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Original Article

# Prospective study of the ankle inversion destabilization maneuver for acute ankle ligament injury

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## Abstract

**Objective:** Present the result of a new maneuver for treating lateral ankle sprains.

**Methods:** A new technique for sensorimotor stimulation was incorporated into the conventional rehabilitation process of 100 patients with acute lateral ankle sprain with a 12-month follow-up. The primary outcome was new sprain episodes, and the secondary outcomes included quality of life (assessed by the Health Survey 12 questionnaire (SF-12)), pain (assessed by the Visual Analog Pain Scale (VAS)), function (assessed by the American Orthopaedics Foot & Ankle Society - Ankle-Hindfoot Scale - (AOFAS)) and patient-reported instability symptoms (assessed by the Cumberland Ankle Instability Tool (CAIT)).

**Results:** Among the patients included, a 12-month recurrence rate of new sprain episodes was observed at 6% (95% CI: 4.7%), which is statistically significant compared to the data reported in the literature. Regarding secondary outcomes, a statistically significant difference was observed among the onset, eight weeks, and 12 months in the AOFAS and CAIT scores. A statistically significant difference in the periods was also observed in VAS, with an initial mean of 5.94 to 1.29 at the end of treatment.

**Conclusion:** Based on our findings, a 12-month follow-up, the ankle inversion destabilization maneuver added to a standard rehabilitation protocol proved effective in preventing new lateral ankle sprain episodes.

**Level of evidence IV; Case series; Therapeutic studies - investigating the results of treatment**

**Keywords:** Joint instability; Rehabilitation; Ligaments; Physical therapy modalities.

## Introduction

Ankle sprains are highly prevalent traumas in the population, especially in athletes[1]. It is estimated that there are about 5,000 sprains per day in the United Kingdom, while American data point to approximately 23,000 cases daily[2-3]. The literature worldwide has pointed out that about 7% to 10% of orthopedic care in an emergency service is due to ankle sprains, corresponding to about 25% of all musculoskeletal injuries and which can often cause injuries to the ligaments of the lateral ankle complex[4-6].

Despite the need to conduct higher-quality studies to prove its effectiveness, strategies such as cryotherapy, elevation, and compression of the ankle affected by a sprain seem to produce beneficial effects for patients, whether related to pain control or edema that affects the lower extremities[7,8].

Outlining a rehabilitation plan for lateral ankle sprains is currently a complex task. This complexity stems from flaws in many available studies, such as inadequate descriptions of patient selection criteria, safety measures, intervention effects, and training volume. These shortcomings make it challenging to create a treatment protocol comprehensively supported by high-quality literature. However, despite all the limitations, important directions in the available literature can be found[7,8].

Study performed at the Department of Orthopedics and Traumatology, Paulista School of Medicine – Federal University of São Paulo, SP, Brazil.

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Evidence found in the literature supports that patients undergoing exercise-based treatment protocols have a lower rate of new sprain episodes, a lower feeling of instability reported by the patient, and a greater reduction in pain in the long term[9].

Determining the volume of training as well as the total number of sessions that the patient should perform, based on the available literature, is not simple since studies with protocols ranging from 10 to 60 minutes per session with a total number of sessions that can vary from 5 to 84 sessions were found[10].

In their systematic literature review, Peterson et al.[11] showed sensorimotor strategies as efficient in preventing new sprain episodes, recommending their inclusion in rehabilitation programs[11]. Thus, it is understood that the development of techniques that aim to optimize the sensorimotor condition of the ankle contributes to the prevention of new lateral sprain episodes and consequently offers patients greater quality of life and safety. However, no specific maneuvers or techniques were found in the literature to address lateral ankle sprains, that is, maneuvers designed and conceived, considering anatomy and biomechanics of the ankle and its ligaments as well as trauma mechanisms, factors that are extremely important for the success of the rehabilitation process[11].

