RESEARCH PAPER

Comparative Effects of Isometric and Eccentric Resistance Exercises on Pain and Function in Achilles Tendinitis among Badminton Players

Aniket Tomar[1], Taruna Verma[2], Yash Partap[3]

[1*]Student, School of Allied Health Science, Galgotias University, Greater Noida, U.P, India, 203201
Email ID: Anikettomar.2500@gmail.com ORCID ID : 0009-0004-6424-1644
[2]Professor , School of Allied Health Science, Galgotias University, Greater Noida, U.P, India, 203201
Email ID: drtarunaverma21@gmail.com ORCID ID : 0000-0002-0892-1352
[3]Professor, School of Allied Health Science, Galgotias University, Greater Noida, U.P, India, 203201
Email ID: yash.pratap@galgotiasuniversity.edu.in ORCID ID : 0000-0002-9013- 6619

ABSTRACT

Background: Badminton players often have Achilles tendinopathy, an overuse ailment attributable to the sport's demands for rapid changes in direction, jumping, and lunging. The study aimed to compare the effects of isometric versus eccentric resistance exercises on pain and functional outcomes in this athletic population.

Methods: Forty badminton players (aged 15-25) with Achilles tendinopathy were allocated into two intervention groups: Group A (n=20) performed eccentric heel drops with progressive resistance, while Group B (n=20) performed isometric plantar flexion exercises. Pain intensity, assessed Visual Analogue Scale (VAS), and tendon function, evaluated Victorian Institute of Sport Assessment-Achilles (VISA-A).

Results: The two groups revealed statistically significant progress in Pain Intensity and Tendon Function scores from pre-test to post-test. Analysis revealed that the eccentric exercise with resistance group achieved a remarkable decrease in pain and improvements in the isometric exercise group.

Conclusion: The findings indicate that while both exercise modalities are beneficial, eccentric exercise with resistance is a superior intervention to isometric exercise for alleviating pain and enhancing function in badminton players with Achilles tendinopathy over four weeks.

Keywords: Achilles tendinopathy, Badminton player, Eccentric exercise with resistance, Isometric exercise

How to cite this article: Tomar A, Verma T, Partap Y. Comparative Effects of Isometric and Eccentric Resistance Exercises on Pain and Function in Achilles Tendinitis among Badminton Players. Int J Drug Deliv Technol. 2026;16(54s): 340-349. DOI: 10.25258/ijddt.16.54s.29

INTRODUCTION

The largest and strongest tendon in the body is known as the Achilles tendon. The Achilles tendon connects the calf muscle to the calcaneus. We can walk, run, or jump on our toes because the calf muscle contracts, pushing the Achilles tendon against the heel (Adams, 2024). Recreational runners, athletes, and anybody who engages in an activity that involves a lot of running and jumping may develop Achilles tendons. Achilles tendons treated at home using simple methods(Kanniappan & Sathosh, 2020). Surgery may be required to repair tendon tears (ruptures) in more severe cases of Achilles tendinitis. The patient can have more severe pain during a long duration of running, stair climbing, or sprinting. Achilles tendonitis is a condition in when the band of tissue linking calf muscles to the heel bone, the Achilles tendon, is subjected to repeated or intense strain(Silbernagel et al., 2020). Achilles tendon structural changes with aging render it more susceptible to damage, especially in those who only do sports on the weekends or have recently upped the intensity of their running regimens (Y. K. Lee & Lee, 2018).

Badminton is a solitary, non-contact sport that is considered extremely safe due to the absence of physical contact with other players. Injury risk rises with quick direction changes, hops, lunges toward the net, and rapid arm movements to hit the shuttlecock in different positions. It has been demonstrated that taking part in badminton practice and competition increases the risk of injury by 15 to 39 percent. In training than in competition, injuries were more frequent. Badminton has a high non-contact injury rate (35%) in badminton matches at the 2012 London Olympic Games (Engebretsen et al., 2013). Recreational players were more likely to sustain injuries than elite athletes. However, other studies have found comparable risks among these athletes. The physical work is intermittent and consists of bursts of intense effort followed by quick rest intervals. The game demands quick, jerky movements. In badminton, acute Achilles tendon ruptures are more common than overuse injuries (Malliaras et al., 2012). Achillodynia, or pain in the Achilles region, is the cause of all badminton injuries, and it affects both elite and recreational players equally frequently. Little is known about painful disorders in the Achilles tendon region among badminton players, which seem fairly common (Boesen et al., 2011; J. Hoon Lee & Yoo, 2012).

The two types of exercises for Achilles tendinitis that are most often used are eccentric and isometric exercises. Eccentric exercise is the best Achilles tendinopathy treatment. Eccentric exercises stress the muscles by slowing down muscular elongation, which

*Author for Corresponden ***drtarunaverma21@gmail.com***

may lead to stronger muscles, quicker muscle recovery, and an increased metabolic rate. By serving as a braking mechanism for muscle and tendon groups engaged in concentric movement, eccentric movement safeguards joints against damage. Recent research suggests that eccentric exercise is a promising therapy for lower extremity tendinitis. Individual workouts are given the greatest consideration when it comes to tendon-loading exercises for tendinitis therapy. Eccentric exercise may be more beneficial than certain therapies, such as splinting, non-thermal ultrasound, and friction massage, since it works best after a period of rest (Gatz et al., 2020; Zwiers et al., 2016). However, owing to discomfort from exercise, some patients are unable to perform Eccentric exercises for the whole treatment duration. Rio et al. (2015) thus suggested isometric exercises (ISOs) as a novel tendinopathy therapy approach.

