

A Comparative Study on Sensory-Targeted Ankle Rehabilitation Strategies and Proprioceptive Training in Improving Functional Performance among Adults with Chronic Ankle Instability

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ABSTRACT

Objective: This study aimed to compare the effects of sensory-targeted ankle rehabilitation strategies and proprioceptive training on dynamic balance and functional performance in individuals with chronic ankle instability. **Methodology:** A quasi-experimental study with randomized group allocation and single blinding was conducted on 52 participants with CAI. Group A (n = 26) received STARS and Group B (n = 26) underwent proprioceptive training, each for six weeks (two sessions per week). Outcomes included the Star Excursion Balance Test (SEBT) and the Foot and Ankle Ability Measure—Activities of Daily Living (FAAM-ADL) and Sports (FAAM-Sport). Paired and independent t-tests were applied with significance set at $p < 0.05$. **Results:** Both groups showed significant within-group improvements ($p < 0.001$). In Group A, SEBT improved from 80.16 ± 3.70 to 83.24 ± 3.76 , FAAM-ADL from 68.73 ± 8.33 to 77.12 ± 5.26 , and FAAM-Sport from 22.62 ± 3.63 to 29.15 ± 2.69 . In Group B, SEBT increased from 81.73 ± 2.94 to 86.12 ± 3.09 , FAAM-ADL from 69.58 ± 10.05 to 77.35 ± 6.86 , and FAAM-Sport from 22.31 ± 3.22 to 29.88 ± 1.77 . Between-group analysis showed greater SEBT improvement in the Proprioception group (mean diff = -1.31, $p = 0.000$), no significant difference for FAAM-ADL ($p = 0.567$), and superior FAAM-Sport gains in the Proprioception group (mean diff = -1.04, $p = 0.032$). **Conclusion:** Both interventions enhanced dynamic balance and functional outcomes, with proprioceptive training yielding greater improvements in SEBT and FAAM-Sport

KEYWORDS: Chronic ankle instability, proprioceptive training, sensory-targeted rehabilitation, balance performance, functional recovery, SEBT, FAAM, clinical rehabilitation

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INTRODUCTION

Ankle injuries are common among athletes and the general population. Increased sports participation and training intensity heighten the risk of sprains, while everyday individuals also face ankle injuries from routine activities, often without realizing the extent of damage, making prevention and awareness essential for both groups. Following an initial ankle sprain, around 40% of individuals experience repeated episodes of the ankle "giving way," along with recurrent sprains or a persistent sense of instability in the joint. This condition is known as chronic ankle instability (CAI) (Xue et al., 2021). Alshahrani et al., (2024) characterised CAI as a sense of joint instability, chronic discomfort, and frequent ankle sprains. Individuals with CAI have been shown to exhibit decreased postural control and changed joint kinematics which are common indicators of deficits in functional performance (Gribble et al., 2016; Alshahrani et al., 2024). Management of CAI has evolved significantly. Earlier rehabilitation focused on muscle strengthening and range of motion, which proved inadequate for restoring stability. Contemporary rehabilitation emphasizes sensorimotor retraining to enhance proprioception, dynamic stability, and neuromuscular responsiveness, with balance training, perturbation exercises, and joint mobilization as essential components (Hertel & Corbett, 2019). Identifying this shortcoming, Sensory-Targeted Ankle Rehabilitation Strategies (STARS) were designed to target the compromised sensory pathways implicated in proprioceptive deficits and neuromuscular delay. STARS targets the quality and integration of sensory information crucial for the upkeep of dynamic postural control. It has shown promise in enhancing neuromuscular and sensory responses (McKeon & Wikstrom, 2016; McKeon & Wikstrom, 2018). Proprioceptive training has proven to be a pivotal element of the rehabilitation protocols for restoring sensorimotor function among individuals with CAI. Comparing simpler strengthening and static balance exercises to more complicated dynamic tasks, Han et al. (2022) found that the former were especially successful in regaining proprioceptive acuity. Yilmaz et al. (2024) reported that incorporating proprioceptive exercises into regular training significantly enhances strength, balance, and dynamic performance while reducing injury risk. Current literature lacks direct comparative evidence between STARS and proprioceptive training for chronic ankle instability (CAI). This study aims to fill that research gap by systematically comparing their impact on dynamic balance and functional performance, contributing to evidence-based practice in ankle rehabilitation.

