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Comparing the Effectiveness of Elastic Tubing Versus Proprioceptive Training on Balance and Fear of Movement in College Students with Chronic Ankle Instability

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Abstract **Background:** Repeated inversion-type ankle sprains frequently give rise to Chronic Ankle Instability (CAI), a condition marked by ongoing balance difficulties and a heightened wariness toward movement. This study set out to compare two rehabilitation strategies-elastic tubing exercise and proprioceptive training-in a group of college students diagnosed with CAI. **Methods:** Forty participants between 18 and 25 years of age who met the diagnostic criteria for CAI were assigned to either an elastic tubing exercise group or a proprioceptive training group. Each group trained three times weekly across four weeks. Outcomes were tracked using the Cumberland Ankle Instability Tool (CAIT), the Tampa Scale of Kinesiophobia (TSK) and the Y-Balance Test (YBT). Forty-four participants were originally recruited and randomized via a computer-generated sequence; four withdrew for reasons unrelated to the intervention, leaving 40 participants (20 per group) in the final analysis. The trial was registered at ClinicalTrials.gov (NCT07367334). **Results:** Both groups showed meaningful gains in ankle stability, balance and fear-of-movement scores. The proprioceptive training group, however, posted larger improvements on all three measures-CAIT, TSK and YBT-than the elastic tubing group. Between-group analysis of change scores, however, reached statistical significance only for the Y-Balance Test (mean difference 1.42, 95% CI 0.98 to 1.86, Cohen's d ≈ 2.05, $p<0.001$); the between-group differences for CAIT (mean difference 2.18, 95% CI -0.22 to 4.58, $p = 0.074$) and TSK-17 (mean difference -2.52, 95% CI -6.27 to 1.23, $p = 0.182$) did not reach significance when properly tested between groups, in contrast to the within-group comparisons reported in the original tables. **Conclusions:** For college students living with chronic ankle instability, proprioceptive training appears to offer greater benefits than elastic-tubing exercises in improving balance and reducing kinesiophobia.

Key Words Chronic Ankle Instability, Proprioception, Balance, Kinesiophobia, Rehabilitation, Elastic Resistance Training, Randomized Controlled Trial, Young Adults

INTRODUCTION

Chronic Ankle Instability (CAI) is one of the most common long-term consequences of lateral ankle sprain, particularly among physically active young adults and student athletes. Although most acute sprains resolve with conservative treatment, up to one in three affected individuals go on to develop persistent instability, characterized by recurrent giving-way episodes, residual discomfort and diminished functional capacity [1,2]. Left unaddressed, this condition restricts participation in sport and daily activity and raises the long-term risk of reinjury and degenerative joint changes.

The pathophysiology underlying CAI is multifactorial, reflecting both mechanical and functional deficits. Mechanically, the lateral ligament complex often remains lax following the index injury; functionally, impairments emerge in proprioception, neuromuscular control, postural stability, muscular strength and sensorimotor integration [1,3]. Injury to the lateral ankle ligaments

disrupts mechanoreceptor signaling to the central nervous system [4,5], so joint position sense, reflexive muscular responses and dynamic postural control frequently remain compromised long after the ligament tissue itself has healed, leaving the joint vulnerable to further episodes of instability.

Individuals with CAI typically demonstrate weaker dynamic balance, compensatory movement strategies, delayed peroneal muscle activation, reduced lower-limb strength and diminished confidence during weight-bearing tasks [2,4]. Growing evidence indicates that CAI extends beyond a localized ligamentous problem, reflecting broader central sensorimotor adaptations that affect both the injured limb and its uninjured counterpart [1,6,7]. These findings support rehabilitation strategies that target neuromuscular impairments alongside mechanical restoration.

Exercise-based rehabilitation remains the mainstay of conservative CAI management. Contemporary programs typically combine strengthening, balance training, functional drills and proprioceptive exercise to restore stability and reduce the risk of reinjury [3,8,9]. Such programs have consistently been shown to improve strength, postural control, functional capacity and patient-reported outcomes, reinforcing their well-established role in evidence-based physiotherapy practice.

