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Effectiveness of Fascial Distortion Model Versus Instrument-Assisted Soft Tissue Mobilization Combined with Balance Strength Training in Improving Balance and Range of Motion among Individuals with Chronic Ankle Instability: A Comparative Experimental Study

Sureshkumar AR[1], Yalene D[2], Dr. Franklin Shaju MK[3] and Dr. Premkumar M[4]*

[1]*Post Graduate Student, Master of Physiotherapy, RVS College of Physiotherapy, Affiliated to The TN Dr. MGR Medical University, Chennai, RVS Health Science Campus, 242-B, Trichy Road, Sulur, Coimbatore, Tamilnadu, India. ORCID ID: 0009-0005-2288-3427.*

[2]*Assistant Professor, RVS College of Physiotherapy, Affiliated to The TN Dr. MGR Medical University, Chennai, RVS Health Science Campus, 242-B, Trichy Road, Sulur, Coimbatore, Tamilnadu, India.*

[3]*Professor & Professor, RVS College of Physiotherapy, Affiliated to The TN Dr. MGR Medical University, Chennai, RVS Health Science Campus, 242-B, Trichy Road, Sulur, Coimbatore, Tamilnadu, India.*

[4]*Professor cum HOD, Institute of Physiotherapy, Srinivas University, City Campus, Pandeshwar, Mangaluru, Karnataka, India. ORCID ID: 0000-0001-6182-2014.*

***Correspondence:**

M. Premkumar, Professor cum HOD, Institute of Physiotherapy, Srinivas University, City Campus, Pandeshwar, Mangalore, Karnataka, India.

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ABSTRACT

Background: *Chronic ankle instability (CAI) is common sequelae of lateral ankle sprains characterized by recurrent episodes of giving way, impaired proprioception, reduced balance, neuromuscular deficits, and restricted ankle dorsiflexion range of motion (ROM). Approximately one-third of individuals sustaining an ankle sprain develop persistent instability and functional limitations. Current rehabilitation approaches emphasize neuromuscular training, balance exercises, and manual therapy interventions. Fascial Distortion Model (FDM) and Instrument-Assisted Soft Tissue Mobilization (IASTM) are increasingly used in clinical practice; however, evidence directly comparing these interventions in CAI remains limited.*

Objective of this Study: *To compare the effectiveness of Fascial Distortion Model combined with Balance Strength Training (BST) and Instrument-Assisted Soft Tissue Mobilization combined with Balance Strength Training in improving balance and ankle dorsiflexion ROM among individuals with chronic ankle instability.*

Materials and Methods: *A comparative pre-test and post-test experimental study was conducted among 40 participants with chronic ankle instability. Participants were allocated into two groups (n=20 each). Group A received Fascial Distortion Model and Balance Strength Training, while Group B received Instrument-Assisted Soft Tissue Mobilization and Balance Strength Training. The intervention was administered for four weeks. Balance was assessed using the Flamingo Balance Test, and ankle dorsiflexion ROM was measured using a universal goniometer. Statistical analysis was performed using paired and unpaired t-tests.*

Results: *Both groups demonstrated statistically significant improvements in balance and ankle dorsiflexion ROM following intervention ($p<0.005$). Group A exhibited greater improvement in balance compared with Group B (mean difference 6.25 vs. 4.25; $t=3.782$). Significant improvements in ankle dorsiflexion ROM were also observed, with between-group analysis favoring Group A ($t=3.944$).*

Conclusion: *Both interventions effectively improved balance and ankle dorsiflexion ROM in individuals with chronic ankle instability. However, Fascial Distortion Model combined with Balance Strength Training demonstrated superior clinical outcomes and may represent a more effective rehabilitation strategy for individuals with CAI.*

Keywords
Chronic ankle instability, Fascial Distortion Model, Instrument-Assisted Soft Tissue Mobilization, Balance training, Ankle dorsiflexion, Rehabilitation, Manual therapy.