Thera band Loops, thick elastic bands, may be used to improve muscles. By using the resistance that Thera bands provide, it is easy to strengthen muscles. Even though Thera bands are latex rubber, people who are allergic to it might choose an alternative. The prescription of resistance exercises seems to be quite significant for tendon healing. According to tendinopathy research, eccentric or high-load activities might mechanically stress the tendon. These exercise routines incorporate elements like load, repetitions, sets, and time under stress that are crucial for aiding tendon recovery(Christensen et al., 2020). Early-stage resistance training may delay the onset of muscle atrophy, but it is crucial to avoid interfering with tendon healing at the same time. High loads may prevent tendon healing, even though properly dosed loads may work as a stimulant for tendon repair and remodeling (Holden & Barton, 2019).

Among the greatest strategies to ease tendon discomfort, encourage tendon healing, & avoid tendon damage is isometric exercise. A muscular contraction that is constant during isometric exercise entails no discernible change in the joint angle. The term "isometric" derives from the Greek letters isos (equal) metric (measurement), which signifies that throughout this training neither the muscle length nor the angle of the joint changes., but the contraction force may do so(O'Neill et al., 2019). Contrarily, isotonic contractions do not affect joint angle or muscle length and very little do so. Isometric exercises may be used for rehabilitation when muscle strengthening without placing an excessive load on the joint is necessary, as well as for general strength training (McAuliffe et al., 2019). Exercises like Isometric may be used to increase the body's capacity to produce power from a standing position and, in the situation of isometric holds, from a seated position, to increase the body's ability to hold a position for an extended amount of time. Isometric presses, when viewed as an exercise, are also crucial to the body's capacity to be prepared for what comes immediately after power activities. Isometric preload is a common name for this kind of training. By reducing pressure on the cortical muscle, isometric exercise may act as an analgesic (Gatz et al., 2020).

These two kinds of exercises have each been the subject of several studies to confirm their efficiency, but no studies have compared the effectiveness of the two. Because of this, the goal of this quantitative research study is to evaluate the effectiveness of eccentric with resistance and isometric workouts in treating Achilles tendinitis in badminton players.

The basis for isometric exercises is the theory that painful movement affects motor control, results in abnormal motor patterns, and increases inhibition of neural motor pathways. This could contribute to the emergence of refractory tendinopathy brought on by dysfunctional motor patterns. Isometric exercises may reverse pathologic alterations in motor patterns since they should be done painlessly or with a modest level of intensity if pain arises (Rio et al., 2017). According to clinical studies on patellar tendinopathy, isometric exercises reduced discomfort after 4 weeks without necessitating a decrease in load(Rio et al., 2019).

As previously noted, Achilles tendinopathy is a painful condition brought on by overuse that affects many sportsmen, particularly badminton players who engage in running and jumping sports. Apart from pain, Achilles tendinopathy alters tendon structure and mechanical properties, a decrease in the function of the lower limbs and apprehension while moving. Changes in tendon structure and mechanics, impaired lower extremity function, and dread of movement are all symptoms of Achilles tendinopathy in addition to pain. The performance and participation in sports are restricted by these disabilities taken together. The participation and performance in sports are hampered by these impairments when they are combined. An extensive evaluation and detailed treatment strategy emphasizing progressive tendon loading is necessary to ensure complete recovery of tendon health and lower the risk of reinjury(Silbernagel et al., 2020). However, many exercises may help you get your lower limbs back to normal function while also reducing stiffness and pain. However, it may be used to prevent the negative effects and treat muscular depressions without reducing muscle strength before or after exercise. These two kinds of exercises have each been the subject of several studies to confirm their efficiency, but no studies have compared the effectiveness of the two. Because of this, the goal of this research is to evaluate the effectiveness of eccentric with resistance and isometric workouts in treating Achilles tendinitis in badminton players.

Objective:

- To determine the sort of injury that badminton players' lower limbs have.
- To evaluate the effectiveness of eccentric exercises with resistance against Achilles tendinitis affected badminton players.

- To find out how helpful isometric exercises are for badminton players with Achilles tendonitis.
- To assess and contrast the effects of eccentric exercise with resistance and isometric exercise for Achilles tendonitis in badminton players

METHODOLOGY

Study Design and Ethical Considerations

A randomized comparative trial with pre- and post-test measurements was conducted over four weeks.

Participants and Sampling

A sample of 40 male badminton players was recruited from local sports clubs in Delhi using a purposive sampling technique. Participants were randomly allocated into one of two intervention groups (Group A or Group B, n=20 each) using a **computer-generated randomisation sequence** to minimise allocation bias. The flow of participants through the study is detailed in the CONSORT diagram (Figure 1).

Inclusion criteria were:

- Males aged 15–25 years.
- Active badminton players with a minimum of one year of playing experience.
- Symptoms of bilateral Achilles tendinopathy for at least one year.
- A pain score between 5–7 and a score of ≤30 Achilles Tendon Function.

Exclusion criteria were:

- A history of Achilles tendon rupture within the previous year.
- Previous surgery on the Achilles or patellar tendon.
- Recent use of oral or injectable corticosteroids (within 3 months).
- Recent fracture or significant soft-tissue injury to the lower limbs (within 6 months).

