates tenocytes to synthesize collagen and remodel the extracellular matrix, thereby restoring tensile strength and reorganizing disrupted collagen fibers (9,10).

Conservative management has traditionally emphasized eccentric strengthening exercises, considered the gold standard for Achilles tendinopathy. These exercises promote tendon remodeling, reduce pain, and improve functional outcomes by enhancing viscoelastic properties and preventing degenerative changes associated with inactivity (11–14). More recently, accelerated rehabilitation protocols have been introduced, emphasizing earlier functional loading and dynamic progression to restore both tendon integrity and neuromuscular control. Such programs aim to improve proprioception, coordination, and muscle activation patterns within the gastrocnemius–soleus–Achilles complex, reducing the likelihood of compensatory movement patterns and facilitating energy storage and release during activity (15–17). Despite evidence supporting the benefits of both eccentric strengthening and accelerated rehabilitation, no direct comparative studies have been conducted to determine which approach offers superior outcomes in terms of pain reduction, functional recovery, and time to return to normal activity. This knowledge gap creates uncertainty for clinicians in selecting the most effective rehabilitation protocol. Given the significant impact of Achilles tendinopathy on physical performance, quality of life, and healthcare resources, it is crucial to identify the optimal strategy for efficient recovery. Therefore, this study aims to compare the clinical outcomes of eccentric strengthening and accelerated rehabilitation in patients with Achilles tendinopathy, with the objective of determining the more effective approach for improving pain, function, and return to daily activities.

METHODS

This study was designed as a single-blinded randomized controlled trial conducted at Punjab Social Security Health Management Company Hospital over a period of six months following synopsis approval and ethical clearance from the Institutional Review Board (IRB) of Superior University, Lahore. A calculated sample size of 34 participants, with 17 individuals allocated to each group, was determined after adjusting for a 10% attrition rate to maintain adequate statistical power. Recruitment was performed through purposive sampling, and all participants provided written informed consent prior to enrollment. Ethical principles of confidentiality, anonymity, voluntary participation, and the right to withdraw at any stage were strictly maintained throughout the study. The study population included male and female patients over the age of 18 years who were clinically diagnosed with Achilles tendinopathy for a duration exceeding one month. Diagnostic confirmation was based on positive clinical tests, such as the Thompson test, along with localized tenderness or pain during physical activity. Exclusion criteria were carefully established to minimize confounding variables and included systemic inflammatory or neuromuscular disorders such as rheumatoid arthritis or diabetes, history of Achilles tendon rupture or surgery, concomitant lower limb injuries such as fractures or ligament tears, and severe tendon degeneration or calcification confirmed by imaging studies. Participants were randomized into two groups (Group A and Group B) using a sealed-envelope lottery method to reduce selection bias. The trial was single-blinded in design, as participants were unaware of their group allocation. Unique identification codes were assigned to all participants to ensure confidentiality during data handling. Both groups received a standardized baseline treatment prior to intervention, which included a 10-minute general warm-up, 10 minutes of moderate-intensity hot pack application, and 10 minutes of active or passive ankle mobilization exercises.

Group A underwent an Accelerated Rehabilitation Protocol in addition to the baseline regimen. This consisted of three structured phases administered over 12 weeks. Phase 1 (Weeks 1–4) emphasized pain reduction and restoration of range of motion through modalities