Introduction
Lateral ankle sprain is one of the most frequently encountered musculoskeletal injuries among athletes and physically active individuals. Despite appropriate acute management, approximately 30–40% of individuals who sustain an ankle sprain subsequently develop chronic ankle instability (CAI), a condition characterized by recurrent episodes of giving way, repeated sprains, pain, impaired balance, proprioceptive deficits, neuromuscular dysfunction, and reduced functional performance [1,2]. CAI represents a substantial clinical challenge because it not only affects athletic participation but also influences activities of daily living, quality of life, and long-term joint health.

The concept of functional instability following ankle injury was initially described by Freeman et al., who proposed that recurrent ankle instability is strongly associated with impaired proprioception resulting from damage to ligamentous mechanoreceptors [3]. Hertel later expanded this concept by introducing a comprehensive model explaining CAI as a multifactorial condition involving both mechanical insufficiencies and functional deficits [4]. More recently, Hertel and Corbett updated this model, emphasizing the interaction between sensory, motor, and mechanical dysfunctions contributing to persistent instability and recurrent injury risk [5].

The International Ankle Consortium has established diagnostic criteria and research recommendations for individuals with CAI, highlighting its prevalence and long-term consequences [1,2]. According to the Consortium, deficits in proprioception, postural control, neuromuscular function, and joint mobility are central features of the condition. These impairments contribute to altered movement strategies during dynamic activities such as cutting, landing, and jumping, increasing susceptibility to reinjury [6].

Ankle proprioception plays a critical role in maintaining balance and postural stability. Han et al. reported that proprioceptive deficits are strongly associated with impaired balance control and reduced athletic performance [7]. Consequently, rehabilitation programs targeting proprioceptive and neuromuscular function have become a cornerstone of CAI management. Casanova et al. demonstrated through systematic review and meta-analysis that balance training significantly improves functionality, ankle stability, and dynamic balance outcomes in individuals with chronic ankle instability [8].

Balance assessment is essential in both clinical practice and research. The Flamingo Balance Test has been widely used as a reliable and valid measure of static balance and postural control [9,10]. Previous investigations have shown that balance impairments are strongly associated with recurrent ankle instability and reduced functional performance. Therefore, improvements in balance represent an important rehabilitation outcome.

In addition to balance deficits, restricted ankle dorsiflexion ROM is commonly observed among individuals with CAI. Limited dorsiflexion contributes to altered gait mechanics, reduced shock absorption, compensatory movement patterns, and increased injury risk. Joint mobility assessment through standardized goniometric measurement remains an important component of clinical evaluation [11,12].

Manual therapy interventions have gained increasing attention as adjuncts to conventional exercise-based rehabilitation. One such approach is the Fascial Distortion Model (FDM), developed by Typaldos [13]. FDM proposes that musculoskeletal dysfunction results from six specific fascial distortions affecting movement quality, tissue mobility, and proprioceptive function. Treatment focuses on correcting these distortions through targeted manual therapy techniques. Anker demonstrated acceptable inter-rater reliability in identifying body-language patterns associated with fascial distortions, supporting the clinical applicability of FDM assessment [14].

Recent studies have reported beneficial effects of FDM on musculoskeletal disorders. Lee and Kim demonstrated improvements in proprioception, dynamic balance, and isometric strength among individuals with chronic ankle instability treated using FDM [15]. Similarly, Kovacs et al. reported favorable outcomes among athletes with chronic ankle instability following FDM intervention [16]. Mazzone et al. further demonstrated the clinical effectiveness of FDM in the treatment of ankle sprains [17]. Contemporary fascial research also supports the role of fascia in force transmission, movement coordination, and proprioceptive regulation [18,19].

Instrument-Assisted Soft Tissue Mobilization (IASTM) represents another commonly utilized manual therapy technique. IASTM involves the use of specialized instruments to mobilize soft tissues, improve tissue extensibility, reduce adhesions, and facilitate tissue remodeling. Systematic reviews have reported positive effects of IASTM on mobility, flexibility, and musculoskeletal function [20,21]. Ikeda et al. demonstrated significant changes in

musculoskeletal properties following IASTM intervention [22], while Park and Rhi reported improvements in ROM, strength, and balance among taekwondo athletes with chronic ankle instability [23]. Kim et al. also demonstrated improvements in ankle stiffness and dynamic balance following IASTM treatment [24].