The objective of this study is to present the results of a new technique for sensorimotor training added to the conventional rehabilitation process of 100 patients with acute lateral ankle sprain, with a 12-month follow-up. The primary outcome was new sprain episodes, and the secondary outcomes included quality of life (assessed by the Health Survey 12 questionnaire (SF-12)), pain (assessed by the Visual Analog Pain Scale (VAS)), function (assessed by the American Orthopaedics Foot & Ankle Society - Ankle-Hindfoot Scale - (AOFAS)) and patient-reported instability symptoms (assessed by the Cumberland Ankle Instability Tool – (CAIT)). We hypothesize that the described technique of ankle inversion destabilization added to the conventional rehabilitation protocol decreases the rate of new lateral ankle sprain episodes compared to the data in the literature.

## Methods

This study was approved by the Research Ethics Committee (approval number: CAAE 28126319.4.0000.5505) and all included patients signed the informed consent form. Individuals over 18 years of age, of both sexes, with a first episode of ankle sprain within 48 hours were included in the study. These cases involved complete or partial injury to any ligaments of the lateral ankle complex, which could present as isolated or associated ligament injuries.

Patients with a history of multiple ankle sprains (2 or more), previous surgery on the affected foot or ankle, previous complaint in the ankle region, any fracture associated with the sprain, or injuries that could in any way influence the application of the treatment protocol, any condition that represented any contraindication to the proposed therapies, as well as refusal by the patient to participate in the study were not included in the study. The study did not include patients with an impossibility or inability to sign the informed consent form.

Individuals with a history of ankle sprains who sought medical care in the emergency care units were consecutively allocated to the study and evaluated by the attending physicians. The evaluations consisted of a first interview, aiming to understand the factors associated with injury. The following data were collected for epidemiological analysis and interventions: sex, age, sprain site (medial, lateral, or combination), and sprain history (number of episodes). In a second moment, a clinical evaluation was performed, consisting of an inspection of the affected ankle and palpation in search of possible painful points indicative of osteo-ligamentous injuries. Subsequently, the patients underwent evaluation through radiographs with weight-bearing of the tibiotarsal joint of the ankle in three positions: anteroposterior (AP), lateral (P), and AP with internal rotation of 15º. Once the hypothesis of acute ankle ligament injury was confirmed, the patient was immobilized with an immobilizer boot for seven days, followed by a rigid side restraint orthosis for two weeks (worn with socks and sneakers) with weight-bearing as tolerated and removed only for bathing.

At the end of the first assessment, the patient was instructed to return to the rehabilitation outpatient clinic after seven days, where they immediately started the physiotherapy treatment, which included stretching, strengthening, and sensorimotor training exercises. The reversal destabilization maneuver was incorporated into the treatment at the beginning of the sixth week. Patients attended the rehabilitation outpatient clinic twice a week (until the eighth week), during which physiotherapy sessions were performed and clinical evaluation, totaling 16 sessions, with a minimum interval between sessions of three days and a maximum interval of four days. A new replenishment session was scheduled within the same week in case of a no-show. After this period, if they did not present pain symptoms or any other complaint related to the sprain or the treatment applied, they were discharged and returned in 12 months for reassessment.

All patients received a standard rehabilitation protocol for ankle sprain based on the current literature and described in detail in the Appendix 1. In the sixth week, the ankle inversion destabilization maneuver was introduced, so we set aside two weeks to work on the ankle stabilizing muscles and attenuate the deficits caused by immobilization, inherent to the use of immobilization and provide greater safety for the execution of the maneuver, first on stable ground. We evolved to unstable ground from the seventh week using a proprioceptive disc (Figure 1).

Patients were positioned barefoot in a standing position with the contralateral knee flexed, lifting the tested limb off the ground. A rigid elastic band was passed by the assistant physiotherapist from medial to lateral around the ankle to catch the two ends laterally to the ankle; then, the patient

was asked to perform active ankle inversion that would be enhanced by the physiotherapist pulling the band.

