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Proprioceptive Training on Ankle Stability and Balance in Athletes with Recurrent Ankle Sprain Effectiveness

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ABSTRACT

Background

Repeated episodes of ankle injury may interfere with neuromuscular coordination and increase susceptibility to subsequent injury. Proprioceptive training is commonly incorporated into sports rehabilitation because it challenges joint-position awareness, balance, muscular coordination, and dynamic postural control. Recurrent ankle sprain is a frequently encountered sports-related musculoskeletal condition that may result in persistent ankle instability, impaired proprioception, deficient postural control, and reduced functional performance.

Aim

To determine the effect of proprioceptive training on ankle stability and balance in athletes with recurrent ankle sprain.

Methods

A two-arm, parallel-group experimental study was planned over a four-month period among 110 athletes with a history of recurrent ankle sprain. Participants meeting the predetermined eligibility criteria were randomly allocated into a proprioceptive-training group (n=55) or a conventional-exercise/control group (n=55). The intervention consisted of structured proprioceptive and balance exercises, including single-leg stance, weight shifting, unstable-surface activities, balance-board exercises, reaching activities, perturbation exercises, and progressive sport-specific balance tasks. Outcome assessment included the Cumberland Ankle Instability Tool (CAIT), Balance Error Scoring System (BESS), Y-Balance Test, and Foot and Ankle Ability Measure (FAAM). Assessments were performed before and after the intervention. Statistical analysis was planned using appropriate parametric or non-parametric tests according to data distribution, with statistical significance established at $p<0.05$.

Results

The illustrative pre- and post-intervention values supplied for the study indicate improvement in ankle stability, static balance, dynamic balance, and functional performance following proprioceptive training. CAIT scores increased from 18.4±3.2 to 26.1±2.7, while BESS scores decreased from 22.6±5.1 to 14.3±4.2. Y-Balance Test performance improved across the anterior, posteromedial, and posterolateral directions. FAAM-ADL scores increased from 78.6±8.4% to 91.5±6.2%, and FAAM-Sports scores increased from 69.8±10.1% to 87.6±7.8%. These values are illustrative and should not be interpreted as actual statistically verified findings until participant-level data are analyzed.

Conclusion

A structured proprioceptive-training programme may be useful for improving ankle stability, balance, and functional performance in athletes with recurrent ankle sprain. Incorporating progressive proprioceptive and balance exercises into sports physiotherapy rehabilitation may help address persistent neuromuscular deficits associated with recurrent ankle instability.

Keywords: Proprioceptive training; recurrent ankle sprain; chronic ankle instability; ankle stability; balance; Y-Balance Test; CAIT; FAAM; athletes; sports physiotherapy.

INTRODUCTION

Ankle sprain is one of the most common musculoskeletal injuries encountered in sports and physically active populations. It frequently occurs during running, jumping, landing, rapid acceleration, deceleration, pivoting, and sudden changes in direction. Excessive inversion or other movements beyond the physiological range may place substantial stress on the ankle ligaments, particularly the lateral ligament complex. Although many athletes recover following an initial injury, a considerable proportion experience recurrent sprains and persistent symptoms that may affect athletic participation and performance.

Recurrent ankle sprain may be accompanied by pain, swelling, weakness, restricted movement, impaired balance, altered proprioception, and a subjective sensation of the ankle giving way. Repeated injury may influence both mechanical and functional components of ankle stability. Mechanical instability is related primarily to structural insufficiency or laxity of ligamentous structures, whereas functional instability involves impaired neuromuscular control, proprioceptive deficits, weakness, and reduced postural stability[1]

The ankle complex plays an important role in maintaining the body's interaction with the ground. During standing and dynamic activities, the ankle must continuously adapt to changes in body position and external forces. Ligaments and other passive structures provide mechanical support, while muscles surrounding the ankle contribute to dynamic stabilization. Sensory information from muscles, tendons, ligaments, joints, and skin is integrated by the central nervous system to assist in maintaining posture and coordinating movement.

Proprioception refers to the capacity to perceive joint position and movement. It is an important component of sensory-motor control and contributes to balance, coordination, and functional movement. Injury to ligamentous and surrounding tissues may interfere with normal sensory input. Pain, swelling, weakness, restricted movement, and muscle inhibition may further influence proprioceptive and neuromuscular responses.

Athletes with recurrent ankle sprain may consequently demonstrate impaired single-leg balance and difficulty controlling the lower limb during dynamic tasks. These impairments may become particularly evident during landing, cutting, jumping, or rapid changes in direction. Such movements are common in sports including football, basketball, volleyball, badminton, tennis, handball, and athletics[2].

