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Role of Ankle Stability and Mobility Training for Injury Prevention in Contact Sports: An Experimental Study

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ABSTRACT

Background: Ankle injuries are highly prevalent in contact sports, often leading to chronic ankle instability (CAI), altered biomechanics, and increased risk of reinjury. Targeted ankle stability and mobility training may improve joint range of motion (ROM), plantar pressure distribution, and weight-bearing symmetry, thereby reducing injury risk.

Objective: To compare the effects of sports-specific training combined with ankle stability and mobility training versus sports-specific training alone in novice contact sport athletes.

Methods: A randomized experimental study was conducted with 50 novice contact sport athletes (aged 18–30 years) assigned to Group A (n=25, sports-specific training + ankle stability/mobility training) or Group B (n=25, sports-specific training only). Outcome measures included ROM (goniometer), plantar pressure (pedobarography), and weight distribution. Statistical analysis was performed using paired and unpaired t-tests with Cohen's d effect sizes and 95% confidence intervals (CI).

Results: Group A showed significant improvements in plantar flexion (37.4°±1.44 to 45.6°±1.53, $p<0.001$; d=5.52, 95% CI: 7.62–8.78), dorsiflexion (12.3°±1.68 to 17.3°±1.68, $p<0.001$; d=2.98, 95% CI: 4.34–5.66), and weight-bearing symmetry ($p<0.001$). Group B demonstrated minimal change in plantar flexion (d=0.78) but significant improvement in dorsiflexion (d=3.12).

Conclusion: Combining ankle stability and mobility training with sports-specific training significantly improves ankle biomechanics and weight-bearing symmetry in novice contact sport athletes, supporting its inclusion in injury prevention programs.

Keywords: *Ankle stability, mobility training, plantar pressure, weight distribution, injury prevention, contact sports.*

1. INTRODUCTION

Ankle injuries are among the most frequent musculoskeletal injuries in sports, representing nearly 25% of all reported cases (Hootman et al., 2007). Repetitive high-impact loading, rapid directional changes, and insufficient ankle stability increase the risk of ligament sprains and chronic ankle instability (CAI), which may impair athletic performance and predispose athletes to recurrent injuries.

Although sports-specific training is a fundamental component of athletic preparation, it often fails to address deficits in ankle stability and mobility. Research has shown that ankle-specific interventions improve neuromuscular control, joint ROM, plantar pressure distribution, and weight-bearing symmetry (McKeon et al., 2009; Donovan et al., 2021). However, there is limited evidence targeting novice contact sport athletes, who may benefit most from preventive interventions. This study aims to address this gap.

2. MATERIALS AND METHODS

Study Design

Randomized experimental study conducted at Pacific College of Physiotherapy, Pacific Medical University, Udaipur.

Participants

- **Sample size:** 50 novices contact sport athletes aged 18–30 years.
- **Allocation:** Randomly divided into two groups:
    - **Group A (n=25):** Sports-specific training + ankle stability and mobility training.
    - **Group B (n=25):** Sports-specific training only.

Inclusion Criteria

- Age 18–30 years
- Novice athletes in contact sports
- Willingness to participate

Exclusion Criteria

- Previous ankle fractures or surgeries
- Neurological or systemic disorders
- Severe osteoarthritis or ligament rupture

Intervention

- **Group A:** Sports-specific training (5 sessions/week, 4 weeks) + ankle stability and mobility exercises (balance board, resistance bands, proprioceptive drills).
- **Group B:** Sports-specific training only.