Although both FDM and IASTM have demonstrated therapeutic benefits, comparative evidence evaluating these interventions in individuals with chronic ankle instability remains scarce. Therefore, this study aimed to compare the effectiveness of Fascial Distortion Model combined with Balance Strength Training and Instrument-Assisted Soft Tissue Mobilization combined with Balance Strength Training in improving balance and ankle dorsiflexion ROM among individuals with chronic ankle instability.

Material and Methods

Study Design

A comparative pre-test and post-test experimental study was conducted at the Outpatient Department of RVS College of Physiotherapy, Sulur, Coimbatore, Tamil Nadu, India. The study duration was four weeks.

Ethical Approval

The study protocol was approved by the Institutional Ethics Committee of RVS College of Physiotherapy, Sulur, Coimbatore, Tamil Nadu, India (Ref. No. EC/RVS/79/2024). All procedures were conducted according to the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment.

Participants

A total of 40 participants diagnosed with chronic ankle instability were recruited and allocated equally into two groups.

Table 1: Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
Age 20–40 years	Acute ankle injury
Ankle pain >3 months	Recent fracture
Recurrent ankle sprains	Lower limb surgery
Reduced ankle ROM	Neurological disorders
Independent ambulation	Pregnancy
Willingness to participate	Osteoporosis or malignancy

Participant Allocation

- Group A (n=20): Fascial Distortion Model + Balance Strength Training
- Group B (n=20): Instrument-Assisted Soft Tissue Mobilization + Balance Strength Training

Outcome Measures

Primary Outcome

Flamingo Balance Test [9,10]

Secondary Outcome

Ankle dorsiflexion range of motion measured using a universal goniometer according to standardized procedures [11,12].

CONSORT Flow Diagram

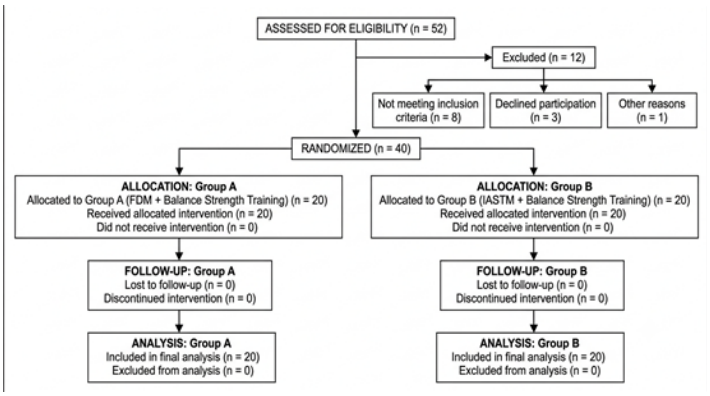

Figure 1: Presents participant recruitment, allocation, follow-up, and analysis.

Interventions

Group A: Fascial Distortion Model

Participants received FDM treatment based on principles described by Typaldos [13]. Treatment focused primarily on trigger-band and continuum distortions identified through patient body language, palpation findings, and movement assessment [14].

Figure 2: Fascial Distortion Model treatment applied to the lateral ankle region.

Group B: Instrument-Assisted Soft Tissue Mobilization

Participants received IASTM using a stainless-steel instrument applied to the lateral ankle and calf musculature according to established procedures [20-22].

Balance Strength Training Program

Both groups received:

- Standing calf raises
- Resisted dorsiflexion exercises
- BOSU-ball balance training

Figure 3: Fascial Distortion Model correction of fascial distortions along the distal leg and ankle complex.

Training was administered twice daily, three sets per session, ten repetitions per set for four weeks.

Statistical Analysis

Data were analyzed using descriptive and inferential statistics. Paired t-tests assessed within-group changes, while unpaired t-tests compared outcomes between groups. Statistical significance was established at $p<0.005$.

Results

A total of 40 participants with chronic ankle instability completed the study. No participant was lost during follow-up, and all participants were included in the final statistical analysis. Baseline demographic and clinical characteristics were comparable between groups, indicating homogeneity at study commencement.

Baseline Characteristics

Table 2: Baseline Characteristics of Participants.