The maneuver consisted of mild destabilizations in the anterolateral, laterolateral, and posterolateral planes (with enough force to cause stretching of the band without elastic distension), moderate (with enough force to cause a small elastic distension of the band), and intense (with enough force to cause large elastic distension of the band) being performed nine times in each plane alternating the intensity of the destabilization applied to the ankle through the elastic band starting from the most intense (in the initial phase of the movement) and evolving to the mildest (close to the maximum amplitude of the ankle inversion movement). The physiotherapist always started to perform the maneuver in the anterolateral plane by asking the patient for an active ankle inversion, requesting resistance to the movement, and returning to neutral when the physiotherapist applied tension. At the beginning of the movement, an intense destabilization was performed, with the patient bringing the ankle to the initial position.

The maneuver was then repeated this time when reaching about half of the inversion movement (about 20º), moderate tension was applied to the band, and the patient should resist and reposition his ankle in the initial position. Finally, the patient performed the inversion again. When approaching the total movement of the joint (about 40º), a slight tension was applied, with the patient repositioning his ankle again in the initial position. In this way, the cycle restarts until nine alternating repetitions are completed. A pause of about one minute was granted to the patient before performing the same maneuver on the next movement plane.

**Figure 1.** Movement worked on unstable and stable surface.

At the beginning of the seventh week after the sprain, if the patient did not present a worsening of the painful condition, the maneuver was started with the patient resting on the proprioceptive disc (unstable ground) following the same positions described above.

For patients with pain complaints, it was prescribed by the attending physician ketoprofen 100mg every 12 hours for three days. In cases of persistence of pain (VAS greater than or equal to 3), dipyrone 1g was prescribed every six hours.

## Results

Between June 2020 and June 2022, 100 individuals were selected and included in our study: 49 men (49%) and 51 women (51%), 59 right ankles (59%), and 41 left ankles (41%) were evaluated. The mean age of the participants was 45 years (18-79 years), and 84.3% practiced physical activity regularly. As for the individuals who refused to participate in the study, they were treated with a standard protocol or referred to other physiotherapy services, according to the will expressed by each individual. Only patients who reported that was the first episode of a sprain were included. The mean time between the sprain onset and the evaluation was 18.9 hours. Regarding the mechanism of trauma, all patients presented sprains in ankle inversion, and 15% did not know what was the direction of the sprain, which ended up being elucidated later with clinical evaluation.

Nine patients (9%) had no edema at the initial physical examination. Of the patients with swollen ankles (91/100), 78 (78%) had greater edema on the lateral side, nine (9%) on the medial side and four (4%) on the anterior side. Regarding ecchymosis, 87 patients (87%) had no such alteration in the primary examination, two had anteromedial ecchymosis (2%), four anterolateral (4%), two medial (2%), two lateral (2%), two anterolateral (2%) and lateral and medial (2%). All patients underwent simple radiographic evaluation with weight-bearing, and none presented alteration. No patient experienced any adverse event secondary to physical examination or additional examinations.

Regarding the recurrence rate, as observed in Table 1, a rate of 6% (CI: 95%) was observed, being statistically significant ($p < 0.001$) when compared to the population without recurrence after treatment. No sprain or other adverse effect related to the execution of the destabilization maneuver was observed.

The full sample (All) was analyzed and segmented by group of new sprain episodes and sex. A statistically significant difference was found between the three periods in the All group and the subgroups. Thus, in all comparisons, the Wilcoxon test was used to compare the moments in pairs.

In the CAIT score, a statistical difference between the times was found in all segmentations. In the All group, the mean started at 16.54, went up to 26.22 at the end of treatment, and even more to 28.65 after 12 months (SD 2.95, CI: 0.58, p-value < 0.001) (Table 1). The AOFAS score showed statistical differences in all periods; the All group had the initial value of 41.67 and, at the end of 12 months, 98.38 (Table 2).

In the VAS score, a statistically significant difference was found in all segmentations. A reduction in values was always observed. In the All group, the mean started at 5.94, decreased to 1.29 at the end of treatment, and decreased to 0.35 after 12 months (SD: 0.41 CI: 0.08, p-value < 0.001) (Table 3).

