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Authors: López-González L, Falla D, Lázaro-Navas I, Lorenzo-Sánchez-Aguilera C, Rodríguez-Costa I, Pecos-Martín D, Gallego-Izquierdo T

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Effects of Dry Needling on Neuromuscular Control of Ankle Stabilizer Muscles and Center of Pressure Displacement in Basketball Players with Chronic Ankle Instability: A Single-Blinded Randomized Controlled Trial

https://orcid.org/0000-0001-6451-0083

https://orcid.org/0000-0003-4634-9200

https://orcid.org/0000-0003-3074-3270

Lorenzo-Sánchez-Aguilera

https://orcid.org/0000-0002-6645-2187

https://orcid.org/0000-0001-8690-0998

luislopezgonzalez4@gmail.com

cris_lorenzo85@hotmail.com

isabel.rodriguezc@uah.es

This study aimed to compare the effects of dry needling (DN) versus placebo DN applied to the peroneus longus (PL) and tibialis anterior (TA) on neuromuscular control and static postural control in basketball players with chronic ankle instability (CAI). A single-blinded randomized controlled trial was conducted. Thirty-two male and female basketball players with CAI were randomly assigned to receive either DN (

chronic ankle instability

surface electromyography

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After an initial ankle sprain, anatomical changes such as laxity, impaired arthrokinematics, or synovial changes can lead to joint insufficiencies that predispose to recurrent ankle sprains [

As a result, a wide variety of altered feedback/feed-forward mechanisms has been shown in subjects with CAI, but it remains uncertain whether these deficits are due to local or spinal/supraspinal conditions [

These changes that occur in people with CAI may be correlated with the presence of myofascial trigger points (MTrPs) [

Dry needling (DN) is a technique that aims to diminish persistent peripheral nociceptive inputs by targeting MTrPs [

Thus, the primary objective of this study was to evaluate the short and medium-term of DN applied on latent MTrPs in PL and TA on EMG pre-activation amplitudes of these muscles immediately before the initial foot contact during a dynamic landing maneuver performed by basketball players with CAI. The second objective was to analyze CoP displacement and sway variability during a single leg balance test (SLBT) as a representative measure of static postural control. We hypothesized that DN would be effective both in the decrease of CoP displacement measures during the SLBT and in the increase of PL and TA pre-activation during the landing maneuver in basketball players with CAI.

2. Materials and Methods

A randomized, third-party, single-blinded (subjects and statistician), parallel, controlled trial was conducted following approval from the Committee for Research and Animal Experimentation Ethics of the University of Alcalá, Spain (CEIM/HU/2015/18). The study was prospectively registered in the Australian New Zealand Clinical Trials Registry (ACTRN12616000386437). The study was designed following Consolidated Standards of Reporting Trials (CONSORT) criteria. Ethical principles for clinical research in humans displayed in the Helsinki Declaration were considered. All subjects signed the informed consent and their rights were protected.

2.1. Participant Selection and Randomization

The study population included basketball players aged 18 and over with CAI (Madrid, Spain) meeting selection criteria for the diagnosis of patients with CAI [

The Spanish Version of the Cumberland Ankle Instability Tool (CAIT) [

2.2. Sample Size Calculation and Randomization

The sample size was obtained using GPower 3.0.18 software. Considering pre-activation as the primary outcome, an effect size (ES) of 0.25 was considered and the correlation between repeated measurements was assumed at 0.5. By setting four measurements in two treatment groups, sphericity correction determined a total sample size of 24, with a statistical power of 0.80 and an alpha level of 0.05. Considering a potential 20% dropout, 32 patients were recruited (16 per group) [

At the beginning of the session, the subjects completed a questionnaire to acquire their anthropometric data and exercise habits.

Measures of EMG (pre-activation) and static postural control (AP and ML displacement and sway variability) (see below) were performed at baseline and then repeated immediately after the intervention, at 48 h, and at one month after the intervention to verify the short and medium-term effects. Exercise practices were controlled for both groups within the time the study was conducted. These measures were obtained by the same physiotherapist, who was not involved in DN treatment.