METHODS

Study Design

This study adopted a quasi-experimental design with randomized group allocation and single blinding to compare STARS and

proprioception interventions. Ethical approval was obtained from the Research Ethics Committee of AIMST University. (AUHEC/MPT-FT-003/17/02/2025).

Criteria for Inclusion:

- People who score ≤ 25 in CAIT
- People with history of recurrent ankle sprain
- Both genders
- Age between 18 to 40 years old

Criteria for Exclusion:

- People with acute ankle sprain < 6 weeks
- People with history of ankle surgery or lower extremity surgeries associated with internal derangements or repairs, and/or other conditions known to affect sensorimotor function.

Randomisation and Grouping

Participants were randomly allocated into two groups (n=26) each:

- **Group A:** STARS Intervention
- **Group B:** Proprioceptive Intervention

Baseline measurements were taken prior to intervention.

Outcome Measures

1. Cumberland Ankle Instability Tool (CAIT)
2. Star Excursion Balance Test (SEBT)
3. Foot And Ankle Ability Measure (FAAM)

Intervention Protocols

Group A

Ankle Joint Mobilization: Each session consisted of two sets of two-minute joint mobilizations. Grade III large-amplitude oscillations were provided at a rate of around one oscillation every second. This approach produced an estimated total of 60 oscillations throughout the five-minute mobilization period, focusing on hypomobile structures to facilitate proprioceptive input and arthrokinematic repair.

Triceps Surae Stretching: Participants completed two sets of calf stretches with their knees slightly flexed to focus on the soleus muscle. Each set consisted of three 30-second stretches separated by 10-second pauses, as well as a one-minute break between sets. The stretching strategy was created to improve posterior chain flexibility and normalize muscle tension patterns that may affect ankle joint mechanics.

Group B

Full protocol will be attached

Data Collection, Procedure of Study and Statistical Analysis

Recruitment was carried out through direct personal engagement at several AIMST campus venues. Students and staff who satisfied the eligibility requirements were invited to participate, and written informed consent was taken after receiving a thorough explanation of the study's aims, methodology, and ethical considerations.

Eligibility was assessed using the Cumberland Ankle Instability instrument (CAIT). Following satisfactory screening, individuals were randomly assigned to one of two groups: sensory-targeted ankle rehabilitation methods (STARS) or a proprioceptive training program. Randomisation was performed using a computer-generated sequence, and individuals were enrolled in the order in which they were recruited. A single-blind design was used, in which participants were unaware of their group assignment, eliminating the possibility of response biases. Throughout the study, participants were monitored for any adverse events or discomfort.

Baseline assessments were performed using two outcome measures which were the Star Excursion Balance Test (SEBT) that assesses dynamic balance, and the Foot and Ankle Ability Measure (FAAM), which captures self-reported functional limitations during daily and sports-related activities. SEBT was performed exclusively on the participant's injured leg, as identified through CAIT screening and clinical history. Limb length was measured for all participants using the anterior superior iliac spine to the medial malleolus method. SEBT reach distances were normalized to limb length, expressed as a percentage of limb length, to account for individual anthropometric differences and allow for accurate inter-participant comparisons.

A single researcher conducted all evaluations, as well as the entire intervention procedure, to ensure uniformity in protocol application and outcome measure evaluation. The intervention period lasted six weeks with two supervised treatment sessions per week, for a total of twelve sessions. The trial had no dropouts. Following the six-week intervention period, post-intervention evaluations were conducted with the same tools, SEBT and FAAM, under identical testing conditions.