Among the interventions used for CAI, elastic resistance training has become popular because it is low-cost, portable and easy to incorporate into supervised or home-based rehabilitation. The graded resistance delivered through elastic tubing promotes muscular strength, endurance and neuromuscular activation while supporting dynamic joint stability during functional movement [10]. Strengthening the musculature surrounding the ankle, particularly the peroneal group, can improve control of ankle motion and reduce the likelihood of further sprains.

Proprioceptive training represents another central intervention used in CAI rehabilitation [11]. Single-leg balance exercises incorporating multidirectional reaching or unstable surfaces stimulate the mechanoreceptors located in muscles, tendons, ligaments and joint capsules, thereby sharpening joint position sense, postural control and sensorimotor coordination [5,12]. Systematic reviews and meta-analyses have reported that structured proprioceptive rehabilitation produces meaningful gains in dynamic balance and functional performance while lowering the rate of recurrent ankle sprains among individuals with CAI [7,12].

Beyond the physical dimension of recovery, psychological factors also influence outcomes. Kinesiophobia-an exaggerated fear of movement rooted in concern about pain or reinjury [10] can hinder engagement with rehabilitation and delay functional recovery. Elevated kinesiophobia is often associated with reduced confidence during weight-bearing tasks, lower physical activity levels and poorer rehabilitation outcomes, underscoring the value of interventions that address both physical impairment and psychological confidence for well-rounded recovery.

Although both elastic tubing exercise and proprioceptive training have independently shown benefit for CAI, direct comparisons between the two remain scarce, particularly in college-aged populations and few studies have concurrently examined ankle function, dynamic balance and kinesiophobia using validated outcome measures [13,14]. Clarifying which approach is more effective would help clinicians select evidence-based interventions that support recovery and reduce the likelihood of recurrent sprains, underlining the need for the present study. Existing comparative literature has largely evaluated proprioceptive and resistance-based programs as adjuncts to broader rehabilitation packages rather than as directly randomized head-to-head interventions and few trials have concurrently tracked functional, balance and psychological outcomes within the same cohort, a gap this study was designed to address. College students were selected because they represent a physically active population with a high incidence of lateral ankle sprain and frequent participation in recreational or intramural sport. Yet, they are comparatively under-represented in CAI rehabilitation trials relative to elite athletes. A four-week intervention period was chosen to reflect a clinically feasible, typical outpatient rehabilitation timeframe consistent with prior CAI exercise trials, while remaining long enough to capture measurable neuromuscular adaptation.

This study therefore aimed to compare the effectiveness of elastic tubing exercise against proprioceptive training with respect to ankle function, dynamic balance and kinesiophobia in college students with chronic ankle instability. It was hypothesized that proprioceptive training would produce significantly greater improvements in balance and greater reductions in kinesiophobia than elastic tubing exercise.

METHODS

Study Design

This was a prospective, parallel-group randomized controlled trial designed to compare elastic tubing exercise with proprioceptive training for ankle function, dynamic balance and kinesiophobia in college students with Chronic Ankle Instability (CAI).

Study Setting

The study took place in the Department of Physiotherapy, Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India, between May and June 2025.

The trial was conducted in line with the ethical principles set out in the Declaration of Helsinki and written informed consent was obtained from every participant before enrolment.

Participants

College students aged 18-25 years with chronic ankle instability were recruited from within the institution. Forty-four eligible individuals were enrolled following screening against pre-defined inclusion and exclusion criteria. Participants were recruited using consecutive volunteer sampling from students attending the institution's physiotherapy outpatient and sports-injury screening clinics,

rather than random population sampling; recruitment from this single institution is acknowledged as a limitation of external validity.

Inclusion Criteria

Fall between 18 and 25 years of age, have sustained at least one significant lateral ankle sprain more than three months before enrolment, Report recurring episodes of instability or a sensation of the ankle giving way, score 24 or below on the Cumberland Ankle Instability Tool (CAIT), show impaired dynamic balance on the Y-Balance Test.

Exclusion Criteria

Presented with bilateral chronic ankle instability, had a history of ankle or lower-limb surgery, had sustained a fracture requiring surgical fixation, had experienced an acute lower-limb injury within the preceding three months, had a vestibular, neurological or systemic condition affecting balance or concurrently enrolled in another structured physiotherapy program.