Variable	Group A (FDM + BST) (n=20)	Group B (IASTM + BST) (n=20)	p-value
Sample Size	20	20	-
Age Range (Years)	20–40	20–40	>0.05
Gender Distribution	Comparable	Comparable	>0.05
Duration of Symptoms	Comparable	Comparable	>0.05
Affected Side	Comparable	Comparable	>0.05

No statistically significant differences were observed between groups at baseline ($p>0.05$), confirming comparability of participant characteristics before intervention.

Balance Outcomes

Balance performance was assessed using the Flamingo Balance Test. Both intervention groups demonstrated significant improvements following the four-week rehabilitation program.

Both groups demonstrated statistically significant improvements in balance following intervention. The reduction in Flamingo Balance Test scores indicates improved postural stability and neuromuscular control.

The between-group comparison demonstrated significantly greater improvement in balance among participants receiving Fascial Distortion Model combined with Balance Strength Training compared with participants receiving Instrument-Assisted Soft Tissue Mobilization combined with Balance Strength Training.

Ankle Dorsiflexion Range of Motion Outcomes

Ankle dorsiflexion ROM was measured using a universal goniometer. Significant improvements were observed in both intervention groups.

Between-group analysis revealed a statistically significant difference favoring the Fascial Distortion Model intervention.

Discussion

The present study compared the effectiveness of Fascial Distortion Model (FDM) combined with Balance Strength Training (BST) and Instrument-Assisted Soft Tissue Mobilization (IASTM) combined with Balance Strength Training in individuals with chronic ankle instability (CAI). The findings demonstrated that both interventions significantly improved balance and ankle dorsiflexion range of motion (ROM); however, participants receiving FDM exhibited superior overall clinical outcomes.

Chronic ankle instability is recognized as a multifactorial condition involving both mechanical insufficiencies and functional deficits. Hertel initially described CAI as a condition resulting from interactions between ligamentous injury, neuromuscular dysfunction, proprioceptive deficits, and postural instability [4]. The updated model proposed by Hertel and Corbett further emphasized the complex interplay between sensory, motor, and

Table 3: Within-Group Comparison of Balance Performance.

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	t-value	p-value
Group A (FDM + BST)	11.55 ± 3.35	5.30 ± 1.86	6.25	8.333	<0.005*
Group B (IASTM + BST)	10.70 ± 2.60	5.35 ± 1.84	5.35	9.198	<0.005*

*Statistically significant

Between-Group Comparison of Balance Improvement

Table 4: Between-Group Comparison of Balance Outcomes.

Outcome Measure	Group A Mean Difference	Group B Mean Difference	t-value	p-value
Flamingo Balance Test	6.25 ± 2.25	4.25 ± 1.08	3.782	<0.005*

*Statistically significant

Table 5: Within-Group Comparison of Ankle Dorsiflexion Range of Motion

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	t-value	p-value
Group A (FDM + BST)	12.55 ± 1.83°	19.85 ± 1.95°	7.30°	17.760	<0.005*
Group B (IASTM + BST)	9.90 ± 1.70°	18.40 ± 1.79°	8.50°	22.342	<0.005*

*Statistically significant

Significant increases in ankle dorsiflexion ROM were observed in both groups following the intervention period.

Between-Group Comparison of Ankle Dorsiflexion ROM

Outcome Measure	Group A Improvement	Group B Improvement	t-value	p-value
Dorsiflexion ROM	7.30°	8.50°	3.944	<0.005*

*Statistically significant

mechanical impairments contributing to persistent instability [5]. The findings of the present study support this model, as interventions targeting both soft tissue function and neuromuscular control produced significant improvements in clinical outcomes.

One of the primary findings of the study was the significant improvement in balance performance observed in both intervention groups. Balance deficits are a hallmark feature of chronic ankle instability and contribute substantially to recurrent sprains and functional limitations [1,2]. Previous investigations have identified impaired proprioceptive feedback and delayed neuromuscular responses as major contributors to postural instability among individuals with CAI [3,7]. The significant improvements observed in the present study likely reflect enhanced proprioceptive function and improved neuromuscular control resulting from the rehabilitation program.

