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Revisão de Literatura

Influence of proprioceptive training on postural balance in athletes with ankle injury: A Systematic review

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Abstract

Introduction: Lateral ankle sprain is one of the most frequent injuries in athletes and often results in proprioceptive deficits and impaired postural balance. Proprioceptive training is commonly used in rehabilitation programs to restore neuromuscular control, although evidence regarding its effects on different balance outcomes remains heterogeneous. **Objective:** To evaluate the effects of proprioceptive training on postural balance in athletes with ankle injuries. **Methods:** This systematic review (PROSPERO CRD420251039146) followed PRISMA guidelines9. Searches were conducted in PubMed, Scopus, Web of Science, Cochrane Library, and VHL between 2013 and 2025. Randomized and clinical trials involving athletes with ankle injuries undergoing proprioceptive or balance-based interventions were included. Outcomes included static and dynamic postural balance and neuromuscular control. Methodological quality was assessed using the PEDro scale12. **Results:** Nine studies were included. Proprioceptive training improved static and dynamic postural balance, particularly in SEBT and posturography measures. Combined interventions (balance + strength or plyometric training) demonstrated greater improvements compared to isolated protocols in several studies. Neuromuscular control and functional stability also improved. However, heterogeneity was observed in intervention protocols and outcome measures. **Conclusion:** Proprioceptive training is effective in improving postural balance and neuromuscular control in athletes with ankle injuries. Combined and progressive protocols may provide superior outcomes, although heterogeneity limits definitive clinical recommendations.

Key-words: Rehabilitation; Athletes; Ankle Injuries; Orthopedics.

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INTRODUCTION

The ankle joint plays a central role in sports performance due to its constant exposure to high mechanical demands, such as jumping, landing, and rapid changes of direction. Consequently, it is one of the most frequently injured joints in athletes, with lateral ankle sprain being the most prevalent injury. [1,2] This condition commonly affects the lateral ligament complex, especially the anterior talofibular ligament, resulting in pain, edema, mechanical instability, and functional limitations that may compromise sports participation.[3,4]

Although ligament healing may occur, many athletes develop chronic ankle instability, characterized by recurrent sprains, impaired neuromuscular control, and reduced postural balance. These persistent deficits are closely associated with proprioceptive dysfunction, as ligament injuries may damage mechanoreceptors responsible for joint position sense and movement detection.[5,6] As a result, sensorimotor impairments may persist even after clinical recovery, increasing the risk of reinjury and long-term functional deficits.

Proprioceptive training has been widely incorporated into rehabilitation programs aiming to restore neuromuscular control and improve postural stability in individuals with ankle injuries. These interventions commonly include balance exercises, unstable surface training, and progressive motor control tasks designed to enhance sensorimotor integration and functional joint stability. [7,8] Evidence suggests potential benefits of proprioceptive training for improving balance and reducing instability in athletes.

However, current evidence remains heterogeneous. Differences exist regarding intervention protocols (e.g., duration, intensity, and progression), outcome measures used to assess postural balance, and methodological approaches across studies. In addition, variability in athletic populations and training characteristics limits the comparability of findings and makes it difficult to establish consistent clinical conclusions regarding effectiveness.

Therefore, there is a need to systematically synthesize the available evidence to clarify the effects of proprioceptive training on postural balance in athletes with ankle injuries. The objective of this study is to investigate the effectiveness of proprioceptive Training in improving postural balance in athletes with ankle injuries, considering its effects on neuromuscular control, joint stability, recurrence rates, and functional performance.

METHODOLOGY

This study is a systematic literature review registered in PROSPERO under the code CRD420251039146 and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[9] The review aimed to answer the following research question: "Is proprioceptive training effective in improving postural balance in athletes with ankle injuries?"

Eligibility criteria were defined using the PICO strategy,[10] in which athletes with ankle injuries were considered the population, proprioceptive training the intervention, other rehabilitation interventions or control conditions the comparison, and postural balance the outcome.

A comprehensive systematic search was conducted in PubMed, Scopus, Web of Science, Cochrane Library, and the Virtual Health Library (VHL). The search covered studies published between January 2013 and December 2025. No restrictions regarding publication status were applied.