Balance is another important component of functional ankle stability. Static balance involves maintaining a stable position with minimal movement, whereas dynamic balance involves controlling the body during movement. Athletic performance requires both forms of balance. A deficit in dynamic balance may affect the athlete's ability to control the centre of mass over the supporting limb during high-demand activities.

Following ankle injury, athletes may also develop compensatory movement strategies. An individual may modify foot position, landing technique, or lower-limb movement to avoid instability or discomfort. Although these adaptations may initially be protective, persistent alterations may influence movement efficiency and increase stress on other structures of the lower extremity[3].

Proprioceptive training is therefore frequently incorporated into ankle rehabilitation. It consists of exercises that challenge joint-position awareness, postural control, balance, neuromuscular coordination, and the ability to respond to external disturbances. Training may begin with simple single-leg standing and weight-shifting exercises and progress toward unstable-surface activities, reaching tasks, perturbations, hopping, landing, and sport-specific movements.

Several mechanisms may explain the potential effects of proprioceptive training. Repeated balance challenges may increase the ability of the nervous system to integrate sensory information and generate appropriate motor responses. Training may also facilitate more effective activation of muscles responsible for dynamic ankle stabilization. The peroneal musculature, for example, contributes to resisting excessive inversion and maintaining lateral ankle control.

Proprioceptive exercises may additionally influence the entire lower-extremity kinetic chain. During single-leg activities, the foot, ankle, knee, and hip must coordinate to maintain the body's centre of mass over the supporting limb. Therefore, improvements in postural control may extend beyond the ankle itself.

Assessment of athletes with recurrent ankle sprain should ideally include measures of perceived instability, postural control, functional ability, and sport-related performance. The Cumberland Ankle Instability Tool is commonly used to evaluate perceived ankle instability. The Balance Error Scoring System can be used to assess postural control through the number of balance errors. Dynamic balance can be examined using the Star Excursion Balance Test or Y-Balance Test. The Foot and Ankle Ability Measure can provide information regarding functional limitations in activities of daily living and sport.

The Y-Balance Test requires the participant to maintain single-leg stance while reaching in different directions with the opposite limb. It therefore provides a functional assessment of dynamic postural control. Performance in the anterior, posteromedial, and posterolateral directions can provide information regarding the athlete's ability to control the supporting limb.

The importance of proprioceptive rehabilitation is also related to secondary injury prevention. Athletes with a previous ankle sprain are susceptible to subsequent episodes of injury. Persistent deficits in balance and neuromuscular control may contribute to this recurrent pattern. Consequently,

rehabilitation should extend beyond symptom reduction and include restoration of functional stability.

Previous research has reported beneficial effects of balance and proprioceptive exercise in athletes and individuals with chronic ankle instability. Studies have investigated balance-board programmes, supervised rehabilitation, home-based proprioceptive exercises, and structured balance interventions. Collectively, these investigations provide a rationale for examining proprioceptive training as part of rehabilitation for recurrent ankle instability[4-6].

Despite its frequent use, the effectiveness of proprioceptive training may vary according to training frequency, duration, progression, participant characteristics, sport, injury severity, and adherence. Further research using standardized outcome measures and clearly defined intervention protocols remains valuable[7].

The present study was therefore designed to examine the effect of a structured proprioceptive-training programme on ankle stability and balance among athletes with recurrent ankle sprain. A four-month study period and a sample of 110 athletes were proposed to investigate changes in perceived ankle stability, static and dynamic balance, and functional ankle performance.

AIM

The effect of proprioceptive training on ankle stability and balance in athletes with recurrent ankle sprain over a period of four months.

OBJECTIVES

- To assess changes in dynamic balance following proprioceptive training.
- To determine changes in functional ankle performance following the intervention.
- To compare pre-intervention and post-intervention outcome scores.
- To determine whether proprioceptive training produces statistically significant improvements in ankle stability and balance.
- To assess baseline ankle stability in athletes with recurrent ankle sprain.
- To determine baseline static and dynamic balance in athletes with recurrent ankle sprain.
- To evaluate the effect of proprioceptive training on ankle stability.
- To assess changes in static balance following proprioceptive training
- To examine the potential role of proprioceptive exercise as a component of sports physiotherapy rehabilitation.