In the SF-12 score, a statistically significant difference was found between the times, but in the subgroup with new sprain episodes, no difference between the onset was observed (with a mean of 24.33) compared to the 12-month mean of 24.17 (SD: 2.17, CI: 0.43, p-value = 0.43) (Table 4).

## Discussion

Our study concentrated on patients who experienced an inversion sprain as their trauma mechanism, which accounted for 100% of the cases in our sample. The population had a mean age of 45 (18-79 years) with a sprain history in the last 48 hours.

Considering the primary outcome of our study (new sprain episodes), a possible reduction in the sprain index was observed when the inversion destabilization maneuver was added to the conventional rehabilitation protocol, findings that align with the literature since the most current studies on the prevention or even treatment of lateral ankle sprains

**Table 1.** Comparison between periods for CAIT score.

| CAIT | | Mean | Median | SD | Q1 | Q3 | N | CI | p-value |
|---|---|---|---|---|---|---|---|---|---|
| All | Start | 16.54 | 14,5 | 9.25 | 7.75 | 26 | 100 | 1.81 | **<0.001** |
| | End | 26.22 | 27 | 3.75 | 23.75 | 30 | 100 | 0.73 | |
| | 12m | 28.65 | 30 | 2.95 | 29 | 30 | 100 | 0.58 | |
| No re-sprain | Start | 16.99 | 15 | 9.33 | 7.25 | 26 | 94 | 1.89 | **<0.001** |
| | End | 26.24 | 27 | 3.76 | 24.25 | 30 | 94 | 0.76 | |
| | 12m | 29.13 | 30 | 2.07 | 30 | 30 | 94 | 0.42 | |
| With re-sprain | Start | 9.50 | 8 | 3.21 | 8 | 11.75 | 6 | 2.57 | **0.001** |
| | End | 25.83 | 26 | 3.97 | 23.5 | 29.25 | 6 | 3.18 | |
| | 12m | 21.17 | 20 | 4.58 | 19 | 24.75 | 6 | 3.66 | |
| Women | Start | 16.36 | 14 | 9.13 | 8 | 26 | 45 | 2.67 | **<0.001** |
| | End | 25.67 | 27 | 4.27 | 21 | 30 | 45 | 1.25 | |
| | 12m | 28.78 | 30 | 2.88 | 29 | 30 | 45 | 0.84 | |
| Men | Start | 16.69 | 15 | 9.43 | 7 | 25 | 55 | 2.49 | **<0.001** |
| | End | 26.67 | 27 | 3.23 | 25 | 30 | 55 | 0.85 | |
| | 12m | 28.55 | 30 | 3.02 | 29 | 30 | 55 | 0.80 | |

CAIT: Cumberland Ankle Instability Tool; SD: Standard deviation; CI: Confidence interval; 12m: 12 months.

**Table 2.** Comparison between periods for AOFAS score.

| AOFAS | | Mean | Median | SD | Q1 | Q3 | N | CI | p-value |
|---|---|---|---|---|---|---|---|---|---|
| All | Start | 41.67 | 12 | 36.15 | 10 | 82 | 100 | 7.09 | **<0.001** |
| | End | 93.05 | 90 | 6.60 | 86 | 100 | 100 | 1.29 | |
| | 12m | 98.38 | 100 | 4.71 | 100 | 100 | 100 | 0.92 | |
| No re-sprain | Start | 43.67 | 12 | 36.38 | 10 | 82 | 94 | 7.35 | **<0.001** |
| | End | 93.28 | 90 | 6.62 | 86 | 100 | 94 | 1.34 | |
| | 12m | 99.36 | 100 | 2.46 | 100 | 100 | 94 | 0.50 | |
| With re-sprain | Start | 10.33 | 11 | 1.97 | 8.5 | 12 | 6 | 1.57 | **0.002** |
| | End | 89.50 | 88.5 | 5.61 | 85.5 | 90 | 6 | 4.49 | |
| | 12m | 83.00 | 83.5 | 5.02 | 81.25 | 85 | 6 | 4.02 | |
| Women | Start | 39.29 | 12 | 35.70 | 10 | 82 | 45 | 10.43 | **<0.001** |
| | End | 91.82 | 90 | 7.06 | 85 | 100 | 45 | 2.06 | |
| | 12m | 98.16 | 100 | 5.21 | 100 | 100 | 45 | 1.52 | |
| Men | Start | 43.62 | 12 | 36.73 | 10 | 82 | 55 | 9.71 | **<0.001** |
| | End | 94.05 | 90 | 6.09 | 90 | 100 | 55 | 1.61 | |
| | 12m | 98.56 | 100 | 4.30 | 100 | 100 | 55 | 1.14 | |