The search strategy combined controlled vocabulary (MeSH and DeCS terms) and free-text terms

related to proprioceptive training, ankle injuries, and postural balance, using Boolean operators (AND/OR) to optimize sensitivity and specificity of the search.

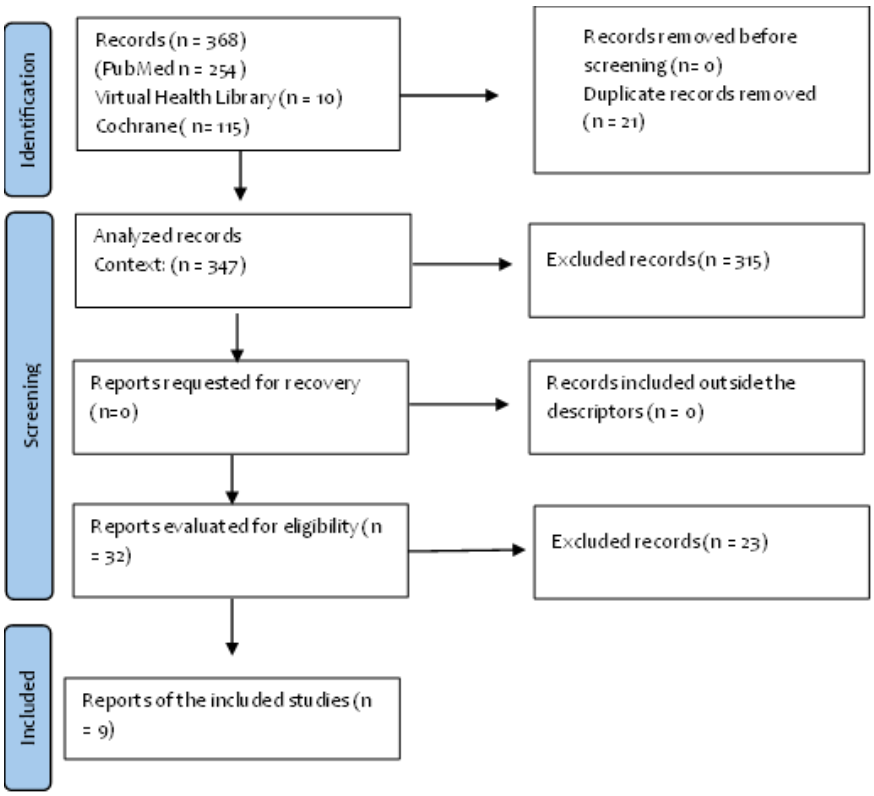
The search strategy combined controlled vocabulary (MeSH and DeCS terms) and free-text terms using Boolean operators: ("proprioceptive training" OR "sensorimotor training") AND ("balance" OR "postural balance" OR "postural control") AND ("athlete*" OR "sports") AND ("postural stability" OR "motor performance" OR "balance assessment").

The inclusion criteria comprised randomized controlled trials and clinical trials involving athletes with ankle injuries. Studies were included if they investigated proprioceptive training or balance-based interventions and reported outcomes related to postural balance or neuromuscular control. Only studies published in English or Portuguese with full-text availability were considered. The exclusion criteria included reviews, case reports, and observational studies, as well as studies involving non-athlete populations. Studies that did not use proprioceptive training as the main intervention or that did not assess postural balance or neuromuscular outcomes were excluded.

Study selection was performed independently by two reviewers (COSTA, M. A. R. and XAVIER, L. R. L.) using the *Rayyan*® platform. In the first stage, titles and abstracts were screened. In the second stage, full texts were assessed for eligibility. Disagreements were resolved by discussion, and when necessary, a third reviewer (JÚNIOR, W. P. N. and ALVES, J. P. F. F.) was consulted to reach consensus.

The study selection and reporting followed the PRISMA 2020 guidelines, ensuring transparency in the identification, screening, eligibility, and inclusion phases of the review process.[9]

Flowchart 1. PRISMA Scale[11]



Source: Adapted by the authors, 2026.