2.3.1. Electromyographic Assessment of a Landing Maneuver

Prior to electrode placement, the skin was shaved, cleaned, and checked for impedance. Circular 20 × 20 mm pre-amplified bipolar surface electrodes (SX230, Biometrics Ltd. Gwent, UK) were used. With an inter-electrode distance of 20 mm, the electrodes were positioned parallel to the TA and PL muscle fibers following the guidelines for electrode placement (SENIAM recommendations) [

A ground electrode (R506, Biometrics Ltd., Gwent, UK) was placed on the bony prominence of the ulnar styloid. The EMG signals were synchronized with a video file obtained using a video camera Casio EX-FH100 Exilim which permitted obtaining up to 1000 frames per second. A handheld switch with LED (IS3LED, Biometrics Ltd., Gwent, UK) set the start point for the video record and electrical registration and allowed the electrical event to be related to phases of the landing test accurately.

The landing maneuver (

The preparatory muscle activity (pre-activation) was computed using PC DATALOG Software version 8.51 (Biometrics Ltd., Gwent, UK) and the initial contact was defined as the first video frame in which the foot contacted the ground during the landing task.

The EMG raw signals were sampled at 1000 Hz and all EMG data were low pass filtered with a common-mode rejection ratio of 110 dB (30 Hz–400 Hz). Then, signals were normalized with respect to peak contraction amplitude averaged from 5 records for each participant, which was obtained before performing the landing maneuver. An analysis window of 200 ms prior to initial contact was set. Then, the analog values of the raw signal were automatically converted into digital values with the Root Mean Square (RMS) analysis, using a time constant of 50 ms. Then, using the RMS values this software calculated the EMG integrated signal, expressed in millivolts/second (mV/s), which permitted to obtain the amount of muscle activity (mV) in the pre-activation phase (200 ms prior to initial contact) [

2.3.2. Single Leg Balance Test Assessment

The SLBT was carried out immediately after the landing maneuver. A force platform (Kistler Type 5691A1) was used to measure the CoP. First, the weight in Newton (N) of each participant was collected, and subsequently, they stood barefoot in the center of the platform on the affected side, with their knee extended, eyes on a horizontal line, and with hands on the iliac crests. Three measurements, each of 10 s, were obtained. A valid attempt was considered when the participant remained stable without touching the ground with the raised limb during that time. The average of 3 valid attempts was used for the analysis [

Bioware 5.1.1.0 (Data Acquisition and InstaCal 6.22) was used to analyze the data. Test result graphs were designed by selecting the graph of displacement in the Ax and Ay axis with respect to measurements of the CoP. In the statistical table, range values in Ax and Ay were taken to establish the AP and ML displacement of the subject's CoP. The value of the standard deviation was assessed to compute AP and ML sway variability.

2.4. Intervention: Dry Needling and Placebo Dry Needling

Diagnosis of the most painful latent MTrPs of each muscle was determined by a physiotherapist with more than 4 years of experience in the diagnosis/treatment of MTrPs. After shaving and disinfecting the patient's skin with antiseptic alcohol, the physiotherapist located the most painful latent MTrPs of each muscle and used a needle, sized 0.25 × 0.25 × 50 mm (APS Agu-Punt), for needling (Hong technique) at a frequency of 1 Hz for 30 s (1 puncture per second) [

2.5. Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) v.22 software for Windows. All statistical tests were performed considering a

The homogeneity of the two intervention groups was studied using Student's T-test for independent samples in the data that were adjusted to the normal and the Mann-Whitney U test for those that did not. For gender, the number of training sessions, training time, and affected side variables the homogeneity were studied using Pearson's χ

The design was used to check if the differences in the analyzed variables were due to the treatment, the passing of time, or their interaction, and a general linear model of repeated measures was carried out. The sphericity assumption was checked with the Mauchly test and in the cases that did not meet the sphericity assumption, the Greenhouse-Geisser correction was used. Then the multiple comparisons by Bonferroni correction were applied and the effect size was estimated using the squared Eta parameter (η