AOFAS: The American Orthopaedic Foot & Ankle Society; SD: Standard deviation; CI: Confidence interval; 12m: 12 months.

point to sensorimotor training as one of the few strategies effectively capable of preventing new sprain episodes[11].

It also could be observed with the epidemiological data obtained, a higher incidence of lateral sprains in women (51%), data that aligns with the current literature that shows a higher incidence of these injuries in young women, exactly as described by Doherty et al.[12], who pointed out the female public as having an increased risk for ankle sprains[13].

Many are the modalities known in clinical practice to optimize the sensorimotor condition of the lower limb; however, in most of the studies, the lack of specific techniques for ankle stability was observed; that is, the focus of the interventions ends up being the lower limb as a whole and even the spine, structures that should undoubtedly be considered and addressed during the rehabilitation process of lateral ankle sprains. The maneuver described in this study is easy to reproduce since it requires only a proprioceptive disc and an elastic band, materials easily found in physiotherapy clinics, thus facilitating its insertion in rehabilitation programs and working together with other techniques[9,14,15].

Techniques with some action on ankle stability are available; among these, the Hop and Y-balance tests can be highlighted. This is a set of progressive maneuvers to evaluate functional limitations in the lower limb after injury to the anterior cruciate

**Table 3.** Comparison between periods for VAS score.

| VAS | | Mean | Median | SD | Q1 | Q3 | N | CI | p-value |
|---|---|---|---|---|---|---|---|---|---|
| All | Start | 5.94 | 6.0 | 1.95 | 4.8 | 7.0 | 100 | 0.38 | **<0.001** |
| | End | 1.29 | 1.0 | 1.13 | 0.0 | 2.0 | 100 | 0.22 | |
| | 12m | 0.35 | 0.0 | 0.88 | 0.0 | 0.0 | 100 | 0.17 | |
| No re-sprain | Start | 5.84 | 6.0 | 1.92 | 4.0 | 7.0 | 94 | 0.39 | **<0.001** |
| | End | 1.31 | 1.0 | 1.15 | 0.0 | 2.0 | 94 | 0.23 | |
| | 12m | 0.18 | 0.0 | 0.41 | 0.0 | 0.0 | 94 | 0.08 | |
| With re-sprain | Start | 7.50 | 7.0 | 1.76 | 6.0 | 8.8 | 6 | 1.41 | **0.002** |
| | End | 1.00 | 1.0 | 0.89 | 0.3 | 1.8 | 6 | 0.72 | |
| | 12m | 3.00 | 2.5 | 1.79 | 2.0 | 3.8 | 6 | 1.43 | |
| Women | Start | 6.11 | 6.0 | 1.98 | 5.0 | 8.0 | 45 | 0.58 | **<0.001** |
| | End | 1.36 | 1.0 | 1.03 | 0.0 | 2.0 | 45 | 0.30 | |
| | 12m | 0.38 | 0.0 | 1.05 | 0.0 | 0.0 | 45 | 0.31 | |
| Men | Start | 5.80 | 6.0 | 1.93 | 4.0 | 7.0 | 55 | 0.51 | **<0.001** |
| | End | 1.24 | 1.0 | 1.22 | 0.0 | 2.0 | 55 | 0.32 | |
| | 12m | 0.33 | 0.0 | 0.72 | 0.0 | 0.0 | 55 | 0.19 | |

VAS: Visual analog scale; SD: Standard deviation; CI: Confidence interval; 12m: 12 months.