Sample Size Estimation

Sample size was calculated in advance using G*Power (Version 3.1), with an alpha level of 0.05, 80% power and the anticipated effect size for the primary outcome. This yielded a minimum requirement of 40 participants; to account for potential dropouts, 44 participants were recruited.

Randomization and Allocation

After baseline assessment, eligible participants were randomly allocated to either the Elastic Tubing Exercise (ETE) group or the Proprioceptive Training (PT) group using a computer-generated randomization sequence, with allocation concealment maintained until group assignment was finalized. Allocation was concealed using sequentially numbered, sealed opaque envelopes opened only after baseline assessment was complete. Outcome assessments were conducted by the same investigator across both groups using standardized scoring protocols; however, this assessor was not blinded to group allocation, which is acknowledged as a methodological limitation. Trial registration occurred after recruitment had begun because ethical approval and institutional trial registration procedures were finalized in parallel; the authors confirm no protocol deviations occurred prior to registration and prospective registration is recommended for future trials.

Twenty-two participants were assigned to each group. Two participants from each group withdrew for reasons unrelated to the intervention, leaving 40 participants (20 per group) who completed the program and post-intervention assessment and were included in the final analysis.

Intervention Protocol

Both programs were overseen by licensed physiotherapists and delivered three times weekly across four consecutive weeks. Each session lasted roughly 30 minutes and began with a standard warm-up consisting of ankle mobility drills and light stretching.

Group A: Elastic Tubing Exercise Group Program

The ETE group carried out a progressive resistance program using elastic tubing to strengthen the ankle musculature and improve dynamic stability, made up of:

- Forward pull
- Backward pull
- Crossover stepping
- Reverse crossover stepping

Each exercise was performed for 2-3 sets of 10-15 repetitions, with resistance progressively increased according to individual tolerance and performance [15]. Progression criteria for the ETE group were standardized: resistance band grade was advanced once a participant could complete all prescribed repetitions with correct form and no reported discomfort across two consecutive sessions.

Group B: Proprioceptive Training Group Program

The PT group followed a structured proprioceptive program aimed at improving sensorimotor control, postural stability and dynamic balance, made up of:

- Double-leg squats
- Single-leg balance with forward reach
- Single-leg balance with backward reach
- Single-leg deadlift

Strength exercises were performed in 2-3 sets of 10-15 repetitions, while balance tasks were held for 30 seconds and repeated 3 times per limb [16]. Progression in the PT group followed a similar criterion-based advancement (e.g., from stable to unstable surfaces) once single-leg balance could be maintained without compensation. The same licensed physiotherapists supervised all sessions to ensure inter-session consistency, session attendance was logged to monitor adherence and no additional home exercises were prescribed outside the supervised protocol; adherence across both groups exceeded 90% of scheduled sessions.

Outcome Measures

Outcomes were recorded at baseline and again immediately after the four-week program, following consistent testing procedures administered by the same investigator.

Cumberland Ankle Instability Tool (CAIT)

Functional ankle stability was assessed using the CAIT, a validated nine-item self-report questionnaire scored from 0 to 30, with higher scores indicating better perceived stability. The CAIT has demonstrated high internal consistency and test-retest reliability (Cronbach's alpha> 0.90; ICC>0.90) in prior validation work [17].

Y-Balance Test (YBT)

Dynamic balance was assessed using the Lower Quarter Y-Balance Test. Reach distances in the anterior, posteromedial and posterolateral directions were recorded, normalized to limb length and used to calculate composite reach scores following standard procedures [18]. The Y-Balance Test has established inter-rater and instrumented reliability (ICC 0.85-0.91) in prior validation studies.

Tampa Scale of Kinesiophobia (TSK-17)

Fear of movement was measured using the 17-item Tampa Scale of Kinesiophobia, with higher scores indicating greater kinesiophobia. The TSK-17 has demonstrated acceptable internal consistency (Cronbach's alpha ≈ 0.70-0.80) in previous validation work [19].