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such as transcutaneous electrical nerve stimulation (TENS), cryotherapy, isometric calf strengthening, and partial weight-bearing activities. Phase 2 (Weeks 5–8) progressed to balance training, resistance band exercises, calf raises, and low-intensity aerobic activities including cycling and walking. Phase 3 (Weeks 9–12) incorporated advanced sport-specific and functional tasks, including plyometric drills and eccentric heel drops. Exercises were supervised by a physiotherapist and performed twice daily in two sets of five repetitions. Group B followed an eccentric strengthening program based on the Curwin and Stanish protocol, combined with baseline therapy. This protocol comprised three sets of 15 repetitions per exercise, with progressive resistance using external loads (5–10 lbs or more) and gradual increases in difficulty across the weeks. The regimen began with bilateral exercises without dorsiflexion, progressed to unilateral tasks performed in maximum dorsiflexion, and advanced to high-resistance and functional movements such as hopping and single-leg heel drops during the final four weeks of training. Outcome measures included the Numeric Pain Rating Scale (NPRS) for pain intensity and the World Health Organization Quality of Life-BREF (WHOQOL-BREF) for quality-of-life assessment. The NPRS is a widely validated tool with excellent test–retest reliability (ICC = 0.86–0.95) and a minimal clinically important difference of 1–2 points. The WHOQOL-BREF evaluated four health domains—physical, psychological, social, and environmental—scored on a 0–100 scale, with higher values reflecting better quality of life. All data were entered and analyzed using SPSS version 20. Quantitative variables such as age were expressed as mean ± standard deviation, while categorical variables including gender and group distribution were presented as frequencies and percentages. Between-group comparisons were performed using appropriate parametric and non-parametric tests, depending on the normality of data distribution, and a p-value ≤ 0.05 was considered statistically significant.

RESULTS

The study included 34 participants, with Group A consisting of 12 males (70.6%) and 5 females (29.4%), and Group B including 9 males (52.9%) and 8 females (47.1%). The mean baseline scores for Group A and Group B were 38.35 ± 9.36 and 37.59 ± 8.74, respectively, confirming comparability at the start of the trial. Baseline pain levels measured on the Numeric Pain Rating Scale (NPRS) were similar across groups with a median score of 9.00 (IQR: 1.00) in both. Baseline quality of life scores assessed through WHOQOL-BREF showed a median of 53.00 (IQR: 2.00) in Group A and 67.00 (IQR: 1.50) in Group B. Post-intervention analysis demonstrated statistically significant between-group differences. Eccentric strengthening exercises resulted in superior outcomes compared to the accelerated rehabilitation protocol. Group B achieved a marked reduction in pain with a post-treatment median NPRS score of 2.00 (IQR: 1.00), compared to 6.00 (IQR: 1.00) in Group A ($p < 0.001$, $r = 0.868$). Quality of life also improved significantly in Group B, with a median WHOQOL score of 82.00 (IQR: 1.50), whereas Group A reached 61.00 (IQR: 2.00) after treatment ($p < 0.001$, $r = 0.859$). Within-group analyses further confirmed improvements in both cohorts. In Group A, significant reductions in pain were observed for all participants ($Z = -3.663$, $p = 0.000$), accompanied by improvements in quality of life ($Z = -4.025$, $p = 0.000$). Similarly, in Group B, all participants demonstrated significant reductions in pain ($Z = -3.658$, $p = 0.000$) and enhancements in quality of life ($Z = -4.123$, $p = 0.000$). These findings establish that although both interventions were effective in reducing symptoms and improving quality of life, eccentric strengthening yielded more substantial and clinically meaningful improvements.

Table 1: Between Group Comparison (Non-Parametric) of Group A and Group B

Variable	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z-score	p-value	r-value
Pre-NPRS	Group A	17	17.50	297.50	144.500	297.500	0.000	1.000	0.000
	Group B	17	17.50	297.50					
Post-NPRS	Group A	17	26.00	442.00	0.000	153.000	-5.063	0.000	0.868
	Group B	17	9.00	153.00					
Pre-WHOQOL	Group A	17	9.00	153.00	0.000	153.000	-5.011	0.000	0.859
	Group B	17	26.00	442.00					
Post-WHOQOL	Group A	17	9.00	153.00	0.000	153.000	-5.011	0.000	0.859
	Group B	17	26.00	442.00					

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Table 2: Within Group Comparison (Non-Parametric) NPRS and WHOQOL for Group A