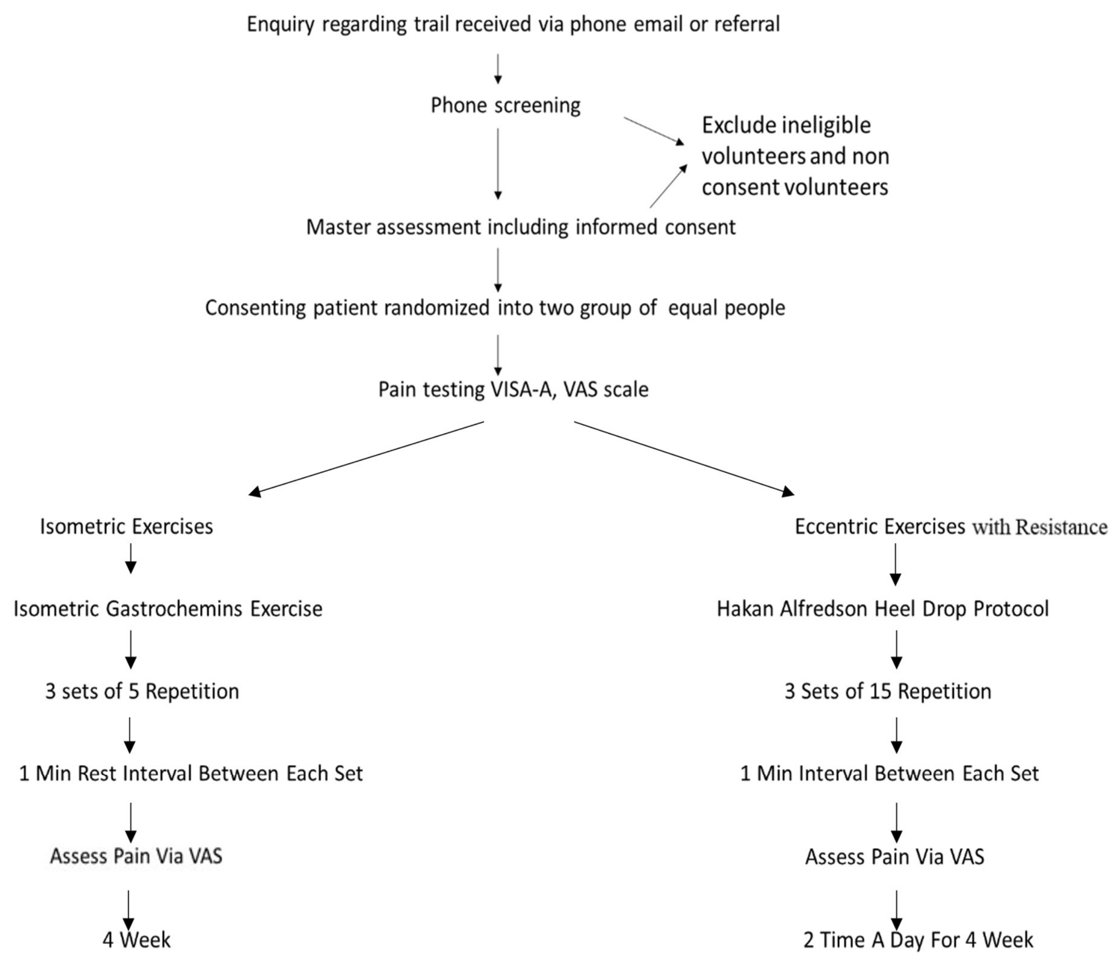

Figure 1: Flow Diagram (CONSORT)

Outcome Measures

The primary outcome measures were:

1. Pain Intensity via Visual Analogue Scale (VAS)
2. Achilles Tendon Function via Victorian Institute of Sport Assessment-Achilles (VISA-A).

These measures were recorded for all participants at baseline (pre-test) and immediately following the four-week intervention period (post-test).

Resistance exercise band

An elastic band is used for strength training and muscle recovery. Usually constructed of latex or synthetic rubber, they vary in resistance and shape.

Intervention Protocols

Following the pre-test assessment, participants commenced their assigned four-week exercise program. All sessions were supervised by a qualified coach to ensure correct technique and compliance. Participants were also followed up with regularly.

The specific exercise protocols for each group are detailed in Table A.

Table A: Exercise Intervention Protocols

Feature	Group A (Eccentric Exercise)	Group B (Isometric Exercise)
Exercise Type	Eccentric heel drops with resistance band	Isometric plantar flexion
Starting Position	Standing on a step with heels off the edge.	Seated with knee fully extended and ankle in end-range plantarflexion.
Action	**Concentric phase:** Rise onto toes using both legs. **Eccentric phase:** Shift weight to the affected leg and slowly lower the heel below the level of the step in a controlled manner (over 3-4 seconds).	Push the ball of the foot into a wall or immovable object to create a maximal voluntary contraction without joint movement.
Sets/Reps/Duration	3 sets of 15 repetitions, twice daily.	3 sets of 5 contractions, each held for 45 seconds.
Frequency	2 times per day, 7 days per week.	1 session per day, 7 days per week.
Rest	1 minute rest between sets.	1 minute rest between sets.
Progression	Resistance was progressively increased using elastic bands (Thera-Band®) of varying tensions when exercises became pain-free.	The intensity of the contraction was maintained at a subjective 7/10 effort level.

Data Analysis

Data analysis for this research was carried out using Windows-compatible IBM SPSS software (version 27). An independent "t" test on paired samples served as the study's statistical tool. The paired sample test was used to examine the pre- and post-test means, and the comparison between Groups A and B was examined using the independent t-test.

RESULTS

In Table 1, participants were equally distributed (N=20, 50.0%) into isometric and eccentric groups. This 1:1 allocation is visually confirmed in Figure 1, demonstrating a balanced study design ideal for comparative analysis of the two intervention groups.