The methodological quality of the included studies was assessed using the Physiotherapy Evidence Database (PEDro) scale. The PEDro scale is a validated instrument specifically designed to

evaluate the methodological quality and risk of bias of randomized controlled trials in physiotherapy. It consists of 11 items; however, only 10 items are used to calculate the final score, ranging from 0 to 10, with higher scores indicating better methodological quality.

The scale evaluates key methodological aspects such as random allocation, concealed allocation, baseline comparability, blinding of participants, therapists and assessors, adequate follow-up, intention-to-treat analysis, between-group statistical comparisons, and reporting of point estimates and variability.

Each study was independently assessed by two reviewers. In case of disagreement, a third reviewer was consulted to reach consensus. Studies were classified according to their final score, allowing the identification of high, moderate, and low methodological quality, which contributed to the interpretation of the strength and reliability of the evidence included in this systematic review (Table 1).

Table 1. Evaluation of publication bias using the PEDro scale[12]

Question	Study 1[13]	Study 2 [14]	Study 3 [15]	Study 4[16]	Study 5 [17]	Study 6 [18]	Study 7 [19]	Study 8 [20]	Study 9 [21]
1	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	Y	Y	Y	N	Y	Y	Y	Y	Y
3	Y	Y	N	Y	N	Y	Y	N	Y
4	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	N	N	Y	N	N	N	N	N	N
6	N	N	N	Y	N	N	N	Y	N
7	N	Y	N	N	Y	Y	Y	N	Y
8	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	Y	Y	Y	N	N	Y	Y	Y	N
10	Y	Y	Y	Y	Y	Y	Y	Y	Y
11	Y	Y	Y	Y	Y	Y	Y	Y	Y
TOTAL	**6/11**	**8/11**	**6/11**	**7/11**	**7/11**	**8/11**	**8/11**	**7/11**	**8/11**

S= Yes / N= No

Source: Produced by the authors, 2025

RESULTS

The search in the databases identified potentially relevant studies and, after the removal of duplicates and the application of eligibility criteria, those included in this systematic review were selected. The studies analyzed evaluated the effects of proprioceptive training on postural balance in athletes with ankle injuries, considering different intervention protocols, follow-up periods, and assessment methods. Overall, the results indicated improvements in postural balance, both static and dynamic, as well as a reduction in the occurrence of new injuries. Table 2 presents a summary of the characteristics of the included studies, including authors, year of publication, sample, type of intervention, assessment instruments, and main outcomes.

Table 2. Data extraction

Author, Year	Sample	Intervention type	Frequency / Protocol details	Duration	Outcomes	Results
Marotta et al., 2023	19 semi-professional volleyball athletes	Proprioceptive training (balance board, single-leg stance, unstable surface tasks – as reported)	3 sessions/week	Not reported	BAL, PP, JP	Improved jump performance, reduced rearfoot load, improved plantar pressure distribution
Sadaak et al., 2024	30 elite athletes	Aquatic therapy vs conventional therapy (hydrotherapy + balance and gait training vs land-based rehab)	NR	NR	PA, BAL, RTS	Aquatic therapy showed greater pain reduction, improved balance and faster return to sport
Lee et al., 2013	41 athletes	Exercise training with orthosis vs exercise alone	3 sessions/week	NR	PROP, BAL	Both groups improved balance and proprioception; no between-group differences
Lamb et al., 2014	Gymnastics athletes (n=7)	Progressive proprioceptive training (single-leg balance, dynamic unstable tasks, progression phases)	NR	2 months	BAL	Progressive improvement in postural balance, especially in later phases
Cain et al., 2020	43 adolescents	Elastic band training, balance board training, combined rehab programs	3 sessions/week	4 weeks	BAL, FUN	All intervention groups improved; no superior protocol identified
Huang et al., 2021	30 athletes	Plyometric training vs combined plyometric + balance training	3–5 sessions/week	6 weeks	EMG, PROP	Both improved neuromuscular control; combined training showed slightly better balance precision
Sohrabi et al., 2024	30 female athletes	Corrective exercise training (mobility, balance, neuromuscular control exercises)	3 sessions/week	8 weeks	DF, PROP, BAL	Improved dorsiflexion, proprioception, and neuromuscular control
de Vasconcelos et al., 2020	19 fencers	Proprioceptive training (dynamic balance, SEBT-based progression tasks)	3 sessions/week	12 weeks	SEBT, BAL	Improved dynamic neuromuscular control in all SEBT directions
Park et al., 2024	51 soccer players	Strength training vs balance training	3 sessions/week	6 weeks	CAIT, BAL, FUN	Balance training reduced kinesiophobia; both improved stability and function

