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Predictors of chronic ankle instability: Analysis of peroneal reaction time, dynamic balance and isokinetic strength☆

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ABSTRACT

Background: Previous studies have reported the factors contributing to chronic ankle instability, which could lead to more effective treatments. However, factors such as the reflex response and ankle muscle strength have not been taken into account in previous investigations.

Methods: Fifty recreational athletes with chronic ankle instability and 55 healthy controls were recruited. Peroneal reaction time in response to sudden inversion, isokinetic evertor muscle strength and dynamic balance with the Star Excursion Balance Test and the Biodex Stability System were measured. The relationship between the Cumberland Ankle Instability Tool score and performance on each test was assessed and a backward multiple linear regression analysis was conducted.

Findings: Participants with chronic ankle instability showed prolonged peroneal reaction time, poor performance in the Biodex Stability System and decreased reach distance in the Star Excursion Balance Test. No significant differences were found in eversion and inversion peak torque. Moderate correlations were found between the Cumberland Ankle Instability Tool score and the peroneal reaction time and performance on the Star Excursion Balance Test. Peroneus brevis reaction time and the posteromedial and lateral directions of the Star Excursion Balance Test accounted for 36% of the variance in the Cumberland Ankle Instability Tool.

Interpretation: Dynamic balance deficits and delayed peroneal reaction time are present in participants with chronic ankle instability. Peroneus brevis reaction time and the posteromedial and lateral directions of the Star Excursion Balance Test were the main contributing factors to the Cumberland Ankle Instability Tool score. No clear strength impairments were reported in unstable ankles.

1. Introduction

After their first ankle sprain, patients can suffer residual symptoms such as pain, swelling, recurrent sprains, episodes of the ankle joint "giving away" or decreased function (Arnold et al., 2009b; Delahunt et al., 2010), which is referred to as Chronic Ankle Instability (CAI) (Delahunt et al., 2010). Among self-reported outcome instruments that are commonly used to determine the presence of CAI, one of the most employed is the Cumberland Ankle Instability Tool (CAIT) (Arnold et al., 2009b; Hiller et al., 2006), a questionnaire that also assesses the severity of the instability, with a lower score meaning decreased ankle function.

Several authors have associated CAI with certain deficits, but results are equivocal. While some studies have reported a delayed reaction time (RT) in ankles with CAI (Donahue et al., 2014; Hoch and McKeon, 2014; Mendez-Rebolledo et al., 2015), no differences have been found in other studies (Eechaute et al., 2009; Munn et al., 2010). Similarly, some authors have associated CAI with ankle weakness (Arnold et al., 2009b; Willems et al., 2002), whereas no deficits have been reported by others (Kaminski and Hartsell, 2002). Furthermore, dynamic balance impairments have also been found in participants with CAI (Arnold et al., 2009a; Munn et al., 2010).

These deficits have been connected to CAI individually and with conflicting findings (Thompson et al., 2016). A few studies have taken a multifactorial approach (Houston et al., 2015; Rosen et al., 2016). Houston et al. (2015) analysed the prevalence of clinician and laboratory-oriented measures of function capable of explaining health-related quality of life in individuals with CAI. It was found that postural control, dorsiflexion range of motion, plantar cutaneous sensation, and ankle arthrometry contributed to a significant proportion of the variance associated with health-related quality of life. Rosen et al. (2016) examined how the active range of motion, dynamic postural stability and lateral ankle laxity and stiffness contribute the most to self-reported dysfunction as measured by the CAIT (Hiller et al., 2006). Previous

