Effectiveness of proprioceptive training in athletes with and without ankle instability: systematic review

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ABSTRACT
Background: The proprioceptive program is directly related to neuromuscular control, which uses proprioceptive afferences to provide dynamic stabilization of the joint. Some variables can be considered risk factors for injuries, such as sprains, sudden and unexpected movement activities, simple quick changes of direction, soil type or footwear, among others. The balance training program contributes to lower injury rates and increases sports performance rate. Thus works the perception and maintenance of postural balance from information coming from sensory afferences. Objective: To perform a systematic review and verify the effect of proprioceptive training on ankle joint in athletes. Methods: A search for clinical trials was performed in the PUBMED, WEB OF SCIENCE, PEDro and SCIELO databases, the terms used for the search were "Proprioception", "Athletic" and "Rehabilitation", with the filters: articles published between the years of 2015 to 2020 and research in humans. Only studies published in the English language that addressed the proposed theme were included. The PEDro scale was used to evaluate the quality of studies with clinical trials, where studies with a score lower than 6/10 on the scale were excluded. Results: With the search 69 articles were found, removing the duplicates we obtained 67 eligible articles, of these, 15 studies met the inclusion and exclusion criteria. After complete analysis, 9 studies were included. Conclusion: Proprioceptive training in athletes, lasting at least three weeks with weekly protocols composed of dynamic exercises directed at individuals with ankle instability is totally effective for both joint injury prevention and rehabilitation. In addition to the increase of variables such as postural balance, coordination, postural control and functional performance. Keywords: Proprioception; Athlete; Rehabilitation; Ankle joint.

BACKGROUND
Musculoskeletal injuries can affect muscles, tendons, ligaments, nerves, joints and bones, and are classified as mild, moderate or severe. They are usually caused by bruises, strains or lacerations and over 90% are sport-related. Usually the injury is followed by a lot of pain, swelling at the site of the trauma and redness, requiring complementary tests for the diagnosis of each case.(1)

Athletes have specific morphological and physiological characteristics, and they are constantly exposed to a set of physical demands according to the motor tasks required, in view of the different modalities practiced, both individually and in groups, also presenting specific movements of the modality such as: acceleration, deceleration, impulsion, turns, lateral movements and jumping in specific spaces, thus being able to subject musculoskeletal injuries, especially in the lower limbs(2).

According to Ergen (2008)³ the most common sports injuries are ankle sprains. Coming from the idea that they require fast movements and some generate high impact on the joints. A sprain is defined as a traumatic injury, where there is stretching or rupture of one or more ligaments within a joint. In addition, it is an injury that can lead to new episodes and residual symptoms in up to 40% of the time(4) generating a picture of functional disability, making adequate treatment and corrective exercises important.

The anatomy of the ankle is formed by the distal end of the tibia and fibula, the anterior talofibular ligament, the peroneal calcaneus, and the posterior talofibular ligament. The joint is composed of three parts: upper ankle (tibio-tarsal), subtalar joint that provides the foot with three axes of rotation allowing two movements: inversion and eversion. And the talocrural part, which is uniaxial, is responsible for dorsiflexion and plantar flexion(5). The main function of this joint is to stabilize, provide control, flexibility, cushion shocks during ambulation, and prevent forced eversion movement. One of the treatments used by physiotherapy both in rehabilitation and in the prevention of recurrences is the proprioceptive training program, which aims to restore the sensory properties, capsular and ligament structures injured, providing the reestablishment of neuromuscular control. The program is based on the improvement of different variables that can be considered risk factors for musculoskeletal injuries, such as sudden and unexpected movement activities, simple quick changes in direction, type of soil or footwear, among others.

The proprioceptive exercise program contributes to the reduction of injury rates and increases the athlete's performance level. Its importance is directly related to neuromuscular control working with the perception and maintenance of postural balance from information coming from muscle spindles, golgi tendon organs and receptors located at the level of ligaments, joint capsules and skin tissues(6).

Several studies have attributed extrinsic and intrinsic risk factors to ankle sprains.

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Submission date 13 December 2021; Acceptance date 22 December 2021; Publication date 27 December 2022

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https://doi.org/10.17784/mtprehabjournal.2022.20.1277

Manual Therapy, Posturology & Rehabilitation Journal
Formerly REVISTA TERAPIA MANUAL
One of the most complex aspects is the association between the role of mediated proprioceptive neuromuscular control after injury and its influence on the development of rehabilitation programs. Given the above, proprioception contributes to the precision of the motor programming necessary for the neuromuscular control of movements and also for the muscle reflex, providing joint dynamic stability to perform the movement. The effect of ligament trauma, resulting in mechanical instability and proprioceptive functional deficits, in turn contributes to instability, which could ultimately lead to micro trauma and a new injury (2).