Abbreviations: BAL = Balance; PP = Plantar Pressure; JP = Jump Performance; PA = Pain; RTS = Return to Sport; PROP = Proprioception; EMG = Electromyography; DF = Dorsiflexion; FUN = Functional Performance; CAIT = Cumberland Ankle Instability Tool; SEBT = Star Excursion Balance Test; NR = Not Reported. PT = Proprioceptive Training; AT = Aquatic Therapy; CT = Conventional Therapy; EX = Exercise; OR = Orthosis; ST = Strength Training.
Source: Produced by the authors, 202.

The studies included in this systematic review evaluated athletes from different sports modalities, mainly volleyball, gymnastics, fencing, and soccer. The interventions analyzed were heterogeneous, including proprioceptive training, balance exercises, unstable surface training, elastic resistance exercises, plyometric training, and combined rehabilitation protocols. Overall, these interventions targeted improvements in postural balance, neuromuscular control, joint stability, and functional performance outcomes.

Intervention protocols varied across studies, with durations ranging from 2 to 12 weeks and training frequencies of 2 to 3 sessions per week. The most commonly used exercises included single-leg stance, balance board training, unstable surface exercises, perturbation-based training, elastic band resistance, and sport-specific functional tasks. In most studies, progressive overload and increasing task complexity were applied to enhance neuromuscular adaptations and postural control improvements.

Marotta et al.[13] demonstrated that proprioceptive training in volleyball athletes improved plantar pressure distribution, reducing rearfoot load and enhancing jump performance, including increased concentric strength and power output. Sadaak et al.[14] reported that aquatic physiotherapy was more effective than conventional rehabilitation in athletes with severe ankle sprains, leading to improved balance, pain reduction, and faster return to sport.

Lee et al.[15] found that rehabilitation exercises improved balance and proprioception in athletes with chronic ankle instability, although orthoses did not provide additional benefits. Lamb et al.16 observed progressive improvements in postural balance following a structured proprioceptive training program with increasing complexity in rhythmic gymnasts.

Cain et al.[17] demonstrated that elastic band training, balance board exercises, and combined protocols all improved balance and functional outcomes in adolescents with chronic ankle instability, with no significant differences between methods. Huang et al.[18] showed that both plyometric training and combined training improved neuromuscular control, with combined protocols showing slightly superior fine motor adjustments.

Sohrabi et al.[19] reported that corrective exercise programs improved dorsiflexion range of motion, balance, proprioception, and reduced compensatory muscle activation. de Vasconcelos et al.[20] demonstrated significant improvements in dynamic neuromuscular control following proprioceptive training in fencing athletes. Park et al.[21] found that balance training reduced kinesiophobia and improved static balance, while both balance and strength training improved ankle stability and functional performance.

Overall, proprioceptive and balance-based interventions are effective in improving postural balance and neuromuscular control in athletes with ankle injuries. However, combined training approaches (e.g., balance plus strength or plyometric training) and longer-duration progressive protocols appear to provide more consistent and functionally relevant improvements compared to isolated or short-term interventions.

DISCUSSION

The main findings of this systematic review show that proprioceptive and balance training lead to improvements in postural balance (both static and dynamic), neuromuscular control, and functional performance in athletes with ankle injuries. Across the included studies, consistent improvements were observed in commonly used clinical and functional measures such as the Star Excursion Balance Test (SEBT), posturography assessments, jump performance (CMJ and SJ), ankle stability (CAIT), agility-based tasks (figure-8 and side-hop tests), and electromyographic (EMG) activity. Some studies also reported

reductions in pain and kinesiophobia, as well as faster return-to-sport, particularly in combined rehabilitation approaches.