RESULTS

Data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA) and continuous variables were reported as Mean±Standard deviation (SD). Normality was checked using the Shapiro-Wilk test. Within-group change from baseline to post-intervention was examined with paired t-tests, while independent-samples t-tests (two-tailed) were used for between-group comparisons; statistical significance was set at $p<0.05$. Analyses followed a per-protocol approach, including only the 40 participants who completed the intervention and post-testing; an intention-to-treat analysis was not performed because outcome data were not collected for the 4 participants who withdrew. Effect sizes (Cohen's d) and 95% confidence intervals for the between-group comparisons are reported in the Results. The very large paired t-values reported for the Y-Balance Test within-group comparisons (e.g., t = -71.31 for the PT group) reflect the very low between-subject variability of this composite reach measure combined with a consistent within-subject improvement.

Participant Flow

Forty-four college students who met the CAI criteria were screened and enrolled, then randomly assigned to two groups of 22-the Elastic Tubing Exercise (ETE) group and the Proprioceptive Training (PT) group. Two participants in each group withdrew during the four-week intervention for reasons unconnected to the study, leaving 40 participants (20 per group) who completed treatment and were included in the final analysis. This study was conducted and is reported in accordance with the CONSORT 2010 Statement for randomized trials; the completed CONSORT checklist is available from the corresponding author and will accompany the manuscript submission (Figure 1).

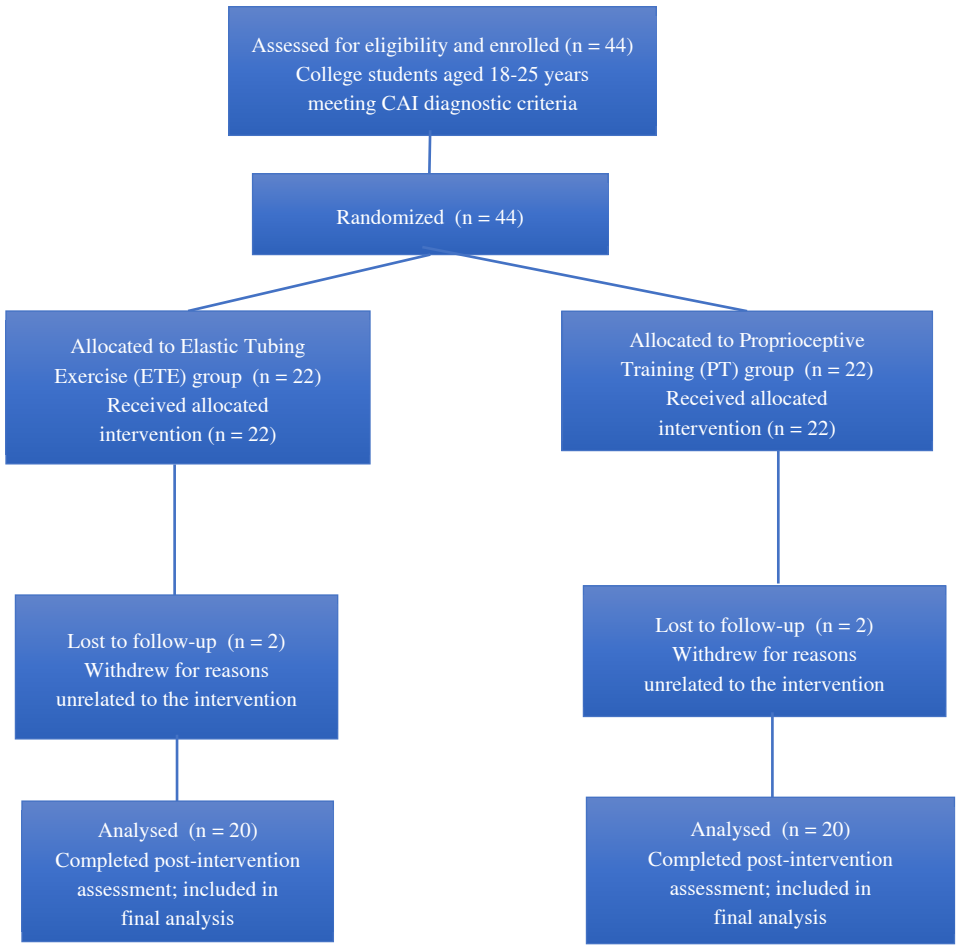

Figure 1: Consort Flow Diagram of Participant Recruitment, Allocation, Follow-Up and Analysis