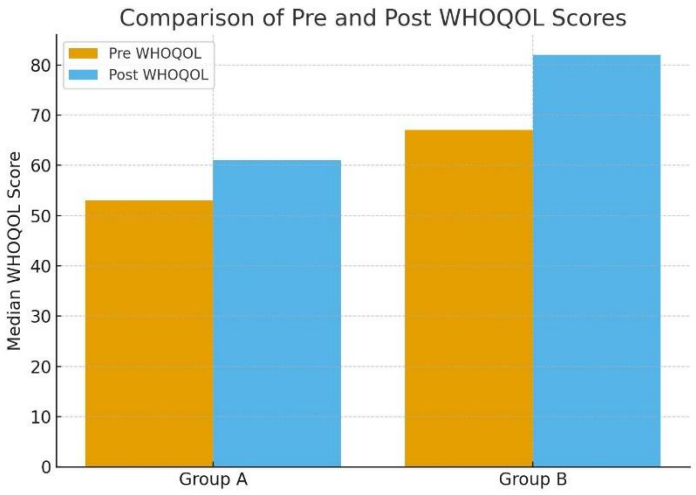
Groups		N	Mean Rank	Sum of Ranks	Z-Score	P-Value
Post-Pre NPRS	Negative Ranks	17	9.00	153.00	-3.663	.000
	Positive Ranks	0	.00	.00		
Post-Pre WHOQOL	Negative Ranks	0	.00	.00	-4.025	.000
	Positive Ranks	17	9.00	153.00		

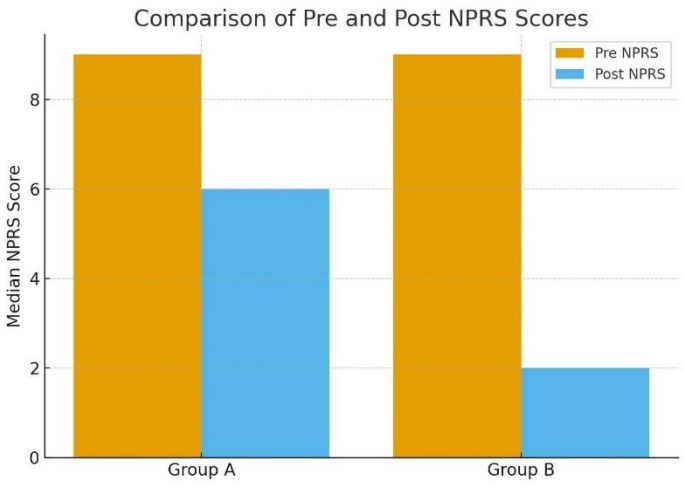
Table 3: Within Group Comparison (Non-Parametric) NPRS and WHOQOL for Group B

Groups		N	Mean Rank	Sum of Ranks	Z-Score	P-Value
Post-Pre NPRS	Negative Ranks	17	9.00	153.00	-3.658	.000
	Positive Ranks	0	.00	.00		
Post-Pre WHOQOL	Negative Ranks	0	.00	.00	-4.123	.000
	Positive Ranks	17	9.00	153.00		

Table 4: Interquartile Range (IQR)

Variable	Group	N	Median	IQR (Q3–Q1)
Pre-NPRS	Group A	17	9.00	1.00 (9.00–8.00)
	Group B	17	9.00	1.00 (9.00–8.00)
Post-Treatment NPRS	Group A	17	6.00	1.00 (6.50–5.50)
	Group B	17	2.00	1.00 (3.00–2.00)
Pre-WHOQOL	Group A	17	53.00	2.00 (54.00–52.00)
	Group B	17	67.00	1.50 (67.50–66.00)
Post-WHOQOL	Group A	17	61.00	2.00 (62.00–59.50)
	Group B	17	82.00	1.50 (82.50–81.00)