Table 1. Group of Participants

Group		
	N	%
Isometric	20	50.0%
Eccentric	20	50.0%

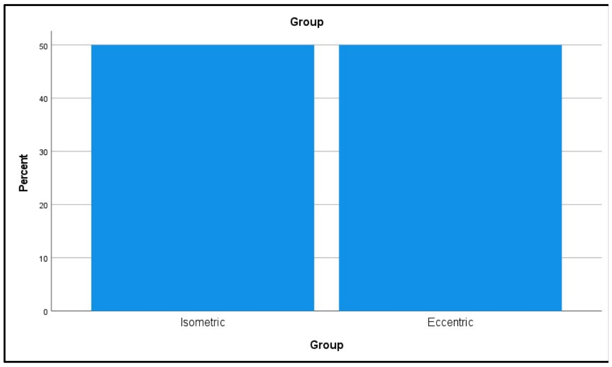

Figure 1. Percentage of Participants

The analysis of the isometric exercise group reveals statistically significant improvements in both pain and function. The VAS scale, measuring pain intensity, demonstrated a significant decrease of mean=6.65 (SD=0.48) in pre-test to mean=5.45 (SD=0.51) in post-test. This reduction was statistically significant (t(19)=13.077, p=.000), indicating a substantial alleviation of pain following the isometric intervention. Concurrently, the VISA-A worksheet, assessing functional capacity, showed a significant increase from a pre-test mean of 40.85 (SD=6.83) to a post-test mean of 47.85 (SD=4.00). This improvement was also highly statistically significant (t(19)=-5.972, p=.000), reflecting enhanced functional performance. (Table 2; Figure 2)

The consistent direction of change across both metrics—decreased pain and increased function—strongly supports the efficacy of the isometric exercise protocol. The exceedingly low p-values ($p < .001$) for both scales suggest that these findings are very unlikely to be due to chance. The visual representation in Figure 2 effectively complements the statistical analysis by illustrating the mean scores with standard deviation error bars, allowing for a clear comparison of the pre- and post-test conditions for each measure. The figure likely contrasts these results with an eccentric exercise group, providing a broader context for interpreting the relative effectiveness of the isometric intervention within the study's comparative design. In conclusion, the data provide robust evidence that isometric exercise yielded significant clinical benefits for participants for pain reduction and function improvement.

Table 2. Comparison of test results during an isometric workout

Scales	MEAN	Standard Deviation	t-value(df=19)	P-value ($p < 0.05$)
VISA-A (pre-test)	40.85	6.83	-5.972*	.000
VISA-A (post-test)	47.85	4.00		
VAS scale (pre-test)	6.65	0.48	13.077*	.000
VAS scale (post-test)	5.45	0.51		

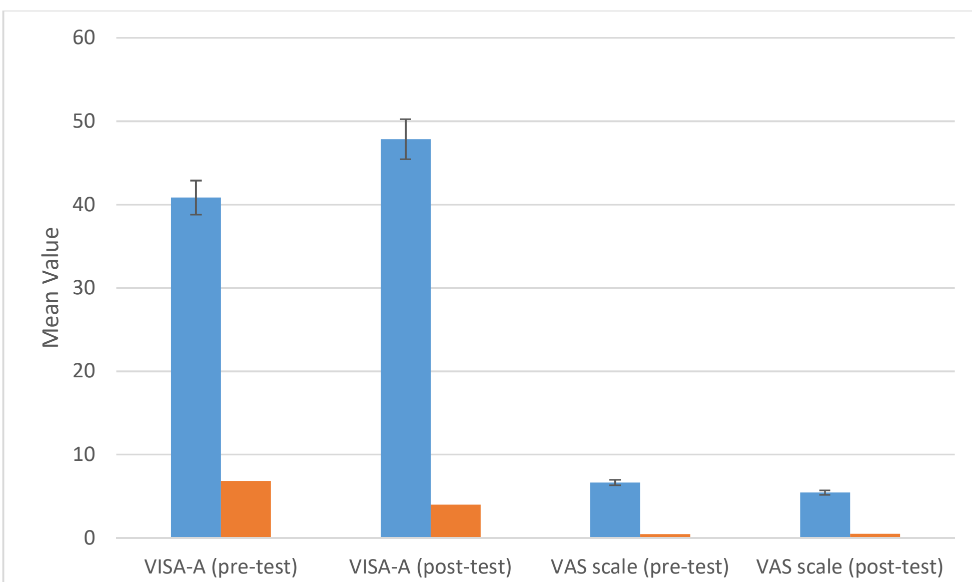

Figure 2. (MEAN with SD) under Isometric exercise & Eccentric exercise with resistance

The eccentric exercise with resistance intervention resulted in profound and statistically significant improvements in both functional capacity and pain reduction. The VISA-A scores, indicative of function, increased substantially from a pre-test mean=41.40 (SD=5.26) to a post-test mean=57.50 (SD=3.97). This marked improvement was highly statistically significant (t(19)=-28.674, $p < .001$). Concurrently, the VAS, measuring pain intensity, demonstrated a dramatic decrease from a pre-test mean of 6.65 (SD=0.49) to a post-test mean of 3.10 (SD=0.72), which was also highly significant (t(19) = 31.104, p < .001) (Table 3; Figure 3).

The magnitude of change observed in the eccentric exercise group is notably large. The functional improvement on the VISA-A represents an increase of over 16 points, while the VAS pain score was more than halved, decreasing by 3.55 points. The extremely high t-values and corresponding p-values far below the .05 threshold provide robust evidence that these changes are not due to random variation but are a direct result of the intervention. Figure 3 visually reinforces these findings, graphically depicting the substantial mean score differences between the two conditions, with error bars illustrating the standard deviations. The results conclusively demonstrate that eccentric exercise with resistance was an exceptionally effective intervention for this participant cohort, yielding clinically important enhancements in functional performance alongside a significant alleviation of pain.