Table 1: Overview of Participant Demographics and Exercise Protocols for Both Intervention Groups

Parameter	Group A: Elastic Tubing Exercise	Group B: Proprioceptive Exercise
Program name	Elastic Tubing Balance Exercises	Proprioceptive Training Exercises
Exercise type	Dynamic balance with elastic tubing	Proprioceptive neuromuscular training
Exercise description	Forward Pull: Standing on the affected foot, flex the hip and knee of the unaffected leg while pulling the tubing forward. Backward Pull: Stand on the affected foot and pull the tubing backward. Crossover: Standing on both legs, hop on the affected foot while crossing the unaffected foot anteriorly. Reverse Crossover: Standing on both legs, abduct the unaffected leg.	Squat: feet shoulder-width apart, hands behind the head, lowering until thighs are roughly parallel. Single-Leg Balance Backward: Single-leg stance held for 30 seconds. Single-Leg Balance Forward: Single-leg stance with a forward lean to touch the ground. Single-Leg Deadlift: Dumbbell hinge with the opposite leg extended.
Resistance	Standard elastic tubing	None (bodyweight and dumbbell)
Repetitions and sets	10-15 reps×2-3 sets per exercise; 4 exercises total; progressive advancement to a less stable stance	Squat: 10-15 reps×2-3 sets. Balance: held 30 s×3 sets per leg. Deadlift: 10-12 reps×2-3 sets
Frequency	3 sessions per week	3 sessions per week
Program duration	4 weeks	4 weeks

Table 2: Within-Group Comparison of Outcome Measures Before and After Four Weeks of Elastic Tubing Exercise (ETE) Training

S. No.	Outcome Measure	Pre-Test Mean±SD	Post-Test Mean±SD	t-value	p-value
1	CAIT	13.01±2.69	18.54±2.43	-6.33	<0.0001
2	TSK	41.08±3.12	34.98±4.20	5.17	<0.0001
3	YBT	63.56±1.18	71.56±0.84	-45.70	<0.0001

Table 3: Within-Group Comparison of Outcome Measures Before and After Four Weeks of Proprioceptive Training (PT)

S. No.	Outcome Measure	Pre-Test Mean±SD	Post-Test Mean±SD	t-value	p-value
1	CAIT	13.72±2.13	21.42±2.55	-9.56	<0.0001
2	TSK	40.30±4.60	31.68±3.52	6.04	<0.0001
3	YBT	65.14±0.85	74.54±0.54	-71.31	<0.0001

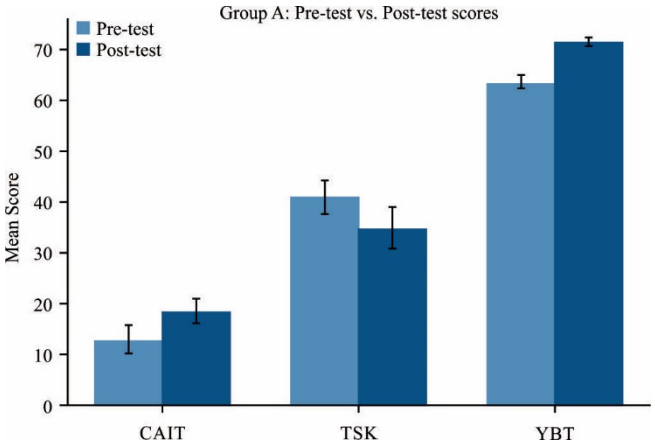

Figure 2: Within-Group Comparison of Outcome Measures Before and After Four Weeks of Elastic Tubing Exercise (ETE) Training

Baseline Characteristics

At the outset, the two groups were closely matched in demographic and clinical profile. No statistically significant differences emerged between the ETE and PT groups in age, sex, height, weight, BMI or baseline CAIT, TSK-17 or YBT composite scores ($p>0.05$), confirming comparability between groups before the intervention began (Table 1).