Thus, when this injury occurs, regardless of the degree, it becomes necessary to stimulate the proprioceptive system, in order to prevent balance deficits, joint instability and recurrent sprains. Therefore, proprioception can be defined as the ability of the body itself to perceive changes in joint positioning, balance and respond consciously and unconsciously to movement stimuli, being characterized by information generated by mechanoreceptors that are located in the skin, muscles, tendons, ligaments and joint capsules, being interpreted at the level of the central nervous system, programmed into forms of muscle activation for joint stabilization. Based on this principle, proprioceptive training is an alternative treatment, prevention of new recurrences of sprains to minimize the deficits of the proprioceptive system (7).

Therefore, the aim of this systematic review is to evaluate the effectiveness of proprioceptive training on ankle joint instability in athletes.

**METHODS**

The study is a systematic review carried out in Anápolis/GO. Searches were carried out from September 6 to 21, 2019. Searches were carried out for clinical trials in the PUBMED, WEB OF SCIENCE, PEDro and SCIELO databases with the descriptors “Rehabilitation”, “Athletic” and “Proprioception” associated with Boolean operator “AND”. The filters used were human research, complete articles published between the years 2015 to 2020.

Articles in English were eligible for the study, framed in the subject of proprioceptive training in athletes, in subjects of any age or sex and that addressed injuries in the ankle joint. Articles that talked about upper limbs, with scores below 6/10 in the PEDro assessment, that were not linked to the ankle joint, that used proprioceptive training as a secondary form, or that contained comparisons with other joints were excluded.

The qualitative assessment instrument PEDro was used, which has the function of assessing methodological quality such as internal validity (criteria 2 to 9 of the scale), statistical description (criteria 10 and 11 of the scale), eligibility, distribution of groups, initial comparison and final by counting the number of scale items that have been fulfilled in the clinical study. The PEDro scale has numbered factors in a total of 11 items, of which only the last 10 items are scored (8).

**RESULTS**

Initially, 69 articles were found, among these, 2 were duplicates and were excluded. After reading the remaining articles, 50 studies were excluded for not meeting the inclusion criteria. At the end of the selection process, 14 articles met the inclusion criteria, these were evaluated using the PEDro scale after analysis, 9 articles were included in the qualitative synthesis.

One of the criteria to be added in this Systematic Review was to reach a score of 6, with 10 being the maximum limit of the scale score. Of the selected articles, 1 reached (10 points), 4 (9 points), 2 (7 points) and 2 (6 points), as shown in Table 1.

After searching and selecting articles, nine studies with clinical trials met the proposed selection and inclusion criteria. The study sample consisted of...
individuals aged between 14 and 31 years old. To assess whether proprioceptive training was effective in improving balance, coordination, postural control, injury prevention, and functional performance in (athletes with ankle instability).

Table 1. Scoring of articles - PEDro Scale.

<table>
<thead>
<tr>
<th>STUDIES</th>
<th>1</th>
<th>2</th>
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<th>4</th>
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<th>6</th>
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<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<tr>
<td>Anguish et al. 2018(9)</td>
<td>S</td>
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<td>S</td>
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<td>N</td>
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<td>S</td>
<td>S</td>
<td>9/10</td>
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<tr>
<td>Bailey et al. 2016(10)</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
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<td>N</td>
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<td>N</td>
<td>S</td>
<td>S</td>
<td>7/10</td>
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<tr>
<td>Brandolini et al. 2019(11)</td>
<td>S</td>
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<td>S</td>
<td>N</td>
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<tr>
<td>Cruz-Díaz et al. 2014(12)</td>
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<td>S</td>
<td>S</td>
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<td>Franco et al. 2015(13)</td>
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<tr>
<td>Hall et al. 2014(14)</td>
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<td>Heleno et al. 2016(15)</td>
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<td>Shin et al. 2017(16)</td>
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<td>S</td>
<td>10/10</td>
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<tr>
<td>Sierra-Guzmán et al. 2017(17)</td>
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<td>S</td>
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<td>S</td>
<td>N</td>
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The authors performed an initial assessment to verify (age, weight, height) in addition to assessing which was the dominant lower limb (LLL). Of which six used sensorimotor training and balance training, using tests such as the Y-Balance test, the figure eight test (F8), the lateral jump test (TSL), the star excursion balance test (TEEE) and a platform of force. One of the articles used plyometric training, and another used fascial manipulation to improve range of motion (ROM) and symptomatology.

Table 2. Characteristics of selected articles.
Proprioception in athletes without ankle instability

Two-tailed t-test, control test, and Kin-Com® 125AP isokinetic dynamometer for balance and fine movement control.

SEBT and exercises and warm-up 5 to 10 m. 7 exercise circuit using disc, resistance band, foam roller, mini walk, bosu and dynair.

Balance tape: 4-stage kinesiology elastic tape. The assessment was performed using the GAITRite portable walkway system.

Forced ankle inversion test, isokinetic strength test. Vibrating platform and Bozu.

FAAM and FAAM-Sports subscale; Star excursion balance test in anterior, posteromedial and posterolateral directions; and weight bearing JPS blocks.

Pre-test and post-test.

They were allocated in blocks of four, within one of the two test sequences.

GC: performed the usual training
GI: received the same usual activity, in addition to a balance program.