Table 3. Comparison of eccentric exercise with resistance between pre- and post-tests

Scales	MEAN	Standard Deviation	t-value (df=19)	p-value (p < 0.05)
VISA-A (pre-test)	41.40	5.26	-28.674*	.000
VISA-A (post-test)	57.50	3.97		
VAS scale (pre-test)	6.65	0.49	31.104*	.000
VAS scale (post-test)	3.1	0.72		

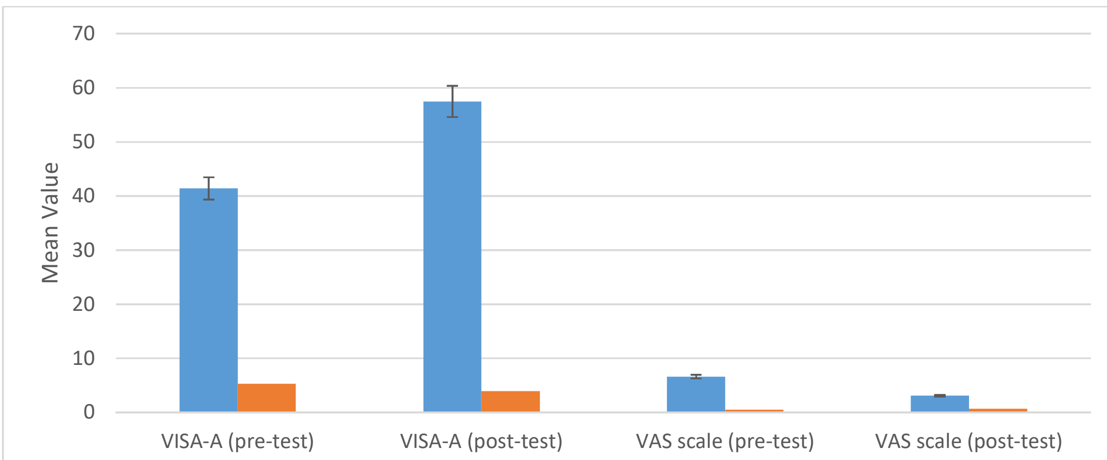

Figure 3. VISA-A (Pre & Post) and VAS(Pre & Post) (MEAN with SD) under eccentric exercise with resistance.

The eccentric exercise with resistance demonstrated a statistically superior effect compared to isometric exercise on both functional capacity and pain outcomes. Post-intervention, the eccentric group achieved a significantly higher mean VISA-A score (M=57.50, SD=3.96) than the isometric group (M=47.85, SD=4.00), a difference that was highly statistically significant (t(19)=-7.138, p<.001). This indicates a substantially greater improvement in functional performance for participants undergoing eccentric training (Table 4; Figure 4).

Similarly, a highly significant between-group difference was observed for pain reduction on the VAS scale. The eccentric exercise group reported a much lower mean pain score (M=3.10, SD=0.71) compared to the isometric group (M=5.45, SD=0.51) (t(19)=12.010, p<.001). The magnitude of this difference, visually emphasized in Figure 4, suggests that eccentric exercise was far more effective at alleviating pain.

The exceptionally high t-values(-7.138*, 12.010*) and p-values far below .001 provide robust evidence that the observed differences in post-test means are genuine and not attributable to chance. Figure 4 effectively illustrates this comparative efficacy, clearly showing the mean scores for each intervention and underscoring the greater mean improvement associated with eccentric exercise for both outcome measures. In conclusion, while both interventions yielded benefits, the analysis provides compelling evidence that eccentric exercise with resistance is a significantly more effective intervention than isometric exercise for improving function and reducing pain in the studied population.

Table 4. Eccentric, resistance, and isometric exercise effects on VISA-A and VAS.

Scales	**MEAN**	**Standard Deviation**	**t-value (df=19)**	**P-value (p < 0.05)**
VISA-A (Isometric)	47.85	4.00	-7.138*	.000

VISA-A (eccentric with resistance)	57.50	3.96		
VAS scale (isometric)	5.45	.51	12.010*	.000
VAS scale (eccentric with resistance)	3.10	.71		

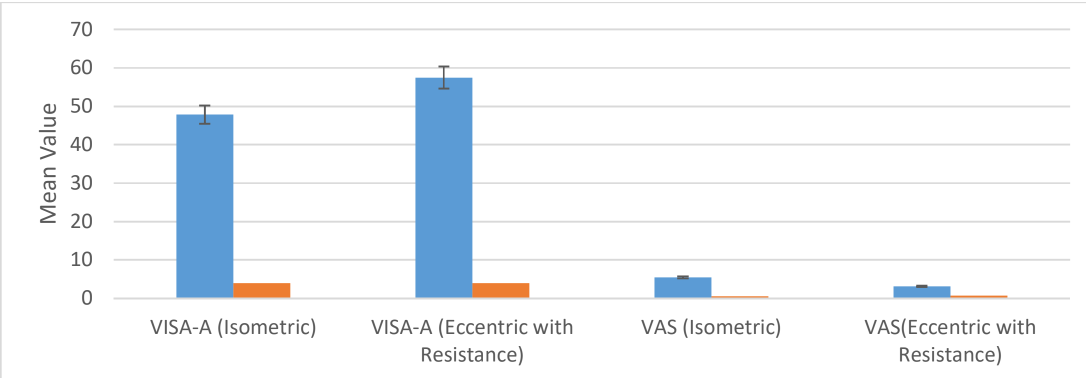

Figure 4. Mean Eccentric exercise with Resistance and Isometric exercise via VISA-A & VAS

Table 5 demonstrates that both groups exhibited improved VISA-A scores from pre- to post-test. However, the eccentric exercise group showed a markedly greater mean improvement (Δ +16.10) compared to the isometric group (Δ +7.00), suggesting superior efficacy for eccentric training in enhancing functional capacity.

Table 5. Descriptive Statistics of VISA-A Scores by Group and Time (N = 40)

Group	Pre-Test (M ± SD)	Post-Test (M ± SD)
Isometric	40.85 ± 6.84	47.85 ± 4.00
Eccentric	41.40 ± 5.26	57.50 ± 3.97
Total	41.13 ± 6.03	52.68 ± 6.27

Based on Table 6, the multivariate analysis revealed a significant effect for Time ($p < .001$, $\eta^2 = .893$) and Time × Group interaction ($p < .001$, $\eta^2 = .563$). This indicates that while scores improved significantly overall, the rate of improvement differed substantially between the exercise groups.