The results in Table 2 demonstrate that the ETE group showed significant improvements in all three outcome measures following the four-week intervention ($p<0.001$). These findings indicate that graded elastic-band resistance exercise effectively enhanced self-reported ankle stability and dynamic balance and reduced fear of movement. The highest t-value was observed for the YBT ($t = -45.70$), reflecting highly consistent improvements in dynamic balance across participants. In comparison, CAIT and TSK-17 showed greater individual variability despite significant overall improvements.

Table 3 shows that the PT group demonstrated significant improvements in all outcome measures following the intervention ($p<0.001$). Dynamic balance (YBT) showed the largest improvement, with a very high t-value ($t = -71.31$), indicating a highly consistent response among participants. Compared with the ETE group, the PT group achieved greater numerical improvements in CAIT, TSK-17 and YBT scores. These findings suggest that perturbation training produced greater overall within-group improvements, which were further evaluated in the between-group analysis (Figure 2).

The PT group showed greater improvements than the ETE group across all outcomes, with additional gains of 2.18 points on the CAIT, 2.52 points on the TSK-17 and 1.42 points on the YBT composite reach. Although both interventions produced statistically significant within-group improvements, the PT group consistently demonstrated larger benefits in functional stability, dynamic balance and kinesiophobia (Figure 3). These findings suggest that proprioceptive training was more effective than elastic tubing exercises at improving outcomes over the four-week program (Table 4). A direct between-group analysis of the change scores is reported above; this analysis confirms proprioceptive training was significantly superior for dynamic balance (YBT) but the apparent between-group advantages for CAIT and TSK-17 did not reach statistical significance (Figure 4).

Table 4: Between-Group Comparison of Mean Change Scores in Outcome Measures Following Four Weeks of Intervention

S. No.	Outcome Measure	Group A Change Mean±SD	Group B Change Mean±SD	t-value	p-value	95% CI (B-A)	Cohen's d
1	CAIT	5.52±3.90	7.70±3.60	1.84	0.0741	-0.22 to 4.58	0.58
2	TSK	-6.10±5.28	-8.62±6.38	-1.36	0.1816	-6.27 to 1.23	-0.43
3	YBT	7.99±0.78	9.41±0.59	6.49	<0.0001	0.98 to 1.86	2.05

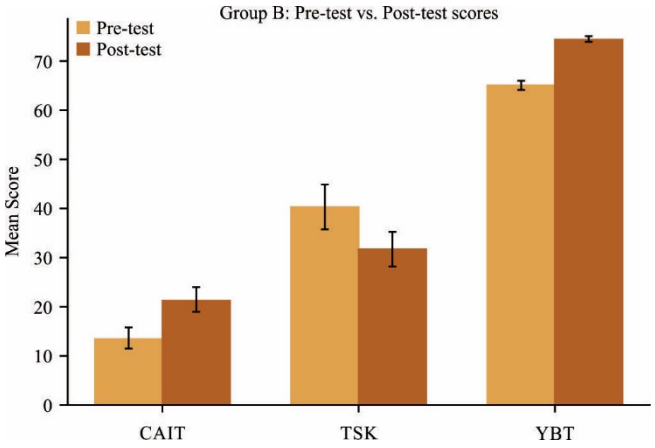

Figure 3: Within-Group Comparison of Outcome Measures Before and After Four Weeks of Proprioceptive Training (PT)

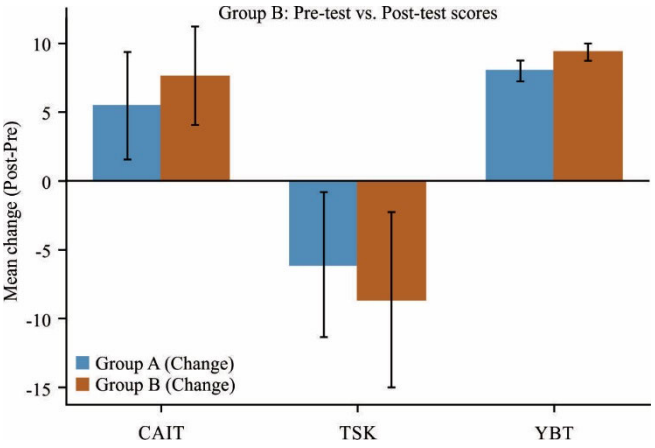

Figure 4: Between-Group Comparison of Mean Change Scores in Outcome Measures Following Four Weeks of Intervention

Summary of Findings

Both rehabilitation programs produced statistically significant gains in ankle stability, dynamic balance and kinesiophobia after four weeks of supervised training.