The positive outcomes observed in both groups may be partially attributed to the Balance Strength Training program. Casanova et al. demonstrated through systematic review and meta-analysis that balance training significantly improves functionality, dynamic balance, and ankle stability in individuals with chronic ankle instability [8]. Similarly, current clinical practice guidelines strongly recommend balance and neuromuscular training as essential components of CAI rehabilitation [25]. The inclusion of BOSU-ball exercises, calf raises, and resisted dorsiflexion exercises in the present study likely contributed substantially to the observed improvements.

Despite improvements in both groups, the FDM group demonstrated significantly greater balance enhancement. This finding is consistent with previous reports supporting the effectiveness of Fascial Distortion Model interventions. Typaldos proposed that specific fascial distortions disrupt normal biomechanics and proprioceptive signaling, leading to pain and functional impairment [13]. Correction of these distortions through targeted manual therapy may restore normal movement patterns and improve neuromuscular efficiency.

The superior balance outcomes observed in the FDM group may also be explained by the growing understanding of fascial tissues as sensory organs. Degenhardt et al. highlighted the role of fascial continuity in force transmission and proprioceptive regulation [18]. Paoletti similarly emphasized the importance of fascial structures in movement coordination and mechanical integration throughout the musculoskeletal system [19]. By restoring fascial mobility, FDM may facilitate improved sensory feedback and postural control.

The present findings are consistent with previous clinical studies evaluating FDM interventions. Lee and Kim reported significant improvements in dynamic balance, proprioception, muscle strength, and ankle function among individuals with chronic ankle instability following FDM treatment [15]. Similarly, Kovacs et al. demonstrated positive outcomes among athletes with CAI treated using Fascial Distortion Model techniques [16]. Mazzone et al. also reported significant functional improvements following FDM treatment in individuals with ankle sprains [17]. More recently, Kweon and Kim demonstrated immediate improvements in balance and range of motion following FDM intervention in healthy adults [26].

The significant improvements observed in ankle dorsiflexion ROM further support the effectiveness of both interventions. Restricted dorsiflexion is commonly observed among individuals with chronic ankle instability and has been associated with altered gait patterns, reduced shock absorption, compensatory movement strategies, and increased injury risk [11,12]. Improvement in dorsiflexion ROM is therefore considered a clinically meaningful outcome.

The increase in ROM observed in the FDM group may be explained by improved fascial extensibility and reduced soft tissue restrictions. Fascial distortions may contribute to abnormal tension patterns limiting joint mobility. Correction of these distortions may restore tissue mobility and improve joint excursion. The findings of the present study align with those of Kweon and Kim, who reported significant improvements in ROM following FDM intervention [26].

Participants receiving IASTM also demonstrated significant improvements in ROM and balance. These findings are consistent with previous evidence supporting the effectiveness of instrument-assisted soft tissue mobilization. Cheatham et al. reported positive effects of IASTM on mobility, pain reduction, and musculoskeletal function [20]. Similarly, LaFond and Vardiman concluded that

IASTM represents an effective rehabilitation intervention for improving soft tissue mobility and functional outcomes [21].

The physiological mechanisms underlying IASTM may include stimulation of fibroblast activity, increased local circulation, disruption of adhesions, and enhanced tissue remodeling. Ikeda et al. demonstrated significant alterations in musculoskeletal properties following IASTM intervention [22]. Park and Rhi further reported improvements in ROM, balance, and isokinetic strength among taekwondo athletes with chronic ankle instability treated using IASTM [23]. Kim et al. also demonstrated improvements in ankle stiffness and dynamic balance following IASTM treatment [24]. These findings support the beneficial outcomes observed in the present investigation.

Although both interventions were effective, the superior outcomes observed in the FDM group suggest that addressing fascial dysfunction may provide additional therapeutic benefits beyond those achieved through conventional soft tissue mobilization. Fascial manipulation may influence both mechanical and sensory components of movement control, thereby enhancing postural stability and functional performance.