SEBT normalization was performed consistently at both baseline and post-intervention to maintain methodological rigor and

allow accurate interpretation of within-group and between-group differences. This pre-post design provides a solid foundation for investigating the varied effects of STARS and proprioceptive training in controlling chronic ankle instability.

All statistical analyses were conducted using IBM SPSS Statistics version 26.0. The reliability of the Star Excursion Balance Test (SEBT) was examined through the calculation of Intraclass Correlation Coefficients (ICC). Standard Error of Measurement (SEM) was computed using the formula $SEM = SD \times \sqrt{1 - ICC}$, providing an estimate of the error likely to occur in repeated measures of the same individual. Paired sample t-tests were utilised to evaluate within-group differences (pre- vs. post-intervention) by comparing SEBT normalised scores and FAAM subscale scores (ADL and Sports) in each intervention group. Independent sample t-tests were performed to compare the change scores between the STARS group and the Proprioceptive group. All statistical analyses were conducted using two-tailed tests, with the threshold for significance established at $p < 0.05$. Descriptive statistics, including means, standard deviations, and 95 percent confidence intervals, were reported for all outcome measures

RESULTS

Table 1: Baseline data of study samples (N=52)

	Mean (SD)	n	%
<u>Study group</u>			
Group A-STARS		26	50.0
Group B-Proprioception		26	50.0
<u>Gender</u>			
Male		21	40.4
Female		31	59.6
<u>Leg side</u>			
Right		35	67.3
Left		17	32.7
<u>Age</u>			
	21.4 (2.33)		
<20		20	38.5
21-25		31	59.6
26-30		1	1.9

Note: SD: Standard deviation; STARS: Sensory-targeted ankle rehabilitation strategies

Table 2: Results of SEBT, FAAM-ADL and FAAM-Sport in group A- STARS (n=26)

	Mean (SD)	SEM	95% CI of the difference		t	P
			Lower	Upper		
<u>SEBT</u>						
Baseline	80.16	0.73				
Post-intervention	(3.70) 83.24 (3.76)	0.74	-3.16	-2.99	-74.482	0.000
<u>FAAM-ADL</u>						
Baseline	68.73	1.63				
Post-intervention	(8.33) 77.12 (5.26)	1.03	-9.92	-6.85	-11.233	0.000
<u>FAAM-Sport</u>						
Baseline	22.62	0.71				
Post-intervention	(3.63) 29.15 (2.69)	0.53	-7.15	-5.93	-22.185	0.000

Note: SD: Standard deviation; SEM: Standard error of mean; CI: Confidence interval; STARS: Sensory-targeted ankle rehabilitation strategies; SEBT: Star excursion balance test; FAAM: Foot and ankle ability measure; ADL: Activity of living

Table 3: Results of SEBT, FAAM-ADL and FAAM-Sport in group B-Proprioception (n=26)

	Mean (SD)	SEM	95% CI of the difference		t	P
			Lower	Upper		
<u>SEBT</u>						
Baseline	81.73	0.58				
Post-intervention	(2.94) 86.12 (3.09)	0.61	-4.49	-4.28	-86.987	0.000
<u>FAAM-ADL</u>						
Baseline	69.58	1.97				
Post-intervention	(10.05) 77.35 (6.86)	1.35	-9.35	-6.19	-10.153	0.000
<u>FAAM-Sport</u>						
Baseline	22.31	0.63				
Post-intervention	(3.22) 29.88 (1.77)	0.35	-8.34	-6.82	-20.552	0.000