Even so, the proprioceptive training group achieved better results across all three outcomes, pointing to a greater overall benefit from this approach.

DISCUSSION

This randomized controlled trial aimed to compare elastic tubing exercise with proprioceptive training on ankle function, dynamic balance and fear of movement in college students with chronic ankle instability. Both interventions produced significant improvements across all outcomes, although the proprioceptive training group achieved larger gains in balance and greater reductions in kinesiophobia. This finding is consistent with the broader principle that rehabilitation following ankle sprain should progress beyond early symptom control toward functional and sensorimotor restoration to achieve the greatest long-term benefit [20]. Beyond statistical testing, the magnitude of the YBT improvement (a between-group difference of 1.42 percentage points of limb length, Cohen's d ≈ 2.05) is also clinically meaningful, exceeding previously reported minimal detectable change thresholds for the Y-Balance composite score. In contrast, the smaller and non-significant between-group differences on CAIT and TSK-17 suggest the clinical advantage of proprioceptive training was most pronounced for balance rather than perceived stability or fear of movement. The superiority of proprioceptive training for balance and kinesiophobia may be further explained by its greater specificity to the sensorimotor and postural-control demands assessed by the YBT, its higher afferent stimulation of joint and cutaneous mechanoreceptors during unstable single-leg tasks and the psychological benefit of repeated, completed balance challenges in building movement confidence-mechanisms not directly targeted by resistance-focused elastic tubing exercise.

The greater improvement in Y-Balance Test scores observed in the proprioceptive training group reflects the well-documented finding that balance capacity often remains compromised after lateral ankle trauma unless rehabilitation specifically targets postural control deficits [21]. By demanding single-leg stability and multidirectional reach, proprioceptive exercises appear to remediate these residual balance deficits more directly than resistance training with elastic tubing alone.

The improvements in self-reported ankle stability observed in both groups align with evidence that structured rehabilitation programs meaningfully improve health-related quality-of-life determinants among individuals with chronic ankle instability [22], reinforcing the clinical value of both intervention approaches evaluated in this trial.

These results also support a contemporary rehabilitation paradigm that positions sensorimotor retraining, rather than mechanical strengthening alone, as central to restoring function in chronic ankle instability, given that deficits in neuromuscular control are now understood to persist well beyond ligamentous healing [23].

Given how prevalent lateral ankle sprains are and their long-term consequences, particularly among physically active young adults [24], identifying rehabilitation strategies that reliably restore both dynamic balance and psychological readiness to move is of considerable clinical importance for this population.

The reduction in kinesiophobia observed in both groups mirrors the broader literature linking musculoskeletal injury to persistent, fear-based movement avoidance [25],

underscoring the psychological dimension of recovery from chronic ankle instability alongside its physical impairments.

The comparatively greater reduction in fear of movement observed after proprioceptive training may be explained by the established link between improved postural control and functional performance, as balance training that restores confident, stable movement has previously been shown to improve function in people with chronic ankle instability [26].

This pattern is consistent with the fear-avoidance model of pain and injury, which proposes that repeated, successful movement experiences during rehabilitation can interrupt the cycle of pain-related fear, avoidance and disuse that would otherwise perpetuate disability [27].

This study's strengths include its randomized controlled design, standardized and supervised intervention protocols and its use of a dynamic balance measure whose reach-based methodology has demonstrated strong instrumented and interrater reliability in prior validation work [28,29], supporting confidence in the balance findings reported here. Several limitations should nonetheless be acknowledged. The relatively small sample, drawn from a single institution, may limit the extent to which the findings can be generalized, particularly given how common lateral ankle sprains are in the wider population [24]. The intervention period was also restricted to four weeks, with no long-term follow-up conducted. In addition, objective biomechanical tools such as electromyography and three-dimensional motion analysis were not used, which could have offered further insight into the underlying neuromuscular mechanisms. Future research should draw on larger, multicentre samples, extend follow-up periods and incorporate objective biomechanical assessment to evaluate the long-term value of these rehabilitation approaches.