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DISCUSSION

The results of this study suggest that eccentric strengthening was more effective than accelerated rehabilitation in reducing pain and improving patient-reported quality of life among individuals with Achilles tendinopathy. The between-group analysis demonstrated a large effect size in favor of eccentric strengthening, with substantial reductions in Numeric Pain Rating Scale scores and marked improvements in WHOQOL-BREF scores. These findings reinforce the growing body of evidence that eccentric training protocols are not only superior to conventional rehabilitation but also offer clinically meaningful benefits that directly translate into improved functional outcomes. Previous research has consistently highlighted the superiority of eccentric exercise in managing tendinopathies. Earlier studies demonstrated significant reductions in tendon-related pain following eccentric training compared to conventional protocols, which aligns with the present findings. Evidence from trials involving both Achilles and patellar tendinopathies has shown that eccentric loading produces greater analgesic effects, likely due to its role in enhancing collagen alignment, promoting tendon remodeling, and reducing nociceptive signaling (18,19). Additional comparative studies across different tendon injuries have supported these observations, indicating that eccentric exercises consistently outperform concentric or standard therapy in pain reduction and functional recovery (20). Other trials have further validated these results by showing significant reductions in pain intensity and improvements in tendon resilience, providing a robust justification for the inclusion of eccentric strengthening as a first-line intervention for tendinopathy (21). The convergence of evidence across multiple studies underscores the reliability of eccentric exercise as a treatment modality.

The implications of these results extend to clinical practice where eccentric strengthening offers a cost-effective, non-invasive, and patient-centered approach to rehabilitation. Given its demonstrated superiority, it may be integrated as a standard protocol for patients with Achilles tendinopathy, with potential for early symptom relief and improved quality of life. Furthermore, the magnitude of pain reduction and functional gains observed in this study provides additional support for incorporating eccentric protocols into rehabilitation programs for both athletes and the general population. This study had several strengths, including its randomized controlled design, standardized intervention protocols, and use of validated outcome measures such as the NPRS and WHOQOL-BREF. The single-blinded methodology reduced the risk of performance bias, and the statistical analysis provided strong evidence of treatment efficacy. However, limitations must also be acknowledged. Adherence to exercise protocols was self-reported rather than objectively monitored, which may have influenced the consistency of intervention delivery. The study duration was relatively short, with no long-term follow-up to determine the sustainability of treatment effects. Psychosocial factors such as motivation, mental health, and patient expectations, which can significantly influence rehabilitation outcomes, were not thoroughly explored. Moreover, no objective biomechanical or imaging assessments were conducted to document tendon remodeling or structural changes, which could have provided mechanistic insight into the observed improvements.

The findings of this trial highlight the need for future research to address these limitations. Longitudinal studies with extended follow-up periods are required to establish the durability of benefits from eccentric strengthening. The inclusion of imaging modalities such as ultrasound or MRI, as well as biomechanical testing, could provide valuable data on tendon adaptation and remodeling. Incorporating technology-based adherence monitoring and structured supervision may improve compliance and outcome reliability. Additionally, comprehensive evaluation of psychosocial factors is warranted to understand their interaction with physical recovery and to optimize patient-centered rehabilitation strategies. Overall, this study contributes to the growing evidence that eccentric strengthening is a superior intervention for Achilles tendinopathy, offering significant clinical benefits in pain reduction and quality of life improvement. While both protocols provided positive outcomes, eccentric exercise demonstrated greater efficacy and should be prioritized in evidence-based rehabilitation approaches.

CONCLUSION

The findings of this study conclude that while both rehabilitation approaches were effective in reducing symptoms of Achilles tendinopathy, eccentric strengthening provided superior improvements in pain relief and overall quality of life compared to accelerated rehabilitation. These results emphasize the practical value of incorporating eccentric exercises into clinical practice as a primary strategy for managing Achilles tendinopathy, offering patients a more effective pathway toward recovery and a faster return to daily function.

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AUTHOR CONTRIBUTION

Author	Contribution
Nawal Fatima	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Sahar Aslam	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ayesha Siddiqua	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Iram Hasssan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Zinnia Akram	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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