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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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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 proprioception 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].

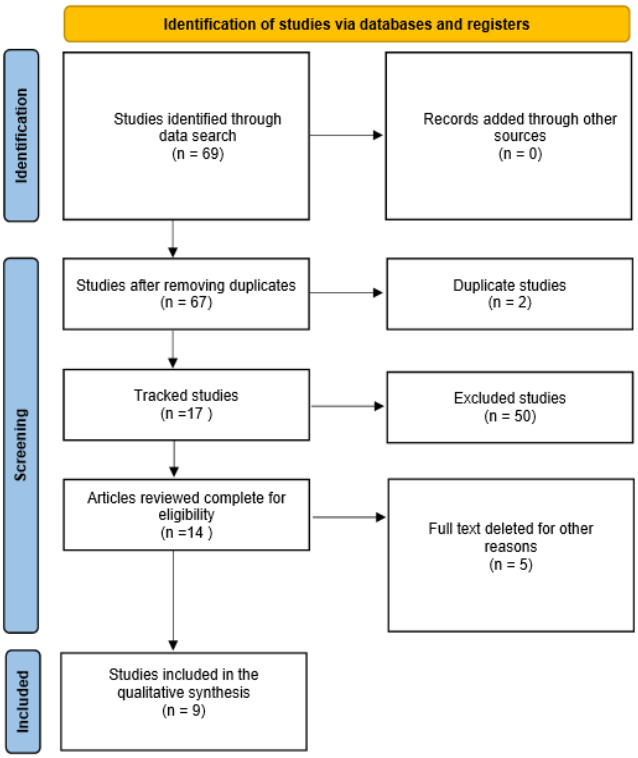

Figure 1. Study tracking flowchart
***Note:** Source: the authors.

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.

STUDIES	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Anguish et al. 2018[9]	S	S	S	S	S	S	N	S	S	S	S	9/10
Bailey et al. 2016[10]	S	S	S	S	S	N	N	S	N	S	S	7/10
Brandolini et al. 2019[11]	S	S	S	N	S	S	N	N	N	S	S	6/10
Cruz-Díaz et al. 2014[12]	S	S	S	S	S	S	S	S	N	S	S	9/10
Franco et al. 2015[13]	S	S	S	S	N	N	N	N	S	S	S	6/10
Hall et al. 2014[14]	S	S	S	S	N	N	N	S	N	S	S	6/10
Heleno et al. 2016[15]	S	S	S	S	S	N	S	S	S	S	S	9/10
Shin et al. 2017[16]	S	S	S	S	S	S	S	S	S	S	S	10/10
Sierra-Guzmán et al. 2017[17]	S	S	S	S	N	S	S	S	S	S	S	9/10

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.

Author/ Year	Participants	Instruments and Measures	Intervention	Conclusion
Lucas Rafael Heleno et al. 2016[15]	N = 22. Age = de 14 e 16 years. GC= (N=10) GI= (N= 12)	F8, TSL, Star Excursion Balance Test (SEBT) and a force platform.	GI: soccer training together with 5 weeks sensory motor program 3 times a week, 50 minutes long. GC: performed only soccer.	GI: significant improvement in postural control, agility and coordination. GC: a decrease in functional performance during analysis of the dominant limb using the TEEE test.
Emily A. Hall et al. 2014[14]	N =39. Age = 19,7 -2,2 years. RBP=(n=13) PNF= (n=13) GC = (n= 13)	F8 test, the triple crossover jump test, isometric strength tests, Y-Balance test and visual analogue scale.	RBP and PNF were assigned treatment protocol 3x for 6 weeks, performed all tests and exercises. CG: only participated in the	RBP and PNF improved isometric strength and increased stability after rehabilitation. PNF improved inversion and eversion strength by

			pre-test and post-test.	up to 35%. In dorsiflexion and plantar flexion, there were no improvements in strength.
Daniel Bailey et al. 2016[10]	N= 20. Age = 18 years 25,2 (± 5,79) years.	Two-tailed t- test, control test, and Kin-Com® 125AP isokinetic dynamometer for balance and fine movement control	They were allocated in blocks of four, within one of the two test sequences.	They did not obtain significant results related to the application of FC in healthy ankles to improve proprioception.
D. Cruz-Diaz et al. 2014[12]	N =70. Age = 30.36 years. GC= (n=35) GI = (n=35)	SEBT and exercises and warm-up 5 to 10 m. 7 exercise circuit using disc, resistance band, foam roller, mini walk, bosu and dynair.	GC: performed the usual training GI: received the same usual activity, in addition to a balance program.	There was no exacerbation or pain relief. Exercise therapy training based on multi-station balance tasks improved dynamic balance.
Young Jun Shin et al. 2017[16]	N=22. Age = 17.72±0.76 Year	Balance tape: 4- stage kinesiology elastic tape. The assessment was performed using the GAITRite portable walkway system.	Subjects were randomly assigned to ankle balance recording, placebo recording, and no recording. Sealed envelopes described with A, B and C.	Application of ankle balance recording using kinesiology tape instantly increased the walking ability of amateur soccer players with ankle sprains
Rafael Sierra-Guzmán et al. 2017[17]	N = 50. VIB (n = 17) 22.4 (2.6) years, N-VIB (N=16) 21.8 (2.1) years. CON (n=17) 23.7 (3.4) years	Forced ankle inversion test, isokinetic strength test. Vibrating platform and Bozu.	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.
Ben Anguish et al. 2018[9]	N = 18. 2 women, 16 men. Age = 18.38 ± 1.81 years	FAAM and FAAM-Sports subscale; Star excursion balance test in anterior, posteromedial and posterolateral directions; and weight bearing JPS blocks.	3 x 4 weeks. The PHSB group performed jumping exercises for stabilization while the SLB group performed a series	Both programs showed similarly improved results. Therefore, it is not known for sure which has the