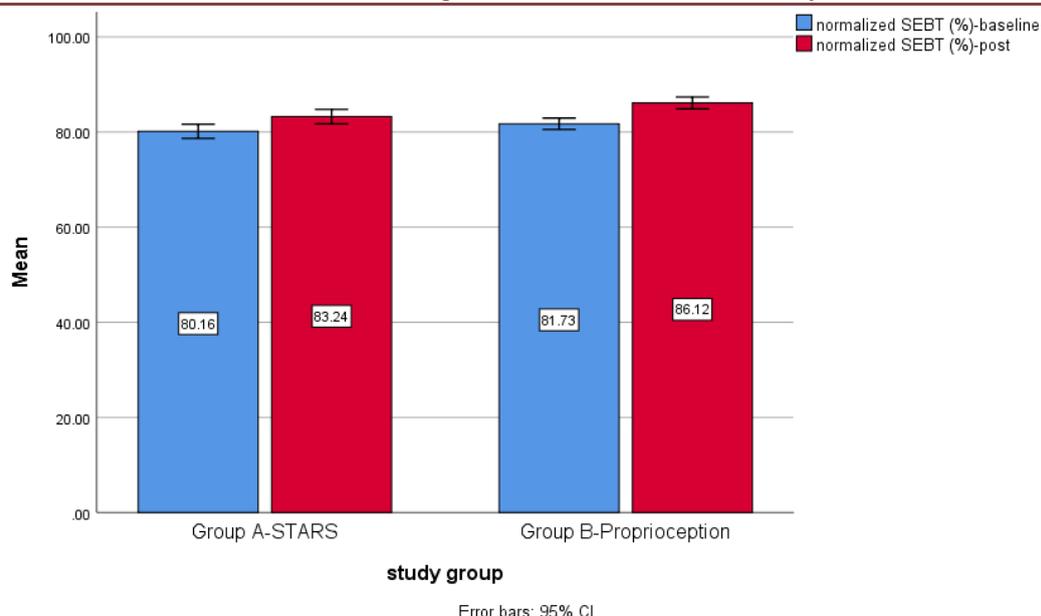
Note: SD: Standard deviation; SEM: Standard error of mean; CI: Confidence interval; STARS: Sensory-targeted ankle rehabilitation strategies; SEBT: Star excursion balance test; FAAM: Foot and ankle ability measure; ADL: Activity of living

Table 4: Comparison in effect of SEBT, FAAM-ADL and FAAM-Sport between Group A-STARS (n=26) and group B-Proprioception (n=26)

	Mean (SD)	Mean difference	95% CI of the difference		t	P
			Lower	Upper		
<u>SEBT difference</u>						
Group A-STARS	3.08 (0.21)					
Group B-Proprioception	2.24 (1.48)	-1.31	-1.44	-1.28	-20.084	0.000
<u>FAAM-ADL difference</u>						
Group A-STARS	8.38 (3.81)					
Group B-Proprioception	7.77 (3.90)	0.62	-1.53	2.76	0.576	0.567
<u>FAAM-Sport difference</u>						
Group A-STARS	6.54 (1.50)					
Group B-Proprioception	7.58 (1.88)	-1.04	-1.99	-0.09	-2.200	0.032

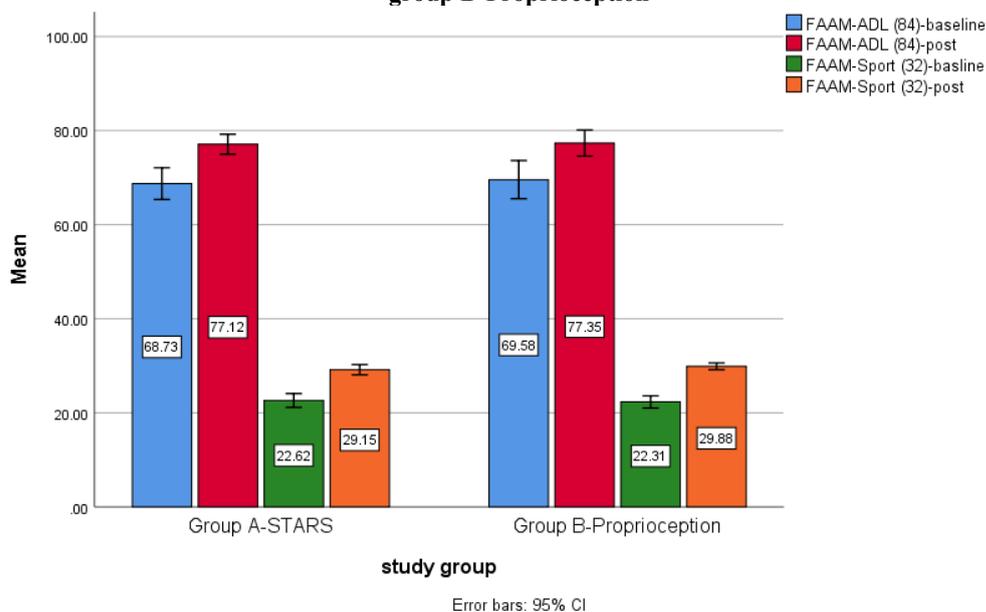
Note: SD: Standard deviation; SEM: Standard error of mean; CI: Confidence interval; STARS: Sensory-targeted ankle rehabilitation strategies; SEBT: Star excursion balance test; FAAM: Foot and ankle ability measure; ADL: Activity of living