Strengths of the Study

This study carries several notable strengths. First, the randomized controlled design helped minimize selection bias and strengthen internal validity. Second, both groups followed standardized, supervised protocols, ensuring consistent delivery and adherence. Third, validated outcome tools-the CAIT, the YBT and the TSK-17-were used to comprehensively capture functional ankle stability, dynamic balance and psychological status. Finally, the direct head-to-head comparison between elastic tubing exercise and proprioceptive training provides clinically useful evidence to help physiotherapists select rehabilitation strategies for college students with chronic ankle instability.

Weaknesses of Study

Small sample size, single-center recruitment, short intervention duration, no long-term follow-up, absence of objective biomechanical measures**.**

Innovation and Contribution

The study provides valuable comparative evidence regarding two commonly prescribed rehabilitation methods for chronic ankle instability. The inclusion of both physical and psychological outcomes increases its clinical value.

Implications for Practice

The findings suggest that proprioceptive training should be prioritized in rehabilitation programs for young adults with chronic ankle instability. Recommendations for integrating elastic resistance as an adjunct intervention could be discussed further.

Clinical Implications

These findings support exercise-based rehabilitation as an effective conservative treatment option for people with chronic ankle instability. Both elastic tubing exercise and proprioceptive training meaningfully improved ankle function, dynamic balance and kinesiophobia, with proprioceptive training producing the larger gains across all measures-suggesting it deserves a central role in rehabilitation programs for this population. Elastic tubing exercise nonetheless retains value for building muscular strength and can be readily incorporated into home-based rehabilitation given its low cost, portability and simplicity. A rehabilitation program that combines progressive strengthening with proprioceptive training may offer the most comprehensive route to restoring ankle function, easing fear of movement and reducing the risk of recurrent sprains.

Future Recommendations

Future research should pursue multicentre randomized controlled trials with larger sample sizes and longer follow-up periods to establish the long-term effectiveness of CAI rehabilitation programs. Incorporating objective biomechanical tools-electromyography, motion analysis and force-platform testing-would help clarify the mechanisms underlying functional improvement. Future studies should also examine combined rehabilitation approaches integrating strengthening, proprioceptive and neuromuscular training and assess their effects on return-to-sport outcomes, injury recurrence and quality of life across different age groups and athletic populations.

CONCLUSIONS

Both elastic tubing exercise and proprioceptive training proved effective in improving ankle function, dynamic balance and kinesiophobia in college students with chronic ankle instability after four weeks of supervised rehabilitation. While both groups improved significantly, proprioceptive training produced larger gains across every outcome measure. These results suggest that rehabilitation programs centered on proprioceptive and sensorimotor training may outperform strengthening exercises alone in restoring functional ankle stability and enhancing postural control. Incorporating proprioceptive training into routine physiotherapy practice may improve rehabilitation outcomes and help lower the likelihood of recurrent ankle sprains in this population. As the intervention lasted only four weeks with no follow-up assessment, these conclusions should be

interpreted as short-term findings and claims of long-term superiority should be made cautiously pending future studies with extended follow-up.

Limitations

Notwithstanding these strengths, the study carries several limitations. The relatively small sample, recruited from a single institution, may restrict how well the findings generalize to broader populations. The intervention lasted only four weeks and no long-term follow-up was conducted to confirm whether the observed improvements were sustained. Objective biomechanical assessments such as electromyography, force-platform analysis or three-dimensional motion analysis were also not included, which might have offered further insight into the underlying neuromuscular mechanisms. Assessors were not blinded to allocation and adherence, though logged, was not reported as a formal outcome. These constraints should be borne in mind when interpreting the results.

Acknowledgement

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Ethical Approval

The study was approved by the Institutional Scientific Review Board (Approval No: 043/05/2025/ISRB/PGSR/SCPT).

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