A total of 63 subjects with a history of previous ankle sprains were screened and 31 were excluded as they did not present with CAI or did not meet the selection criteria. Finally, 32 met the established selection criteria (mean age 23.0 [5.0] years; 23 men and 9 women; weight 73.9 kg [11.1]; height 1.8 cm [0.1]; BMI 20.7 [2.6]) and were randomized into two groups: DN (

3.1. Electromyographic Assessment of Tibialis Anterior and Peroneus Longus

The comparison between experimental and control groups (

3.2. CoP Displacement and Sway Variability

Between group differences were found for the decrease of CoP displacement in the ML direction over time, with a large ES in favor of the DN group [F

Differences for the CoP displacement in the AP direction were also noted and a large ES was obtained for the DN group [F

Differences in ML and AP sway variability were obtained between baseline and the rest of follow-up measurements [F

After a single session of DN of latent MTrPs within the TA and PL muscles in basketball players with CAI, there was a significant increase in muscle pre-activation noted for PL and TA in favor of the DN group during a landing task (

Neuromuscular dysfunctions and postural control deficits observed in people with CAI have been correlated with the presence of MTrPs after suffering multiple ankle injury episodes [

Similarly, Salom-Moreno et al. [

These findings might have important clinical implications given that research has found that in the absence of a direct preparatory stimulus, people with CAI displayed decreased muscle pre-activation and activation values of the entire lower extremity during the unidirectional landing phase when performing a side hop task [

Dynamic joint stiffness (DJS) is defined as the joint constraint provided by the musculoskeletal system (ligaments, tendons, or muscles) in dynamic conditions [

Although changes in feed-forward neuromuscular behavior in the CAI population remain controversial given the heterogeneity of selection criteria, the different tasks considered for EMG analysis, or the choices of EMG measures [

In this sense, DN also was effective in reducing ML and AP CoP displacement and sway variability of basketball players with CAI, who showed a significant improvement of feedback stabilization strategies in favor of the DN group (

Study limitations included the lack of a control group of asymptomatic subjects to observe the behavior of their EMG activity compared to those with CAI. On the other hand, although statistically significant changes were obtained for the EMG variables and measures of postural control in the DN group, only the most affected limb was investigated and therefore, comparisons with neuromuscular control or postural control of the contralateral limb remain unknown. Additionally, the focus on PL and TA muscles only may limit the conclusions that can be drawn on the effect of DN on neuromuscular control of the lower limb as a whole. Further prospective studies with longer follow-ups are required to understand whether this is a clinically relevant change in terms of the prevention of future ankle injuries.

The current study provides further knowledge of DN as a treatment of choice in subjects with CAI, showing good results (relative to placebo DN) at increasing pre-activation of ankle stabilizer muscles (PL and TA), both in the short and medium- term. Static postural control also improved following DN, resulting in lower CoP displacement and sway variability in AP and ML directions during a SLBT. These initial results show the potential value of DN in terms of improving feedback and feed-forward strategies, which could be considered within a comprehensive rehabilitation program for people with CAI, inclusive of proprioception and strengthening exercises.

Conceptualization, L.L.-G., D.P.-M. and T.G.-I.; methodology, L.L.-G., I.L.-N. and C.L.-S.-A.; software, L.L.-G.; formal analysis, I.L.-N.; investigation, L.L.-G. and I.R.-C.; resources, D.P.-M. and T.G.-I.; data curation, L.L.-G.; writing—original draft preparation, L.L.-G., D.F., I.L.-N. and C.L.-S.-A.; writing—review and editing, D.P.-M., T.G.-I.; visualization, L.L.-G.; supervision, I.R.-C. and D.F. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the or Ethics Committee of the University of Alcalá (CEIM/HU/2015/28).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Conflicts of Interest

The authors declare no conflict of interest.

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