Figure 1: SEBT distribution in baseline and post intervention between group A-STARS and group B-Proprioception



Note: STARS: Sensory-targeted ankle rehabilitation strategies; SEBT: Star excursion balance test

Figure 2: FAAM-ADL and FAAM-Sport distribution in baseline and post intervention between group A-STARS and group B-Proprioception



Note: STARS: Sensory-targeted ankle rehabilitation strategies; FAAM: Foot and ankle ability measure; ADL: Activity of living

DISCUSSION

Our results showed significantly greater improvements in SEBT reach distances for the proprioceptive training group than the STARS group. This corresponds with the extensive CAI literature indicating that balance-oriented interventions produce significant improvements in dynamic stability. Guo et al. (2024) discovered that balancing training markedly improved SEBT reach in individuals with CAI. Conversely, individual STARS interventions have yielded only temporary enhancements in single-leg balance. McKeon and Wikstrom (2019) documented immediate improvements following a single session of joint mobilisation or plantar massage, although saw no enduring benefits after two weeks of treatment. Consequently, our discovery that the proprioceptive group surpassed the STARS group on the SEBT aligns with studies indicating that active balance training more effectively challenges and enhances performance.

The outcomes noted in our proprioceptive training group are closely consistent with existing evidence regarding the advantages of balance-oriented therapy for CAI. Our participants demonstrated significant enhancements in SEBT and substantial increases in both FAAM-ADL and FAAM-Sport scores, data corroborated by recent meta-analyses and randomised controlled trials. Guo et al. (2024) revealed that balance training significantly improves dynamic balance and patient-reported outcomes, with effect sizes favouring proprioceptive methods over strength-based or passive therapies. Tedeschi et al. (2024) emphasised that proprioceptive training regularly enhances subjective functional ability in CAI populations, especially when conducted for over

four weeks. Our findings corroborate this, as participants in the proprioceptive group underwent structured, progressive balance exercises over six weeks, yielding clinically significant enhancements.

Zhang et al. (2025) affirmed that exercise therapy produces substantial enhancements in both FAAM-ADL and FAAM-Sport, with mean differences beyond the minimal clinically meaningful difference limits. The congruence of our proprioceptive group's results with these findings enhances the validity of proprioceptive training as a fundamental aspect of CAI therapy. Koshino and Kobayashi (2023) highlighted that although multiple rehabilitation techniques are beneficial, proprioceptive training is essential as it directly addresses neuromuscular deficiencies. Our research contributes to existing evidence by showing that proprioceptive training is effective in controlled trials and yields similar outcomes in a varied university-aged Malaysian demographic.

These findings collectively reinforce the assertion that proprioceptive training is a very successful and scalable intervention for patients with CAI, yielding advantages in both objective (SEBT) and subjective (FAAM) outcome domains.

