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Individuals with chronic ankle instability exhibit decreased postural sway while kicking in a single-leg stance

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ABSTRACT

Individuals with chronic ankle instability (CAI) usually experience deficits in balance control, which increase displacement in the body's center of pressure (COP) when they balance on a single leg. Little is known, however, about whether or not these individuals use the strategies of postural adjustment properly, especially during functional tasks that may predispose them to ankle sprain. The aim of this study was to investigate anticipatory (APA) and compensatory (CPA) postural adjustments in individuals with and without CAI as they kick a ball while standing in a single-leg stance with their ankle in neutral and supinated positions. COP displacements were calculated and their magnitudes (range) analyzed during APA and CPA intervals and over the duration of the whole task, represented by the COP area of sway and mean velocity. The CAI group exhibited a significant decrease in CPA and area of sway over the whole task, relative to controls. These results suggest that the decreased balance sway could be caused by the need for further stabilization of the ankle in more unstable postures to prevent recurrent sprain. Our findings could help clinicians to better understand the strategies of postural adjustments in individuals with CAI, and may assist and motivate new investigations into balance control interventions in such individuals, as well as proactively address recurrent ankle sprain conditions.

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1. Introduction

A lateral ankle sprain is one of the most common sports injuries [1], and it often leads to chronic ankle instability (CAI) [2]. CAI is characterized by recurrent sprains or the feeling of an ankle "giving way", or both [3]. A deficit in postural control is one of the main symptoms of this condition [4–6] and is usually documented by visual inspection [4] or by increased displacement of the body center of pressure (COP) when these individuals balance in a single-leg stance [5–9]. For this reason, standard care in the rehabilitation of patients with CAI involves balance training (see [5,10] for review). This includes such maneuvers as balancing on one leg while postural disturbances are delivered via unstable surfaces, or by being physically perturbed via a pull or push, or asked to throw, catch or kick a ball [11,12].

Studies involving balance perturbation training while standing on unstable surfaces have shown that body disturbances target more than just ankle proprioception. They also may affect proprioceptive afferent signals from other anatomical origins like the hip and spine [13]. Therefore, while dealing with the postural challenges caused by perturbation training, individuals must not only control their ankle position, but the position of their entire body before and after the perturbation to maintain equilibrium [14]. To achieve this, they utilize two principal strategies: (1) anticipatory postural adjustments (APAs) that are driven by feed-forward mechanisms and used to minimize the adverse effects of predictable upcoming disturbance [15]; and (2) compensatory postural adjustments (CPAs), which deal with the disturbance itself after the perturbation and depend upon feedback mechanisms. CPAs can be further subdivided into early and late responses after the perturbation, to differentiate between reflex responses and voluntary reactions, respectively [16]. APAs and CPAs are usually observed via electromyographic (EMG) recordings of muscle activity, as well as by COP displacement and joint movement [15,16]. Although postural perturbations are chief among a therapists' tools to restore ankle proprioceptive acuity

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and, consequently, postural control in patients with CAI, little is known about how these patients control their APAs and CPAs during these tasks. Furthermore, disregarding studies using hop/jump-landing tasks, empirical data on COP displacements during dynamic perturbation tasks are scarce.

Changes in the magnitude of APAs and CPAs resulting from modifications in body configuration [17] and stability [14] are well established in the literature. Thus, dynamic tasks for individuals with CAI that further challenge their ankle/body instability may influence the strategies of postural control. For example, the reactive responses (CPAs) of patients with CAI due to electrical stimulation [18] and landing [19] are greater with the ankle in a supinated than neutral position. It therefore is important to know if postural control strategies used by individuals with CAI change depending on the position of the ankle (*i.e.*, supinated), a condition that could predispose them to episodes of the ankle 'giving way'.

This study investigated the strategies of postural control and postural stability in subjects with CAI when challenged by postural perturbations that are common during sports and rehabilitation. In this task, the subjects were required to kick a moving ball while standing in a single-leg stance with the supporting ankle positioned in neutral or supination. The COP displacements were calculated and analyzed during time intervals typical for APAs and CPAs, as well as over the duration of the entire task. Based upon studies of postural balance in individuals with CAI, our hypothesis was that the postural control strategy would be affected in these individuals as they usually demonstrate greater COP displacement during static and dynamic tasks [6,8]. The knowledge gleaned from the current study will be important to better understanding potential balance control deficits in patients with CAI during dynamic tasks, as well as for the design of new investigative studies aiming to generate better therapeutic approaches. For example, the presence of robust APA results in decreased CPA after postural disturbances, and vice versa [15,16]; thus, the former may be interpreted as better balance control during a dynamic task.