Table 6. Multivariate Tests (Time and Time × Group)

Effect	Test	Value	F	df	df (Error)	p	Partial η²
Time	Wilks' Lambda	.107	315.94	1	38	.000	.893
Time × Group	Wilks' Lambda	.437	49.03	1	38	.000	.563

Table 7 confirms a significant effect of Time ($F(1,38)=315.94$, $p<.001$, $\eta^2=.893$) and a Time × Group interaction ($F(1,38)=49.03$, $p<.001$, $\eta^2=.563$). This indicates that functional scores improved significantly over time, but the magnitude of improvement was dependent on the intervention group.

Table 7. Tests of Within-Subjects Effects

Source	SS	df	MS	F	p	Partial η²
Time	2668.05	1	2668.05	315.94	.000	.893
Time × Group	414.05	1	414.05	49.03	.000	.563
Error (Time)	320.90	38	8.45			

Table 8, a significant effect for Group was found ($F(1,38)=11.66$, $p=.002$, $\eta^2=.235$). This indicates a statistically significant difference in overall VISA-A scores between the isometric and eccentric exercise groups, with the eccentric group demonstrating superior functional outcomes across the study period.

Table 8. Tests of Between-Subjects Effects (Group Main Effect)

Source	SS	df	MS	F	p	Partial η²
Group	520.20	1	520.20	11.66	.002	.235
Error	1696.00	38	44.63			

Table 9, the significant pairwise differences. The eccentric group's mean VISA-A score was significantly higher than the isometric group (MD = -5.10, p=.002). Furthermore, post-test scores were significantly higher than pre-test scores across all participants (MD = -11.55, p<.001), confirming overall improvement.

Table 9. Pairwise Comparisons of Estimated Marginal Means

Comparison	Mean Difference(MD)	SE	p	95% CI (LL, UL)
Isometric vs. Eccentric	-5.10	1.49	.002	-8.12, -2.08
Pre vs. Post	-11.55	0.65	.001	-12.87, -10.24

Plot (Figure 5) of estimated marginal means illustrates the significant Time × Group interaction. The eccentric group demonstrates a substantially greater increase in VISA-A scores from Time 1 (pre-test) to Time 2 (post-test) compared to the isometric group, visually confirming the superior efficacy of the eccentric intervention.

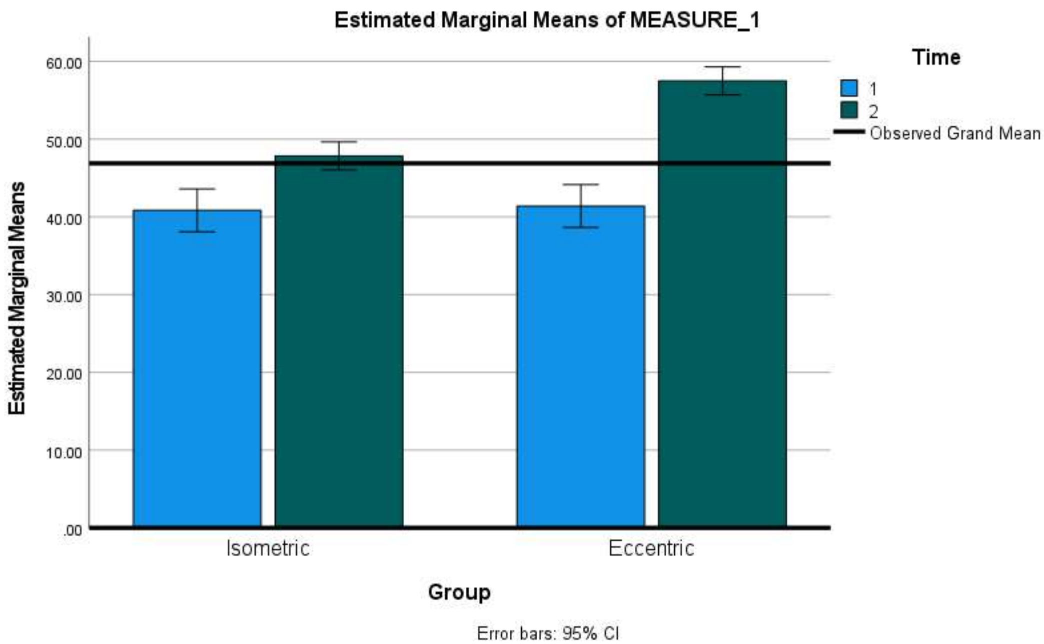

Figure 5: *Estimated Marginal Means of VISA-A Scores by Group and Time*

DISCUSSION

The present study sought to compare the efficacy of isometric exercise and eccentric exercise with resistance in managing pain and improving function in badminton players with Achilles tendinopathy. The results demonstrated that both interventions led to statistically significant improvements in VAS and VISA-A scores from pre-test to post-test. However, the eccentric exercise with resistance group exhibited significantly greater improvements in both pain reduction and functional enhancement compared to the isometric group at the 4-week mark.

The finding that both exercise modalities are beneficial aligns with a growing body of literature advocating for load-based management of tendinopathy. Eccentric exercises have long been considered the gold standard for Achilles tendinopathy(Silbernagel et al., 2007; Zwiers et al., 2016), a stance supported by our results showing its superior efficacy. The significant improvement (Δ +16.10 in VISA-A) in the eccentric group can be attributed to the high mechanical loading of the tendon, which is believed to stimulate collagen synthesis, promote tendon remodeling, and improve its load-bearing capacity(Christensen et al., 2020; Holden & Barton, 2019). Our use of progressive resistance with elastic bands likely augmented this effect by ensuring a continual adaptive challenge, a principle critical for tendon rehabilitation (Silbernagel et al., 2020).