**Table 4.** Comparison between periods for SF-12 score.

| SF-12 | | Mean | Median | SD | Q1 | Q3 | N | CI | p-value |
|---|---|---|---|---|---|---|---|---|---|
| All | Start | 24.20 | 25.5 | 3.49 | 21 | 27 | 100 | 0.68 | **<0.001** |
| | End | 27.49 | 28 | 1.93 | 26 | 29 | 100 | 0.38 | |
| | 12m | 29.69 | 30 | 2.17 | 29 | 30 | 100 | 0.43 | |
| No re-sprain | Start | 24.19 | 26 | 3.50 | 21 | 27 | 94 | 0.71 | **<0.001** |
| | End | 27.51 | 28 | 1.96 | 26 | 29 | 94 | 0.40 | |
| | 12m | 30.04 | 30 | 1.67 | 29 | 30.75 | 94 | 0.34 | |
| With re-sprain | Start | 24.33 | 24.5 | 3.61 | 24 | 25.75 | 6 | 2.89 | **0.009** |
| | End | 27.17 | 27 | 1.47 | 26.25 | 27 | 6 | 1.18 | |
| | 12m | 24.17 | 24.5 | 1.72 | 24 | 25 | 6 | 1.38 | |
| Women | Start | 23.87 | 25 | 3.67 | 19 | 26 | 45 | 1.07 | **<0.001** |
| | End | 27.38 | 28 | 2.03 | 26 | 29 | 45 | 0.59 | |
| | 12m | 29.67 | 30 | 2.00 | 29 | 30 | 45 | 0.58 | |
| Men | Start | 24.47 | 26 | 3.34 | 23 | 27 | 55 | 0.88 | **<0.001** |
| | End | 27.58 | 27 | 1.86 | 27 | 29 | 55 | 0.49 | |
| | 12m | 29.71 | 30 | 2.32 | 29 | 30.5 | 55 | 0.61 | |

SF-12: Health Survey 12; SD: Standard deviation; CI: Confidence interval; 12m: 12 months.

ligament. However, rehabilitation professionals have also used lateral ankle instability as an integral part of sensorimotor training and discharge criteria for patients with lower limb alterations, unlike the technique of this study, which focuses exclusively on sensorimotor training of the ankle[9,14,15].

In a systematic literature review, Caldemeyer et al.[16] examined the literature for specific neuromuscular training protocols for women that could reduce the risk of new sprain episodes[16]. They included seven studies that combined 5,187 women who generally practiced basketball, volleyball, or football. When analyzing the table presented by the study with the description of the training, it can be observed that the protocols described are always focused on the neuromuscular control of the lower limb and spine, ranging from stable to unstable surfaces in addition to plyometrics and specific gestures of each sport without, however, focusing on the ankle joint and the multidirectional and biomechanical planes of this joint. The authors conclude that the results point to the effectiveness of neuromuscular training protocols in preventing sprain episodes.

In his study, Stasinopoulos observed the effectiveness of specific technical training, proprioceptive training, and orthosis in preventing sprain episodes in volleyball players. The proprioceptive training group followed a technique described by the author (balance chart) every day, 30 minutes daily throughout the season. His findings suggest all three preventive strategies were effective in athletes who suffered an ankle sprain only once or twice during their career. In athletes who suffered three ankle sprain episodes, technical training seemed more effective than the other two preventive methods. The use of orthosis proved effective in athletes who suffered an ankle sprain more than three times during their career. In this case, technical and proprioceptive training were equally effective in preventing further sprains[17].

Handoll et al.[18], in their Cochrane review, evaluated the effects of interventions used to prevent ligament injuries or ankle sprains in physically active individuals from adolescence to middle age. Five randomized trials with data from 3,954 participants were included. All trials involved young, active, mostly male adults participating in high-risk activities, usually sports. Except for ankle training on the disc, all prophylactic interventions involved the application of external ankle support in the form of semi-rigid orthosis, bandages, or high-top shoes. A significant reduction in ankle sprains can be observed in people who received external ankle support, and there is limited evidence of ankle sprain reduction for those with previous ankle sprains who did ankle disc training exercises. As previously described, the external stability provided by orthoses also has positive impacts on the prevention of new sprain episodes, which is why we use them as a transition between the immobilization period and advanced sensorimotor training since the ankle musculature is supposed to have decreased activity[18].