2. Methods

2.1. Participants

A total of 42 young adults were recruited from the local community (University and surroundings) and sorted into two groups: 21 individuals with CAI (CAI group – 13 women and 8 men; mean age 25 years, range 20–31) and 21 healthy individuals matched for age and gender (control group – 13 women and 8 men; mean age 25 years, range 21–31). The inclusion criteria for the CAI group were: (1) a history of two or more sprains of the same ankle, including at least one sprain within the last six months; (2) sensation of ankle instability presenting as the ankle "giving way" unilaterally. The exclusion criteria were: (1) acute inflammatory symptoms; (2) a history of fracture or surgery in either ankle; and (3) any other orthopedic, muscular, or neurological condition that could affect sensation or ankle control. Individuals in the healthy comparison group were free of any history of severe ankle, knee, and/or hip injuries, neurological disorder, or any other pathological condition that could impair motor performance. All participants were informed about the objectives of the research and procedures to be performed, and had signed an informed consent form approved by the local Ethics Committee (protocol number 205/2011) prior to their participation.

2.2. Materials

The Cumberland Ankle Instability Tool (CAIT) was used to assess the severity of CAI; lower scores, from 0 to 30, indicate more severe instability. The subjects' age, body weight, height, and number of lateral sprains were also recorded.

A force platform (AMTI-OR 6-7, Watertown, EUA®), positioned on the floor, was used to register ground reaction forces (Fx, Fy, and Fz) and associated moments (Mx, My, and Mz). The timing of leg movement during the act of kicking the ball was identified by an accelerometer attached to the lower leg (see details below). All signals were sent to a computer through a digital/analog acquisition system (model PCI 6259, National Instruments, USA) with a frequency of 200 Hz and resolution of 16 bits, acquired in a LabView environment (SignalExpress® 2010, Version 4.0. 0 for Windows®, National Instruments, USA).

A lab-made ball launcher was constructed to ensure similarity of the experimental tasks between trials and between subjects. The launcher was an adjustable steel tripod (80–140 cm in length) coupled to a halved PVC pipe (120 cm long, cut longitudinally). The height of the PVC pipe was fixed at 83 cm in relation to the support surface on which the subjects were standing, and the pipe was inclined 30° forward to form an angle of 60° with the tripod (Fig. 1). In this way, the official futsal ball (350 g) would reach each subject at a similar latency, height, and speed once launched.

2.3. Procedures

Participants were positioned in single-leg stance with the supporting ankle joint in either one of two different positions: (1) the neutral position, in which they stood on the even surface of the force platform, and (2) a supinated position, wherein the participants were standing with their foot on an inclined

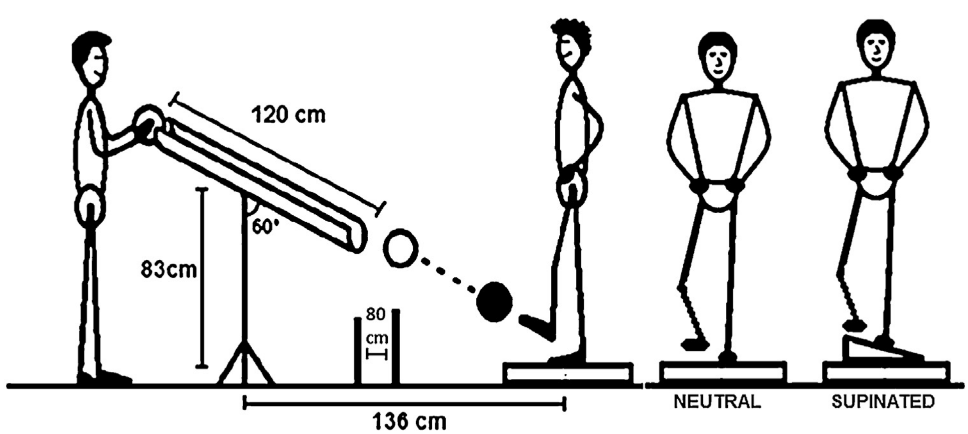

Fig. 1. Representation of the experimental task. The ball launcher and surfaces used to position the ankle in the neutral and supinated positions are illustrated (left and right panels, respectively).