The present findings have important clinical implications. Chronic ankle instability remains a prevalent condition associated with recurrent injury and reduced functional capacity. Rehabilitation strategies capable of improving balance, proprioception, and ankle mobility may reduce recurrence rates and facilitate return to sport. The findings suggest that clinicians may consider incorporating Fascial Distortion Model interventions into comprehensive rehabilitation programs for individuals with CAI.

Nevertheless, several limitations should be acknowledged. The sample size was relatively small and participants were recruited from a single clinical setting. Long-term follow-up was not performed, limiting conclusions regarding sustained treatment effects. Furthermore, patient-reported outcome measures and advanced biomechanical assessments were not included. Future studies should incorporate larger multicenter samples, long-term follow-up assessments, and objective biomechanical analyses to further evaluate the effectiveness of FDM and IASTM interventions.

Clinical Implications

1. Fascial Distortion Model can be effectively integrated into rehabilitation programs for chronic ankle instability.
2. Balance Strength Training remains an essential component of evidence-based CAI management.
3. Improvement in ankle dorsiflexion ROM may reduce injury recurrence and improve functional performance.
4. FDM may provide superior proprioceptive and neuromuscular benefits compared with IASTM.
5. Both interventions may facilitate return to sport and daily activities.

Strengths

- Comparative evaluation of two commonly used manual therapy interventions.
- Inclusion of functional balance and ROM outcomes.
- Standardized rehabilitation protocol across groups.
- Complete participant retention throughout the study.
- Clinical applicability to routine physiotherapy practice.

Limitations

- Small sample size.
- Single-center study.
- Short intervention duration.
- Lack of long-term follow-up.
- Absence of patient-reported outcome measures.
- No biomechanical or electromyographic assessment.

Future Recommendations

- Conduct multicenter randomized controlled trials.
- Include larger sample sizes.
- Perform long-term follow-up assessments.
- Investigate biomechanical and neuromuscular mechanisms underlying FDM.
- Include functional outcome scales and quality-of-life measures.

Conclusion

Both Fascial Distortion Model combined with Balance Strength Training and Instrument-Assisted Soft Tissue Mobilization combined with Balance Strength Training significantly improved balance and ankle dorsiflexion range of motion among individuals with chronic ankle instability. However, Fascial Distortion Model demonstrated superior effectiveness in improving functional outcomes. The findings suggest that fascial-focused interventions may enhance rehabilitation outcomes when incorporated into comprehensive evidence-based management programs for chronic ankle instability.

Summary of Findings

The principal findings of the study can be summarized as follows:

1. Both intervention groups demonstrated statistically significant improvements in balance following four weeks of treatment.
2. Both intervention groups demonstrated statistically significant improvements in ankle dorsiflexion range of motion.
3. Participants receiving Fascial Distortion Model combined with Balance Strength Training exhibited greater improvement in balance compared with participants receiving Instrument-Assisted Soft Tissue Mobilization combined with Balance Strength Training.
4. Between-group analysis demonstrated significant superiority of the Fascial Distortion Model intervention.
5. No adverse events were reported during the intervention period.

Clinical Summary

The findings of the present study indicate that both Fascial Distortion Model and Instrument-Assisted Soft Tissue Mobilization are effective adjuncts to conventional Balance Strength Training in the rehabilitation of chronic ankle instability.

Although both interventions improved balance and ankle mobility, the Fascial Distortion Model produced superior clinical outcomes. This suggests that correction of fascial distortions may enhance proprioceptive function, neuromuscular control, and movement efficiency beyond that achieved through soft tissue mobilization alone.

From a clinical perspective, rehabilitation programs for chronic ankle instability should continue to prioritize balance-strength training while considering the incorporation of fascial-focused interventions such as FDM. Improved balance and dorsiflexion ROM may reduce recurrence risk, improve functional performance, and facilitate return to sport and daily activities.

Key Clinical Messages

- Both interventions are clinically effective.
- Balance-strength training remains a cornerstone of CAI rehabilitation.
- Fascial Distortion Model demonstrated superior overall outcomes.
- Improved balance may reduce recurrent ankle sprains.
- Enhanced dorsiflexion ROM may improve functional movement patterns.
- FDM may be considered a preferred manual therapy adjunct in patients with chronic ankle instability.

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