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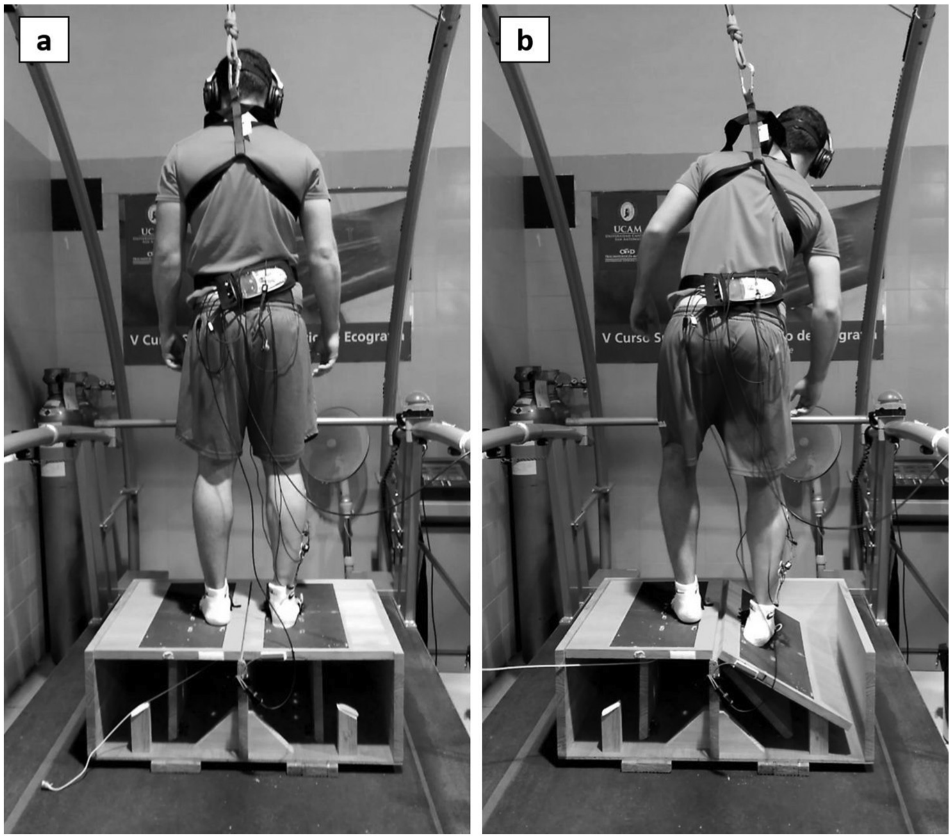

Fig. 1. (a) Participant waiting on the custom-designed ankle inversion platform, (b) Participant after the opening of the platform causing an ankle inversion of 30°.

studies have identified balance measures as one of the contributing factors to CAI from a multifactorial approach (Hartsell and Spaulding, 1999). Other functional measures such as the reflex response or ankle muscle strength have been broadly studied individually, and have been found to be impaired in individuals with CAI (Hertel et al., 2006). However, research is lacking about the contribution of these functional measures to CAI using comparative factor analysis. Identifying the strongest contributors to CAI may help clinicians to develop more effective rehabilitation strategies to address this clinical condition. Therefore, the aim of this study was to analyse peroneal RT, dynamic balance and strength in participants with CAI compared to healthy participants, and to determine what factors contribute the most to CAI. Based on previous literature, it was hypothesised that peroneal RT, dynamic balance and isokinetic strength would be impaired in unstable ankles and be the main contributing factors to CAI.

2. Methods

2.1. Participants

One hundred and five recreational athletes volunteered to participate in the study. They were divided into a CAI group (n = 50, age: 22.6 (2.8) years, height: 172.0 (9.2) cm, body mass: 69.1 (10.1) kg, CAIT: 19.5 (3.4) points), and a healthy group (n = 55, age: 20.9 (1.9) years, height: 172.0 (7.9) cm, body mass: 66.5 (10.8) kg, CAIT: 28.7 (1.4 points). Sample size was previously calculated based on Linens et al. (2014), who measured posteromedial reach direction comparing participants with and without CAI. The minimal number of subjects required for obtaining a power of 0.9 and a bilateral alpha level of 0.05 was calculated to be 50.

Participants in the CAI group were included if they reported a history of at least 1 significant ankle sprain (the most recent injury must have occurred > 3 months prior to study enrolment), 2 or more episodes of the ankle giving way in the last 6 months and a score of ≤24 on the CAIT (Hiller et al., 2006) in their dominant ankle. All subjects had right dominant legs (the one they would use to kick a ball) (Hertel et al., 2006). Exclusion criteria for both groups included a history of previous surgeries to the musculoskeletal structures in either lower extremity, a history of a fracture in either lower extremity requiring realignment, or an acute injury to musculoskeletal structures of other joints in the lower extremity in the previous 3 months that impacted joint integrity and function, resulting in at least 1 interrupted day of desired physical activity (Gribble et al., 2014). Each participant was informed of the risks and discomforts associated with this investigation and signed an informed consent document before the onset of the experiments. The experimental protocol was approved by the Ethics Committee of Clinical Research at the Hospital Complex in Toledo (Spain).

2.2. Procedures

A cross-sectional design was used for the study. The first day participants completed the CAIT, were familiarised with the testing procedure and each participant's position on the dynamometer was recorded to ensure that the test was always carried out under the same conditions. Forty-eight hours later measurements were taken in the following order: 1. Peroneal RT, 2. Balance test on the Biodex Stability System (BSS), 3. Star Excursion Balance Test (SEBT), 4. Isokinetic strength test. All tests were performed at the same time of day (between 9 am and noon). Individual testing procedures are described below.

2.2.1. Peroneal reaction time test

RT of the peroneus longus (PL) and peroneus brevis (PB) were measured. Surface electrodes (Ag/AgC1 sensor, Ambu Blue Sensor N-00-S/25, Ambu A/S, Ballerup, Denmark) were placed following the guidelines for surface electromyography in non-invasive muscle