Overall, the evidence suggests that proprioceptive and balance-based interventions are effective for improving postural control, joint stability, and neuromuscular function in athletes with ankle injuries. These findings are consistent with established literature linking proprioceptive deficits to functional ankle instability and a higher risk of recurrent injuries.[22]

Improvements in strength, coordination, and functional performance appear to be related to adaptations in the sensorimotor system, which enhance motor unit recruitment and dynamic joint control. These adaptations are essential for restoring function and reducing the likelihood of future injuries, especially in athletes with chronic instability.[23]

From a performance perspective, the included studies assessed outcomes using different functional and neuromuscular tools, including jump tests (CMJ and SJ), dynamic balance measures such as the SEBT, agility tasks like the side-hop and figure-8 tests, and EMG analysis. In general, results consistently pointed to better performance after proprioceptive and combined training programs, especially when balance work was integrated with strength or plyometric exercises.[24]

Different rehabilitation approaches were also explored across the studies. Aquatic physiotherapy, for example, showed benefits in terms of pain reduction and reduced joint loading, which may facilitate earlier and safer progression in rehabilitation, particularly in more severe cases.[26]

Another consistent finding was the superiority of combined or progressive training protocols in several outcomes. Programs that integrate balance, strength, and plyometric exercises seem to provide broader neuromuscular stimulation, leading to more robust functional adaptations, particularly in tasks requiring rapid adjustments and refined motor control.[25]

At the same time, some studies showed no significant differences between different intervention types, suggesting that several approaches may be effective as long as key training principles such as progression, specificity, and adequate stimulus are respected. This highlights the importance of tailoring rehabilitation to the individual athlete.[27]

Psychological factors also emerged in some studies, with reductions in kinesiophobia being reported. This suggests that these interventions may also improve confidence and readiness to return to sport, which is particularly relevant in athletes recovering from ankle injuries.[28]

This review has some limitations that should be considered. There was clear heterogeneity among the included studies in terms of intervention protocols, duration, frequency, and exercise types, which limited direct comparisons. Outcome measures also varied considerably, making quantitative synthesis difficult. In some studies, key details such as training intensity and progression were not clearly described. Although only randomized and clinical trials were included, methodological quality varied according to the PEDro scale, which may affect the overall strength of the evidence. Additionally, recurrence rates were not consistently reported across studies, limiting conclusions regarding injury recurrence. Despite these limitations, this review has important strengths. It followed PRISMA guidelines and included a comprehensive search across multiple databases. Only randomized and clinical trials involving athletic populations were considered, which strengthens the clinical relevance of the findings. In addition, methodological quality was systematically assessed using the PEDro scale, improving the transparency and reliability of the evidence synthesis.

Overall, the findings support proprioceptive and balance training as key components in the rehabilitation of athletes with ankle injuries, contributing to improvements in function, performance, and injury prevention.[29]

CONCLUSION

This systematic review indicates that proprioceptive and balance training are effective interventions for improving postural balance and neuromuscular control in athletes with ankle injuries. The included studies consistently demonstrated benefits in both static and dynamic balance, as well as improvements in functional stability and sensorimotor control.

However, outcomes related to functional performance, pain, and return-to-sport were less consistently reported, reflecting heterogeneity among study protocols and assessment methods. This limits the ability to draw definitive conclusions regarding these variables.

From a clinical perspective, proprioceptive and balance exercises should be considered essential components of rehabilitation programs for ankle injuries, particularly in later stages focused on restoring functional stability and sport-specific performance. Combined training approaches, integrating balance with strength or plyometric exercises, appear to provide more robust functional gains than isolated interventions.

Aquatic therapy may be useful in the early rehabilitation phase, especially in cases involving higher pain levels or limited load tolerance; however, land-based proprioceptive training seems more effective for achieving sport-specific neuromuscular adaptations and improving postural balance.

Overall, a progressive and individualized rehabilitation approach, combining different training modalities according to the stage of recovery, appears to be the most appropriate strategy for optimizing outcomes in athletes with ankle injuries. Further high-quality randomized controlled trials are needed to establish standardized protocols and strengthen clinical recommendations.

DECLARAÇÃO DE CONFLITOS DE INTERESSE

Nada a declarar.

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