Subjects were randomly assigned to ankle balance recording, placebo recording, and no recording. Sealed envelopes described with A, B and C.

The N-VIB group trained with BOSU on the floor. The VIB group trained with BOSU on a Fitvibe Excel Pro vibration platform.

Electromyography was performed along with the tests for 6 weeks.

6-week unilateral balance training on an unstable surface + vibration platform improved ankle musculature. There were no differences in isokinetic strength, the addition of vibration improved the response against a sudden inversion.

Both programs showed similarly improved results. Therefore, it is not known for sure which has the
The study by Franco et al. (2015) mentioned that the training had no influence on exacerbation or pain relief. But the study states that patients with ICT, which consequently promotes the prevention of new injuries. Another method that proved to be effective to prevent injuries was used in the study by Franco et al. (2015), who also used a training program for 6 weeks obtained improvement in isometric strength, perceived instability of the ankle and showed improvements in the visual analogue pain scale (VAS).

DISCUSSION

The systematic review by Ramos et al. (2019) mentions that within the most varied findings of physiotherapy, it is possible to verify that proprioceptive training is extremely efficient in the treatment of ankle sprains. In this review it was also possible to observe similar results. Regarding the general context of the analyzed studies, only the article by Bailey et al. (2016) did not present significant results.

The interventions of the studies analyzed in this review ranged from 12 to 18 sessions, so it was possible to observe the results after the 1st service, as shown by Franco (2015), Heleno et al. (2016) pointed out that there is disagreement on the number of sessions, weeks and days required to obtain satisfactory results, as well as the type of material and equipment that should be used. It is worth mentioning that the sample size and the place where the tests were applied also change the final result. The study by Cruz-Dias et al. (2014) during a six-week training program was effective for improvements in dynamic balance and the feeling of instability in patients with ICT, which consequently promotes the prevention of new injuries. But the study states that training had no influence on exacerbation or pain relief. The study by Hall et al. (2014) who also used a training program for 6 weeks obtained improvement in isometric strength, perceived instability of the ankle and showed improvements in the visual analogue pain scale (VAS).

Each of the treatment groups received 3 MF sessions (45 min.) during the pre-seasonal training time period. GC = did not perform physical activities.

The PAI exerts blunt single-leg postural balance on the Jump performance. There is a need for routine planning according to each effect. Play a role in preventing injuries in high-vertical jumps.

*Note: Vibration group = VIB. Non-vibration group = N-VIB. Control group = GC. Intervention group = GI. Star Excursion Balance Test = SEBT. Test in Figure 8 = F8. Side jump test = TSL. Chronic ankle instability = CTI. Fascial manipulation = MF. Star Excursion Balance Test = TEEE. Jump balance program for stabilization = PHSB. Traditional single member balance = SLB. Electromyography = EMG. Strength training pattern = PNF. Strength training pattern = RBP. High Intensity Plyometrics = PAI.

### Simone Brandolini et al. 2019

- **N = 29.**
- **Years = 21-37.**
- **Age = (N = 9) INT (N = 20).**

**FAAM-I Questionnaire. Goniometry and training program.**

### Natália Romero Franco et al. 2015

- **N = 32.**
- **Age = 20-28 years old.**
- **GC: (N = 16) GI: (N = 16).**

**Red plate Opto Jump, Microgate Srl. Borg Classification of Perceived Exertion Scale. Baropodometry and Sensormedics Platform.**

**ADL:**
- **Each of the treatment groups received 3 MF sessions (45 min.) during the pre-seasonal training time period.**
- **GC = did not perform physical activities.**
- **GI = Plyometric: 10 sets and 15 min. warm-up and a high-intensity plyometric protocol**
- **MF = Goniometry and training program.**
- **The PAI exerts blunt single-leg postural balance on the Jump performance. There is a need for routine planning according to each effect. Play a role in preventing injuries in high-vertical jumps.**

Plyometric training = PAI. High Intensity Plyometrics = PAI.
Proprioception in athletes without ankle instability

Proprioceptive training in athletes lasting more than three weeks with weekly protocols composed of dynamic exercises aimed at individuals with ankle instability is totally effective both for injury prevention and for rehabilitation. In addition to the increase in variables such as postural balance, coordination, postural control and functional performance.

Authors' contribution: RFO, AMC, NFS and RKO contributed to the elaboration of the design of the study; RFO, BAPFO, GAMS, NFS development of the study and data acquisition. RFO, RKO, AMC, NFS contributed to article design and data tabulation. RFO, BAPFO, RKO, GAMS, MEML contributed to the critical review, correction and approval of the final version.

Financial support: nothing to declare.

Conflict of interest: the authors declare that they have no conflict of interest.

REFERENCES

CONCLUSION
Proprioceptive training in athletes lasting more than three weeks with weekly protocols composed of dynamic exercises aimed at individuals with ankle instability is totally effective both for injury prevention and for rehabilitation. In addition to the increase in variables such as postural balance, coordination, postural control and functional performance.