			of exercises. The exercises were intensified during the 4 weeks.	greatest effect on postural control.
Simone Brandolini et al. 2019[11]	N= 29. Years = 21-37 age. CONT= (N=9) INT= (N=20)	FAAM-I ADL Questionnaire. Goniometry and training program.	Each of the treatment groups received 3 MF sessions (45 min.) during the pre-seasonal training time period.	MF was effective in improving ROM and symptomatology in soccer players with ICT.
Natália Romero Franco et al. 2015[13]	N =32. Age = 20-28 years old. GC: = (N=16) GI = Plyometric Training: (n=16)	Red plate Opto Jump, Microgate Srl. Borg Classification of Perceived Exertion Scale. Baropodometry and Sensormedics Platform..	GC = did not perform physical activities. GI= Plyometric: Performed 15min. warm-up and a high-intensity plyometric protocol 10 sets and 15 vertical jumps.	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-performance sports.

***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.

DISCUSSION

The systematic review by Ramos et. al. (2019)[18] 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)[10] 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)[13], Heleno et al. (2016)[15] 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)[12] 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)[14] 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).

The study by Bailey (2016)[10] sought to analyze the application of kinesiology tape (KT) in athletes, and did not obtain positive results regarding the improvement in proprioception. On the other hand, in the study by Shin et al. (2017)[16] using the kinesiological tape with the objective of increasing the ability to walk proved to be totally effective when it comes to improving the gait of athletes. In addition, the article by Gehrke (2018)[19] using the tape for a longer period concluded that it is largely significant for improving dynamic balance, causing a sensation of joint stability, increasing the performance of athletes.

Brandolini et al. (2019)[11] demonstrated that Fascial Manipulation (MF) signaled direct improvement in chronic ankle instability, achieved improvement in range of motion and symptomatology, in addition to being considered effective in preventing injuries. Another method that proved to be efficient to prevent injuries was used in the study by Franco et al. (2015)[13] who applied plyometrics, which is recommended as an effective form of physical conditioning, performance

improvement, postural balance as well as agility, coordination and isometric strength.

An interesting factor related to the studies is the Star Excursion Balance Test (SEBT), this test aims to assess neuromuscular control, it has a low cost, is practical, easy to apply, in addition to being effective, and is therefore widely used for avoid risk of injuries, deficits in functional performance and dynamic postural control. In the work carried out by Ribas et. al. (2017)[20], this test was used as an evaluation parameter for the pre- and post-intervention phases, as well as Heleno et. al. (2016)[15], Anguish et. al (2018)[9] and Diaz et. al. (2014)(12) who also used the test as a basis.

Heleno et al. (2016)[15] and Hall et al. (2015)[14] used the SHT and F8 functional tests, both concluded that after rehabilitation there was an improvement in the VAS decrease, postural control, isometric strength and perceived ankle instability. Furthermore, Hall et al. (2015)[14] also states that to give more emphasis on the results it would be important to include in new studies a strengthening program focused on the entire lower extremity, not just the ankle.

All studies mentioned in this review used a previously established training program, in the studies by Franco (2015)[13] and Anguish (2018)[9] training with jumps was established for the intervention group and in the control group different trainings were applied. Even with the difference, both obtained a significant increase in postural balance control and it was indicated for the prevention of new injuries.

Ramos et. al. (2019)[18] describes the effectiveness of proprioceptive training in preventing injuries to the lower limbs, especially to the ankle joint complex, being able to result in significant improvements in the static and dynamic balance performance of athletes, improving ankle stability and preventing lesions and/or recurrences.

According to the information present in the researched references, most authors agree that proprioceptive training improves body balance and, mainly, joint stability; thus benefiting individuals in the prevention and treatment of ostiomioarticular injuries. Therefore, there is emphasis on the introduction of proprioceptive exercises that seek to develop joint protection through reflective training, with coordination and balance activities generating skill and agility, which can be performed together with training sessions.

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.

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