Conversely, the isometric group also showed clinically meaningful improvements (Δ +7.00 in VISA-A). This supports emerging evidence that isometric contractions can provide effective analgesia and improve function in tendinopathy(Rio et al., 2015; van Ark et al., 2016). The proposed mechanism for isometric efficacy is its ability to reduce cortical inhibition and modulate pain pathways without exacerbating tendon pain, allowing for pain-free strengthening(Rio et al., 2015, 2017). However, our results contradict those of (O'Neill et al., 2019), who found that a single bout of heavy isometric plantar flexion did not yield significant immediate analgesic or motor output benefits in Achilles tendinopathy patients. This discrepancy may be due to differences in protocol; our study employed a longer intervention period (4 weeks vs. a single bout), suggesting that the cumulative, neurophysiological effects of repeated isometric sessions may be necessary for sustained improvement.

The superior outcomes with eccentric loading observed in our study are consistent with several previous investigations. (Stasinopoulos & Manias, 2013) found that an Alfredson-based eccentric protocol was superior to a Stanish protocol (which incorporates concentric elements) in improving VISA-A scores. Furthermore, a recent scoping review by (Christensen et al., 2020) emphasized the importance of detailed, progressive loading protocols, which our eccentric intervention embodied. However, our findings appear to contrast with those of (Gatz et al., 2020), who reported that adding isometric exercises to an eccentric regimen did not provide additional benefit over eccentric exercises alone in a 3-month intervention. This divergence could be explained by the shorter duration of our study or the specific population of badminton players, whose sport-specific demands might respond better to the higher tendon loads provided by resisted eccentric exercises.

A key objective was to determine the most effective exercise for this specific athletic population. Badminton involves explosive movements, jumps, and lunges, placing high demands on the Achilles tendon(Engebretsen et al., 2013; Malliaras et al., 2012). The significantly greater improvement in function (VISA-A) and pain (VAS) in the eccentric group suggests that a rehabilitation program incorporating progressive resistance may be more effective at preparing the tendon for a return to the high loads required in badminton. This is critical, as athletes often need to maintain training volumes while managing symptoms. The work by (van Ark et al., 2016) in patellar tendinopathy supports this concept, showing that exercise can reduce pain in-season without requiring a reduction in load.

Several limitations of this study must be acknowledged. The sample consisted solely of male athletes, limiting the generalizability of findings to female badminton players. The 4-week intervention period, while showing significant effects, is relatively short for a chronic condition like tendinopathy. Long-term follow-up is absent, so the durability of these improvements remains unknown, a factor highlighted by (Van Der Plas et al., 2012), who found sustained but not always complete recovery at a 5-year follow-up after eccentric loading. Furthermore, the use of a subjective pain scale (VAS) and a self-reported function questionnaire (VISA-A), while validated, introduces potential for bias. Future studies should incorporate objective biomechanical measures, such as those used by (Deroost et al., 2025), who assessed actual Achilles tendon loading during rehabilitation exercises.

CONCLUSION

In conclusion, the results of this randomized comparative trial indicate that while both isometric exercise and eccentric exercise with resistance are effective interventions for improving pain and function in badminton players with Achilles tendinopathy, eccentric exercise with resistance demonstrates superior efficacy over 4 weeks. This suggests that clinicians should consider implementing progressive eccentric loading protocols for athletes requiring a rapid and robust improvement in symptoms to facilitate a return to sport. However, the choice of intervention may be tailored to the individual athlete's pain response; isometric exercises remain a valuable tool, particularly for athletes in acute pain who cannot initially tolerate high tendon loads. Future research should focus on long-term outcomes, include female participants, and integrate objective functional and biomechanical assessments to further refine optimal rehabilitation strategies for athletic populations.

Conflict of interest

There is no conflict of interest in this study.

REFERENCES

1. Adams, S. B. (2024). The Achilles Tendon: Pathology, treatment and rehabilitation. In *The Achilles Tendon: Pathology, Treatment and Rehabilitation*. Springer New York. https://doi.org/10.1007/978-3-031-45594-0
2. Boesen, A. P., Boesen, M. I., Koenig, M. J., Bliddal, H., Torp-Pedersen, S., & Langberg, H. (2011). Evidence of accumulated stress in Achilles and anterior knee tendons in elite badminton players. *Knee Surgery, Sports Traumatology, Arthroscopy*, *19*(1), 30–37. https://doi.org/10.1007/s00167-010-1208-z
3. Christensen, M., Zellers, J. A., Kjær, I. L., Silbernagel, K. G., & Rathleff, M. S. (2020). Resistance exercises in early functional rehabilitation for achilles tendon ruptures are poorly described: A scoping review. *Journal of Orthopaedic and Sports Physical Therapy*, *50*(12), 681–691. https://doi.org/10.2519/JOSPT.2020.9463,
4. Deroost, F., Petrella, D., Mylle, I., & Vanwanseele, B. (2025). Patients with Achilles tendinopathy use compensation strategies to reduce tendon load during rehabilitation exercises. *Clinical Biomechanics*, *122*.