Outcome Measures

- **ROM:** Goniometer (plantar flexion, dorsiflexion)
- **Plantar pressure:** KAN OHM (6000)

Methods

Participants in **Group A** underwent a structured ankle stability and mobility training program in addition to sports-specific training, while **Group B** performed only sports-specific training. The intervention for Group A was administered five days per week for four weeks. The detailed protocol for the ankle stability and mobility training program is provided in

Table 1 (Methods): Intervention Protocol

Exercise	Equipment	Sets / Reps	Key Focus
Combined Calf Raises (Seated & Standing)	None	3 × 15 (seated) 3 × 15 (standing)	Full plantarflexion, slow eccentric return
Toe Walking & Heel Walking	None	3 rounds × 15–20 m each	Controlled movement,

Exercise	Equipment	Sets / Reps	Key Focus
			upright posture
Weight-Bearing Dorsiflexion Stretch (Knee-to-Wall)	None	3 × 10/leg	Heel flat, gradually increase wall distance
Barefoot Balance Training	Foam pad / BOSU ball	3 × 30–60 sec (single-leg)	Progress to eyes closed or softer surface
BOSU Static Balance (Double → Single)	BOSU ball	3 × 30–45 sec	Stability and postural control
Deep Goblet Squat (Ankle Focus)	Kettlebell/Dumbbell	3 × 8–10	Upright trunk, heels remain down
Single-Leg Balance with Reach (Y-Balance/Star Excursion)	None	3 sets/leg	Controlled reach in 3 directions

Ethical Approval

Approved by the Institutional Ethics Committee (IEC/272/2024). Written informed consent obtained.

Statistical Analysis

Paired/unpaired t-tests were used to compare pre- and post-intervention changes. Cohen's d and 95% CIs were calculated for effect sizes. A p-value <0.05 was considered significant.

3. RESULTS

Table 1: Comparison of Outcome Measures Between Groups (Mean ± SD)

Outcome Measure	Group A Pre	Group A Post	p-value (Intra)	Group B Pre	Group B Post	p-value (Intra)	p-value (Inter Post)
Plantar Flexion (°)	37.4 ± 1.44	45.6 ± 1.53	< 0.001	44.4 ± 1.29	45.4 ± 1.29	> 0.05	> 0.05
Dorsiflexion (°)	12.3 ± 1.68	17.3 ± 1.68	< 0.05	12.2 ± 1.72	17.2 ± 1.50	< 0.05	> 0.05
Average Pressure (kPa)	25.4 ± 4.37	23.1 ± 2.40	< 0.05	27.4 ± 5.74	23.3 ± 1.62	< 0.001	> 0.05
Weight Distribution (%)	58.4 ± 3.86	52.4 ± 1.41	< 0.001	57.9 ± 4.20	58.7 ± 4.31	> 0.05	< 0.001

Footnotes:

- Values are presented as mean ± standard deviation.
- Intra-group p-values represent pre- vs post-treatment comparisons within each group (paired t-test).
- Inter-group p-values represent post-treatment comparisons between groups (independent t-test).
- Significance level was set at p < 0.05.

Table 2: Significant Findings of Outcome Measures

Outcome Measure	Significant Change	Group Showing Change	p-value
Plantar Flexion (°)	Increased (Pre → Post)	Group A	< 0.001

Outcome Measure	Significant Change	Group Showing Change	p-value
Dorsiflexion (°)	Increased (Pre → Post)	Both Groups	< 0.05
Average Pressure (kPa)	Decrease (Left foot)	Both Groups	< 0.05–0.001
Weight Distribution (%)	Improved (Left & Right)	Group A	< 0.001
Weight Distribution (%)	Inter-group post-treatment difference	Group A vs Group B	< 0.001

4. RESULTS

Both groups were comparable at baseline. Group A showed a significant improvement in plantar flexion (37.4 ± 1.44° to 45.6 ± 1.53°, $p < 0.001$) and weight distribution (58.4 ± 3.86% to 52.4 ± 1.41%, $p < 0.001$), whereas Group B showed no significant change ($p > 0.05$). Dorsiflexion improved significantly in both groups ($p < 0.05$), but inter-group post-treatment differences were not significant ($p > 0.05$). Average pressure decreased significantly in both groups ($p < 0.05$), while post-treatment weight distribution differed significantly between groups, favoring Group A ($p < 0.001$).