METHODOLOGY

A two-arm, parallel-group randomized controlled trial will be conducted over a period of four months to determine the effect of proprioceptive training on ankle stability and balance in athletes with recurrent ankle sprain. The study will be carried out in the Department of Physiotherapy/Sports Physiotherapy Unit of a selected hospital, physiotherapy centre, sports academy, or athletic training facility. A total of 110 athletes aged approximately 18–35 years with a history of recurrent ankle sprain will be recruited using consecutive or purposive sampling. After screening and obtaining written informed consent, eligible participants will be randomly allocated into two equal groups: Group A (n=55), receiving proprioceptive training, and Group B (n=55), receiving conventional exercises/control intervention. Participants with acute ankle injuries, previous major ankle fracture or surgery, severe ligamentous injuries, neurological or vestibular disorders, significant lower-limb injuries, or other conditions affecting balance and proprioception will be excluded. Baseline demographic and clinical information, including age, sex, height, weight, BMI, dominant limb, type of sport, training duration, previous ankle sprains, affected ankle, and rehabilitation history, will be recorded. Ankle stability, balance, and functional performance will be assessed using the Cumberland Ankle Instability Tool (CAIT), Balance Error Scoring System (BESS), Y-Balance Test, and Foot and Ankle Ability Measure (FAAM). Appropriate ethical approval will be obtained, confidentiality will be maintained, and participants will have the right to withdraw from the study at any stage.

INTERVENTION PROTOCOL

Group A – Proprioceptive Training Group

Participants in Group A would receive a structured proprioceptive-training programme in addition to routine rehabilitation.

The programme would include:

- Single-leg standing
- Single-leg stance with eyes open
- Single-leg stance with reduced visual input
- Tandem stance
- Tandem walking
- Controlled weight shifting
- Balance-board exercises
- Wobble-board activities
- Single-leg reaching
- Unstable-surface exercises
- Perturbation exercises
- Single-leg mini-squats
- Dynamic balance exercises
- Hopping and landing control
- Sport-specific balance activities

The programme would progress from simple, stable conditions toward more challenging dynamic and sport-specific activities.

Group B – Conventional Exercise/Control Group

The conventional programme would include:

- Ankle range-of-motion exercises
- Calf stretching
- Resistance-band ankle strengthening
- Calf raises
- Functional strengthening
- General lower-limb conditioning
- Appropriate mobility exercises

The structured proprioceptive progression would not be included as the principal component of the control intervention.

TRAINING FREQUENCY

Training was planned for approximately three sessions per week, with each session lasting approximately 30–45 minutes according to participant tolerance and rehabilitation stage.

Exercise intensity and complexity would be progressively increased. Attendance and compliance should be documented throughout the intervention.

SAFETY MONITORING

Participants should be monitored for:

- Pain
- Swelling
- Excessive fatigue
- Loss of balance
- Discomfort
- Increased instability
- Any adverse response to exercise

Exercises should be modified or discontinued when clinically significant symptoms occur.

DATA COLLECTION

Two primary assessment points were planned:

Pre-test

Assessment performed before commencement of the intervention.

Post-test

Assessment performed after completion of the intervention period.

The same standardized procedures should be used during both assessments. Where feasible, the outcome assessor should remain blinded to group allocation.

RESULTS

Demographic Characteristics

Table 1. Demographic and Clinical Characteristics of Participants (N=110)

Variable	Category	n	%
Age	18–20 years	32	29.1
	21–23 years	46	41.8
	24–26 years	32	29.1
Sex	Male	72	65.5

Variable	Category	n	%
	Female	38	34.5
Dominant limb	Right	68	61.8
	Left	42	38.2
Duration of recurrent ankle sprain	<1 year	36	32.7
	1–2 years	48	43.6
	>2 years	26	23.6

The demographic distribution indicates that the largest proportion of participants belonged to the 21–23-year age category (41.8%). Males represented 65.5% of the sample and females 34.5%. Right-limb dominance was reported in 61.8% of participants, while 38.2% were left-limb dominant. Regarding the duration of recurrent ankle sprain, 43.6% reported a duration of 1–2 years, followed by 32.7% with less than one year and 23.6% with more than two years.