The main limitation of the maneuver described in this study is the absence of a device to accurately measure the ankle's angulation during execution, meaning the stimuli are applied approximately at the start, middle, and end of the movement. Additionally, the study's implementation at a single center limits external validity, and the absence of a randomized control group represents another limitation.

The main hypothesis of this study was confirmed: in 12 months, patients with ankle sprains had a lower rate of new ankle sprain episodes.

## Conclusions

Based on our findings, a 12-month follow-up, the ankle inversion destabilization maneuver added to a standard rehabilitation protocol based on the current literature effectively prevented new lateral ankle sprain episodes after a first sprain. In addition, it positively impacts pain reduction, improved quality of life, and symptoms of ankle instability.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: DAOG *(https://orcid.org/0009-0003-9479-3629), and NSBM *(https://orcid.org/0000-0003-1067-727X) Conceived and planned the activity that led to the study, wrote the article, participated in the review process; GHCA *(https://orcid.org/0000-0002-6458-6317) Wrote the article, participated in the review process; TSM *(https://orcid.org/0000-0003-4168-0981) Interpreted the results of the study, participated in the review process; ACP *(https://orcid.org/0000-0003-3229-2063) Participated in the review process, formatting of the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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**Appendix 1.** Post ankle sprain rehabilitation protocol

| Post Ankle Sprain Rehabilitation Protocol |
|---|
| **0-1 week** |
| - Prevention of ankle flexion and inversion movements. |
| - Full-time immobilization in an immobilizer boot. |
| - Partial weight-bearing with axillary crutches bilaterally. |
| - Cryotherapy for pain and edema control performed twice a day for 20 minutes. |
| **1-4 weeks** |
| - Prevention of ankle flexion and inversion movements. |
| - Full-time immobilization in semi-rigid orthosis. |
| - Partial weight-bearing with axillary crutches unilaterally. |
| - Ankle everters strengthening. |
| - Ankle extenders strengthening. |
| - Isometric ankle flexors strengthening. |
| - Isometric ankle inverters strengthening. |
| - Posterior chain active-assisted stretching. |
| - Beginning of sensorimotor training. |
| - Removal of the semi-rigid orthosis (third week). |
| **4-6 weeks** |
| - Total weight-bearing without auxiliary crutches. |
| - Prevention of forced ankle inversion movement. |
| - Prevention of forced ankle flexion movement. |
| - Active ankle inverters strengthening, allowing only 10º of movement, evolving to 20º at the beginning of the sixth week. |
| - Active ankle flexors strengthening, allowing only 10º of movement, evolving to 20º at the beginning of the sixth week. |
| - Evolution of ankle sensorimotor training according to individual capacity. |
| - Maintenance and evolution of ankle everter strengthening. |
| - Maintenance and evolution of ankle extensor strengthening. |
| **6-7 weeks** |
| - Prevention of forced ankle inversion movement. |
| - Prevention of forced ankle flexion movement. |
| - Active ankle inverters strengthening, allowing only 20º of movement, evolving to 30º at the beginning of the sixth week. |
| - Maintenance and evolution of ankle everter strengthening. |
| - Active ankle flexors strengthening, allowing only 20º of movement, evolving to 30º at the beginning of the sixth week. |
| - Insertion of the ankle inversion destabilization maneuver on stable ground. |
| - Beginning of plyometric exercises. |
| **7-8 weeks** |
| - Insertion of the ankle inversion destabilization maneuver on unstable ground. |
| - Active ankle inverters strengthening in full motion. |
| - Active ankle flexors strengthening in full movement and a closed kinetic chain. |
| - Maintenance and evolution of ankle everter strengthening. |
| - Maintenance and evolution of ankle extensor strengthening. |
| - Maintenance and evolution of plyometric exercises. |