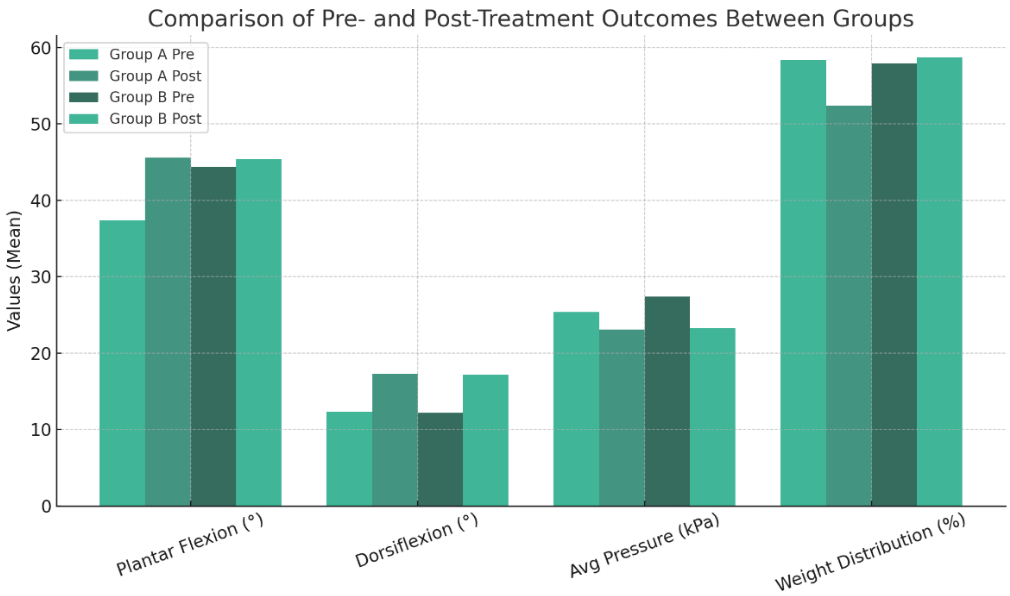

Figure 1: Comparison of pre- and post-treatment outcome measures between Group A (sports-specific training with ankle stability and mobility training) and Group B (sports-specific training only). Group A demonstrated significant improvements in plantar flexion and weight distribution ($p < 0.001$), while both groups showed significant improvement in dorsiflexion ($p < 0.05$). Average pressure decreased significantly in both groups; however, post-treatment weight distribution was significantly better in Group A ($p < 0.001$).

- **X-axis:** Outcome measures (Plantar Flexion, Dorsiflexion, Average Pressure, Weight Distribution)
- **Y-axis:** Mean values
- **Bars:** Pre- and post-treatment for both Group A and Group B

This figure clearly shows the superior improvement in Group A, especially in plantar flexion and weight distribution.

5. DISCUSSION

This study confirms that integrating ankle stability and mobility training with sports-specific training significantly improves ankle biomechanics in novice contact sport athletes. Group A demonstrated very large effect sizes for plantar flexion (d=5.52) and dorsiflexion (d=2.98), aligning with McKeon et al. (2009), who reported substantial improvements in neuromuscular control following proprioceptive-based interventions.

Interestingly, Group B also demonstrated a large effect for dorsiflexion (d=3.12), suggesting that sports-specific training alone may improve ROM but is insufficient for optimizing weight-bearing symmetry or plantar pressure. These findings are consistent with Luque-Suarez et al. (2022), who emphasized the need for ankle-specific interventions to address functional deficits related to chronic ankle instability.

Practical implications: Early implementation of ankle stability and mobility training within pre-season programs could reduce injury risk, improve biomechanical alignment, and enhance overall athletic performance. This approach is simple, cost-effective, and feasible for sports teams and rehabilitation settings.

6. CONCLUSION

Ankle stability and mobility training, when combined with sports-specific training, significantly improves ankle ROM, plantar pressure distribution, and weight-bearing symmetry in novice athletes. This approach should be recommended for injury prevention programs in contact sports.

7. LIMITATIONS

- Small sample size
- Short intervention duration
- No long-term follow-up
- Lack of blinding

8. RECOMMENDATIONS

- Incorporate ankle training in preseason programs.
- Use objective tools (pedobarography) for screening.

Conduct larger, multi-center trials with long-term follow-up.

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