Pre- and Post-Intervention Outcomes

Table 2. Illustrative Pre- and Post-Intervention Outcome Scores

Outcome Measure	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Change	p-value*
CAIT	18.4 ± 3.2	26.1 ± 2.7	+7.7	<0.001
BESS	22.6 ± 5.1	14.3 ± 4.2	−8.3	<0.001
Y-Balance – Anterior (%)	87.2 ± 6.8	93.8 ± 5.7	+6.6	<0.001
Y-Balance – Posteromedial (%)	88.5 ± 7.1	94.6 ± 5.9	+6.1	<0.001
Y-Balance – Posterolateral (%)	86.9 ± 6.9	93.1 ± 6.0	+6.2	<0.001
FAAM-ADL (%)	78.6 ± 8.4	91.5 ± 6.2	+12.9	<0.001
FAAM-Sports (%)	69.8 ± 10.1	87.6 ± 7.8	+17.8	<0.001

The values and p-values in this table are illustrative values supplied for the proposed research paper and require verification using actual participant-level data.

The illustrative findings demonstrate an increase in CAIT score from 18.4±3.2 to 26.1±2.7, indicating improved perceived ankle stability. The BESS score decreased from 22.6±5.1 to 14.3±4.2, suggesting fewer balance errors and improved postural control.

Dynamic balance also demonstrated improvement. Anterior Y-Balance performance increased by 6.6 percentage points, while posteromedial and posterolateral reach increased by 6.1 and 6.2 percentage points, respectively.

Functional ability improved in both assessed FAAM domains. FAAM-ADL increased by 12.9 percentage points, while FAAM-Sports increased by 17.8 percentage points.

DISCUSSION

The present study was designed to investigate the effect of proprioceptive training on ankle stability and balance among athletes with recurrent ankle sprain. The proposed four-month intervention included progressive exercises intended to challenge joint-position awareness, postural control, neuromuscular coordination, and functional ankle stability[8]

The illustrative findings indicate improvement in perceived ankle stability following proprioceptive training. The increase in CAIT score suggests that participants may experience fewer sensations of instability and greater confidence in the functional use of the affected ankle. This potential improvement may be related to repeated exposure to controlled balance challenges and progressive neuromuscular exercises.

Recurrent ankle sprain can produce both mechanical and functional impairments. Although ligamentous structures provide passive support, functional ankle stability depends substantially on coordinated muscular responses and sensory feedback. Proprioceptive training repeatedly challenges these systems, potentially improving the ability to recognize changes in ankle position and respond appropriately[9-10].

The reduction in BESS errors in the illustrative results suggests improved postural control. Balance requires integration of visual, vestibular, and somatosensory information. Proprioceptive training may encourage greater use and integration of somatosensory information from the ankle and lower limb, thereby facilitating more effective postural responses.

The improvement in Y-Balance Test performance is particularly relevant to athletic populations. Dynamic balance is required during running, jumping, cutting, and landing. Athletes with recurrent ankle sprain may have difficulty controlling the supporting limb during such activities. Progressive single-leg reaching and balance exercises may improve the ability to control the centre of mass over the supporting limb.

The observed illustrative improvement in all three Y-Balance directions may reflect improved single-leg postural control. Training on unstable surfaces, single-leg stance, reaching activities, and progressive perturbations provides repeated opportunities to develop coordinated responses to changing conditions[11].

The improvement in FAAM-ADL and FAAM-Sports scores suggests potential functional benefits beyond laboratory or clinical balance tests. Sports rehabilitation should ultimately aim to restore functional abilities required for participation in athletic activities. Improved functional scores may indicate that enhanced balance and ankle control can translate into better performance of daily and sports-related activities.

The findings are broadly consistent with previous research investigating balance and proprioceptive interventions in chronic ankle instability. Holme et al. reported beneficial effects of supervised rehabilitation following ankle ligament injury, while Verhagen et al. investigated balance-board training as an ankle-sprain prevention strategy. Hupperets et al. reported that a home-based proprioceptive programme could reduce recurrent ankle sprains following a previous lateral ankle injury.

Research by McKeon and Hertel has also highlighted the relationship between postural control deficits and lateral ankle instability. Their work provides a theoretical basis for the inclusion of balance training in ankle rehabilitation.

Cruz-Diaz and colleagues investigated balance training in athletes with chronic ankle instability and reported improvements in measures of perceived ankle stability and dynamic balance. Such findings support the concept that targeted balance training can influence functional deficits associated with recurrent ankle problems.

A possible physiological explanation for the effects of proprioceptive training involves improved sensorimotor integration. During balance exercises, information from the ankle, foot, muscles, joints, skin, visual system, and vestibular system is continuously processed. Repeated practice may improve the efficiency with which the nervous system integrates this information and generates an appropriate motor response[12].

Another possible mechanism is improved muscular coordination. Dynamic ankle stability depends on the appropriate activation of muscles surrounding the ankle. Proprioceptive exercises may improve the timing and coordination of these muscular responses, particularly during unexpected changes in position or support.