CONCLUSION

The findings of this study provide significant insight into the comparative effectiveness of two commonly employed rehabilitation methods for CAI. Both intervention groups exhibited statistically significant enhancements in dynamic balance and self-reported functional scores after six weeks of therapy. The proprioceptive training group demonstrated superior enhancements in overall SEBT scores. The FAAM-Sports subscale also reflected slightly superior gains in the proprioceptive group, while both groups improved significantly on the FAAM-ADL subscale. This reinforces the clinical understanding that proprioceptive training enhances neuromuscular control and promotes long-term functional recovery through task-specific engagement and motor learning. The STARS group also showed meaningful improvements, though to a lesser extent. STARS is advantageous for immediate sensory modulation, it may not be as effective as proprioceptive training in fostering enduring neuromechanical enhancements when utilized as an independent intervention. This study's findings support the incorporation of active, neuromuscular rehabilitation strategies as a foundation of CAI management, especially when long-term stability and functional performance are key goals.

REFERENCES

1. Alshahrani MS, Reddy RS, Alshahrani A, Gautam AP, Alsubaie SF. Exploring the interplay between ankle muscle strength, postural control, and pain intensity in chronic ankle instability: A comprehensive analysis. *Heliyon*. 2024 Mar 15;10(5):e27374.
2. Gribble PA, Bleakley CM, Caulfield BM, Docherty CL, Fourchet F, Fong DTP, et al. Evidence review for the 2016 International Ankle Consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains. *Br J Sports Med*. 2016 Dec;50(24):1496–505.
3. Han J, Luan L, Adams R, Witchalls J, Newman P, Tirosh O, et al. Can Therapeutic Exercises Improve Proprioception in Chronic Ankle Instability? A Systematic Review and Network Meta-analysis. *Archives of Physical Medicine and Rehabilitation*. 2022 Nov 1;103(11):2232–44.
4. Guo Y, Cheng T, Yang Z, Huang Y, Li M, Wang T. A systematic review and meta-analysis of balance training in patients with chronic ankle instability. *Syst Rev*. 2024 Feb 12;13:64.
5. Hertel J, Corbett RO. An Updated Model of Chronic Ankle Instability. *Journal of Athletic Training*. 2019 June 4;54(6):572.
6. Koshino Y, Kobayashi T. Effects of Conservative Interventions on Static and Dynamic Balance in Individuals With Chronic Ankle Instability: A Systematic Review and Meta-analysis. *Archives of Physical Medicine and Rehabilitation*. 2023 Apr 1;104(4):673–85.
7. McKeon PO, Wikstrom EA. Sensory-Targeted Ankle Rehabilitation Strategies for Chronic Ankle Instability. *Medicine & Science in Sports & Exercise*. 2016 May;48(5):776.
8. McKeon PO, Wikstrom EA. The effect of sensory-targeted ankle rehabilitation strategies on single-leg center of pressure elements in those with chronic ankle instability: A randomized clinical trial. *Journal of Science and Medicine in Sport*. 2019 Mar 1;22(3):288–93.
9. Tedeschi R, Ricci V, Tarantino D, Tarallo L, Catani F, Donati D. Rebuilding Stability: Exploring the Best Rehabilitation Methods for Chronic Ankle Instability. *Sports*. 2024 Oct;12(10):282.
10. Xue X, Ma T, Li Q, Song Y, Hua Y. Chronic ankle instability is associated with proprioception deficits: A systematic review and meta-analysis. *Journal of Sport and Health Science*. 2021 Mar 1;10(2):182–91.
11. Yılmaz O, Soylu Y, Erkmen N, Kaplan T, Batalik L. Effects of proprioceptive training on sports performance: a systematic review. *BMC Sports Science, Medicine and Rehabilitation*. 2024 July 4;16(1):149.
12. Zhang C, Luo Z, Wu D, Fei J, Xie T, Su M. Effectiveness of exercise therapy on chronic ankle instability: a meta-analysis. *Sci Rep*. 2025 Apr 5;15(1):11709.