https://doi.org/10.1016/j.clinbiomech.2024.106403

5. Engebretsen, L., Soligard, T., Steffen, K., Alonso, J. M., Aubry, M., Budgett, R., Dvorak, J., Jegathesan, M., Meeuwisse, W. H., Mountjoy, M., Palmer-Green, D., Vanhegan, I., & Renström, P. A. (2013). Sports injuries and illnesses during the London Summer Olympic Games 2012. *British Journal of Sports Medicine*, *47*(7), 407–414. https://doi.org/10.1136/bjsports-2013-092380
6. Gatz, M., Betsch, M., Dirrichs, T., Schrading, S., Tingart, M., Michalik, R., & Quack, V. (2020). Eccentric and Isometric Exercises in Achilles Tendinopathy Evaluated by the VISA-A Score and Shear Wave Elastography. *Sports Health*, *12*(4), 373–381. https://doi.org/10.1177/1941738119893996
7. Holden, S., & Barton, C. J. (2019). 'What should I prescribe?': time to improve reporting of resistance training programmes to ensure accurate translation and implementation. *British Journal of Sports Medicine*, *53*(5), 264–265. https://doi.org/10.1136/bjsports-2017-098664
8. Kanniappan, V., & Sathosh, A. M. (2020). To Compare the Effect of Eccentric Exercises and Isometric Exercises for Achilles Tendinitis in Skaters. *Journal of Lifestyle Medicine*, *10*(1), 49–54. https://doi.org/10.15280/jlm.2020.10.1.49
9. Lee, J. hoon, & Yoo, W. gyu. (2012). Treatment of chronic Achilles tendon pain by Kinesio taping in an amateur badminton player. *Physical Therapy in Sport*, *13*(2), 115–119. https://doi.org/10.1016/j.ptsp.2011.07.002
10. Lee, Y. K., & Lee, M. (2018). Treatment of infected achilles tendinitis and overlying soft tissue defect using an anterolateral thigh free flap in an elderly patient a case report. *Medicine (United States)*, *97*(35). https://doi.org/10.1097/MD.0000000000011995
11. Malliaras, P., Voss, C., Garau, G., Richards, P., & Maffulli, N. (2012). Achilles tendon shape and echogenicity on ultrasound among active badminton players. *Scandinavian Journal of Medicine and Science in Sports*, *22*(2), 149–155. https://doi.org/10.1111/j.1600-0838.2010.01156.x
12. McAuliffe, S., Tabuena, A., McCreesh, K., O'Keeffe, M., Hurley, J., Comyns, T., Purtill, H., O'Neill, S., & O'Sullivan, K. (2019). Altered strength profile in Achilles tendinopathy: A systematic review and meta-analysis. *Journal of Athletic Training*, *54*(8), 889–900. https://doi.org/10.4085/1062-6050-43-18
13. O'Neill, S., Radia, J., Bird, K., Rathleff, M. S., Bandholm, T., Jorgensen, M., & Thorborg, K. (2019). Acute sensory and motor response to 45-s heavy isometric holds for the plantar flexors in patients with Achilles tendinopathy. *Knee Surgery, Sports Traumatology, Arthroscopy*, *27*(9), 2765–2773. https://doi.org/10.1007/s00167-018-5050-z
14. Rio, E., Kidgell, D., Purdam, C., Gaida, J., Moseley, G. L., Pearce, A. J., & Cook, J. (2015). Isometric exercise induces analgesia and reduces inhibition in patellar tendinopathy. *British Journal of Sports Medicine*, *49*(19), 1277–1283. https://doi.org/10.1136/bjsports-2014-094386
15. Rio, E., Purdam, C., Girdwood, M., & Cook, J. (2019). Isometric Exercise to Reduce Pain in Patellar Tendinopathy In-Season: Is It Effective "on the Road"? *Clinical Journal of Sport Medicine*, *29*(3), 188–192. https://doi.org/10.1097/JSM.0000000000000549
16. Rio, E., Van Ark, M., Docking, S., Moseley, G. L., Kidgell, D., Gaida, J. E., Van Den Akker-Scheek, I., Zwerver, J., & Cook, J. (2017). Isometric contractions are more analgesic than isotonic contractions for patellar tendon pain: An in-season randomized clinical trial. *Clinical Journal of Sport Medicine*, *27*(3), 253–259. https://doi.org/10.1097/JSM.0000000000000364
17. Silbernagel, K. G., Hanlon, S., & Sprague, A. (2020). Current clinical concepts: Conservative management of achilles tendinopathy. *Journal of Athletic Training*, *55*(5). https://doi.org/10.4085/1062-6050-356-19
18. Silbernagel, K. G., Thomeé, R., Eriksson, B. I., & Karlsson, J. (2007). Full symptomatic recovery does not ensure full recovery of muscle-tendon function in patients with Achilles tendinopathy. *British Journal of Sports Medicine*, *41*(4), 276–280. https://doi.org/10.1136/bjsm.2006.033464
19. Stasinopoulos, D., & Manias, P. (2013). Comparing two eccentric exercise programmes for the management of Achilles tendinopathy. A pilot trial. *Journal of Bodywork and Movement Therapies*, *17*(3), 309–315. https://doi.org/10.1016/J.JBMT.2012.11.003,
20. van Ark, M., Cook, J. L., Docking, S. I., Zwerver, J., Gaida, J. E., van den Akker-Scheek, I., & Rio, E. (2016). Do isometric and isotonic exercise programs reduce pain in athletes with patellar tendinopathy in-season? A randomised clinical trial. *Journal of Science and Medicine in Sport*, *19*(9), 702–706. https://doi.org/10.1016/J.JSAMS.2015.11.006,
21. Van Der Plas, A., De Jonge, S., De Vos, R. J., Van Der Heide, H. J. L., Verhaar, J. A. N., Weir, A., & Tol, J. L. (2012). A 5-year follow-up study of Alfredson's heel-drop exercise programme in chronic midportion Achilles tendinopathy. *British Journal of Sports Medicine*, *46*(3), 214–218. https://doi.org/10.1136/BJSPORTS-2011-090035,
22. Zwiers, R., Wiegerinck, J. I., & van Dijk, C. N. (2016). Treatment of midportion Achilles tendinopathy: an evidence-based overview. In *Knee Surgery, Sports Traumatology, Arthroscopy* (Vol. 24, Issue 7, pp. 2103–2111). Springer Verlag. https://doi.org/10.1007/s00167-014-3407-5