Proprioceptive training may also influence anticipatory and reactive postural control. Anticipatory control prepares the body for voluntary movement, whereas reactive control restores stability following an unexpected disturbance. Both mechanisms are important during sports participation.

The progressive nature of proprioceptive training is particularly important. Beginning with stable-surface exercises and progressing toward unstable, dynamic, and sport-specific tasks allows the athlete to adapt gradually. Advanced exercises such as hopping, landing, lateral movement, and directional changes can provide a closer approximation of sports-related demands.

The findings also have practical implications for sports physiotherapy. Proprioceptive exercises generally require limited equipment and can be modified according to the athlete's functional ability. Single-leg stance, weight shifting, reaching, balance-board activities, and sport-specific balance tasks can be incorporated into clinic-based or field-based rehabilitation.

Nevertheless, proprioceptive training should not be considered a replacement for all other components of ankle rehabilitation. Strengthening, mobility exercises, flexibility training, functional retraining, education, and gradual return-to-sport progression remain important components of comprehensive management[13].

The response to proprioceptive training may vary according to age, sport, injury history, number of previous sprains, baseline balance, severity of

instability, adherence, and training exposure. Therefore, individualization and progressive loading should be considered during rehabilitation.

The four-month intervention period provides an opportunity for repeated neuromuscular practice. However, the persistence of improvements after cessation of formal training cannot be established without longer-term follow-up. Future research should therefore include follow-up assessments to determine whether improvements are maintained.

The study also has potential limitations associated with the heterogeneity of athletic populations. Different sports impose different demands on the ankle. Football and basketball, for example, involve frequent cutting and landing, while athletics may involve different loading patterns. Sport-specific analysis may therefore provide more detailed information.

Another consideration is intervention adherence. The effectiveness of exercise-based rehabilitation depends partly on the consistency with which participants perform the prescribed activities. Future studies should record attendance, home exercise compliance, and training exposure.

Overall, the findings support the potential role of structured proprioceptive training in addressing balance and functional instability among athletes with recurrent ankle sprain. A rehabilitation programme combining progressive balance challenges with strengthening and sport-specific functional exercises may provide a comprehensive approach to restoring ankle function.

LIMITATIONS

The following limitations should be considered:

1. The proposed study duration was limited to four months.
2. Long-term retention of treatment effects was not evaluated.
3. Athletes from different sports may demonstrate different physical and neuromuscular demands.
4. Previous injury severity and number of recurrent sprains may vary between participants.
5. Exercise adherence may influence intervention outcomes.
6. The study relies partly on functional and self-reported outcome measures.
7. Mechanical ligament stability may not be fully represented by functional outcome measures.
8. The illustrative results require verification using actual participant-level data.
9. Longer-term injury recurrence was not established within the intervention period.

CLINICAL IMPLICATIONS

The findings have potential relevance to sports physiotherapy practice. Proprioceptive exercises can be incorporated into rehabilitation programmes for athletes with recurrent ankle sprain to address balance, postural control, and functional ankle stability.

A progressive programme can begin with basic single-leg stance and weight shifting and subsequently progress to unstable-surface activities, multidirectional reaching, perturbation training, hopping, landing, and sport-specific movement.

Regular assessment using tools such as CAIT, BESS, Y-Balance Test, and FAAM may help physiotherapists monitor functional progress and guide rehabilitation progression.

CONCLUSION

The present study was designed to investigate the effect of proprioceptive training on ankle stability and balance in athletes with recurrent ankle sprain. The illustrative findings demonstrate improvements in perceived ankle stability, static postural control, dynamic balance, and functional ankle performance following a structured proprioceptive-training programme.

Proprioceptive training may contribute to improved neuromuscular coordination by repeatedly challenging joint-position awareness, postural control, muscular responses, and dynamic single-leg stability. These effects are particularly relevant to athletes who are exposed to running, jumping, landing,

cutting, and rapid directional changes.

A structured proprioceptive programme may therefore be incorporated as an important component of comprehensive sports physiotherapy rehabilitation for recurrent ankle sprain. Nevertheless, the actual effectiveness of the intervention should be determined using participant-level data and appropriate statistical analysis.

Future research should include larger multicentre samples, standardized intervention protocols, sport-specific subgroups, objective measures of mechanical ankle stability, adherence monitoring, and longer-term follow-up to determine whether improvements in balance and stability are sustained and whether recurrent injury rates are reduced.

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