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Original Research

Postural stabilization after single-leg vertical jump in individuals with chronic ankle instability

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ABSTRACT

Objectives: To investigate the impact different ways to define reference balance can have when analysing time to stabilization (TTS). Secondarily, to investigate the difference in TTS between people with chronic ankle instability (CAI) and healthy controls.
Design: Cross-sectional study.
Setting: Laboratory.
Participants: Fifty recreational athletes (25 CAI, 25 controls).
Main outcome measures: TTS of the center of pressure (CoP) after maximal single-leg vertical jump using as reference method the single-leg stance, pre-jump period, and post-jump period; and the CoP variability during the reference methods.
Results: The post-jump reference period had lower values for TTS in the anterior-posterior (AP) direction when compared to single-leg stance ($P = 0.001$) and to pre-jump ($P = 0.002$). For TTS in the medio-lateral (ML) direction, the post-jump reference period showed lower TTS when compared to single-leg stance ($P = 0.01$). We found no difference between CAI and control group for TTS for any direction. The CAI group showed more CoP variability than control group in the single-leg stance reference period for both directions.
Conclusions: Different reference periods will produce different results for TTS. There is no difference in TTS after a maximum vertical jump between groups. People with CAI have more CoP variability in both directions during single-leg stance.

1. Introduction

Injuries and instabilities of the ankle are commonly seen in people involved in sports (Fong, Hong, Chan, Yung, & Chan, 2007), and the unpleasant consequences of the instabilities, such as the feeling of giving way, are also frequently seen in this population (Gribble et al., 2013). The feeling of giving way, along with impaired motor control, are main characteristics of what is known as chronic ankle instability (CAI) (Freeman, 1965; Gribble et al., 2013; Hertel, 2002; Hiller, Kilbreath, & Refshauge, 2011). Because CAI is frequently associated to sports activities and activities of daily living, many studies investigating different potential aspects of CAI, such as proprioception (Fu & Hui-Chan, 2005; Willems, Witvrouw, Verstuyft, Vaes, & De Clercq, 2002), muscle reaction time (Rosenbaum, Becker, Gerngroβ, & Claes, 2000; Vaes, Van Gheluwe, & Duquet, 2001), muscle strength (Santos & Liu, 2008; Willems et al., 2002), and postural control (Knapp, Lee, Chinn, Saliba, & Hertel, 2011; Munn, Sullivan, & Schneiders, 2010) can be found in the literature.

Postural control has constantly been presented as impaired in people with CAI (Arnold, De La Motte, Linens, & Ross, 2009; Freeman, Dean, & Hanham, 1965; McKeon & Hertel, 2008; Munn et al., 2010). One of the most common assessments that show impaired postural control is the single-leg stance (Arnold et al., 2009; Munn et al., 2010); however, with the aim to assess postural control in a more functional and dynamic way, other methods to look at postural control have been proposed. One of these methods is the time to stabilization (TTS) of balance after dynamic activities such as jumps (Arnold et al., 2009; Ross & Guskiewicz, 2004). Arnold et al. (2009) published a meta-analysis investigating TTS in people with CAI and concluded that people

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with CAI take longer to stabilise balance when compared to healthy people, particularly in the anterior-posterior axis (Arnold et al., 2009). However, TTS has been shown to be a test with low diagnostic accuracy among people with ankle instability (Liu et al., 2013). This low accuracy might happen due to variations of methods used to measure TTS and the activities investigated among the studies and those variations need to be taken into account.

TTS has been investigated in different ways. Some authors have chosen to investigate TTS after going down a step (Wikstrom, Tillman, & Borsa, 2005), while others analysed TTS after a jump (Brown, Ross, Mynark, & Guskiewicz, 2004; Gribble & Robinson, 2009; Liu et al., 2013; Ross & Guskiewicz, 2004; Ross, Guskiewicz, & Yu, 2005; Wikstrom et al., 2010; Wikstrom et al., 2005; de Noronha, Refshauge, Crosbie, & Kilbreath, 2008). However the type of jump can vary. For example, Ross and Guskiewicz (2004) used a vertical jump based in a common clinical test, the hop test, to assess TTS in people with CAI; while de Noronha, Refshauge, Crosbie, et al. (2008) used a drop down jump to analyse TTS in a similar population. It seems that one possible issue when analysing TTS is the differences in tasks presented by different studies, including the fact that some jumps seen in these studies will not mimic the loads and challenges in balance seen in more vigorous sports activities, such as the jump of a volleyball player when blocking or the jump of a basketball player when going for a rebound.

Perhaps another issue with the studies using TTS to measure balance is related to methodological approaches used when analysing TTS. Several ways to measure TTS have been proposed (Gribble & Robinson, 2009; Ross & Guskiewicz, 2004; Wikstrom, Tillman, Chmielewski, Cauraugh, & Borsa, 2007; Wikstrom et al., 2005). There needs to be a numerical reference to what is considered a reference balance so that the time to achieve that balance can be calculated (Ross & Guskiewicz, 2004; Wikstrom et al., 2005). For the studies analysing CAI, that numerical reference has been established by determining the variation (oscillation) of the balance during a single-leg stance (Wikstrom et al., 2005), by deriving the reaction force variation immediately after landing (Gribble & Robinson, 2009) and by analysing the variation of the center of pressure (CoP) position and reaction force in later phases after landing (Ross & Guskiewicz, 2004). Therefore, it is unclear whether the time used to define the reference balance has any influence when analysing TTS, although it seems to be the case.

The current study was set to investigate the impact different ways to define reference balance can have when analysing TTS. Secondarily, the study also aimed to investigate the difference in TTS between people with CAI and healthy controls after a maximal single-leg vertical jump.

2. Methods

2.1. Design

This was a cross -sectional study to compare three different ways to establish the reference balance to TTS calculation: CoP variation during a single-leg stance task, at a pre-jump stage and at a post-jump stage. We also compared postural control in people with and without CAI regarding TTS of the CoP in the anterior-posterior (AP) and medio-lateral (ML) directions.

2.2. Participants

Fifty recreational athletes from academic community agreed to be part of the study, 25 with CAI and 25 without CAI (Table 1). For the CAI group, participants had to have a history of at least 2 lateral ankle sprains in the same ankle, with the latest sprain having occurred within 12 months prior to the study without signs of acute or sub-acute phase of healing; they also had to have a Cumberland Ankle Instability Tool –Portuguese (CAIT-P) score below 23 (de Noronha, Refshauge, Kilbreath, & Figueiredo, 2008; Hiller, Refshauge, Bundy, Herbert, & Kilbreath, 2006). For the control group, participants had no history of ankle sprain and a score over 27 in the CAIT-P. For both groups, participants could not have a history of surgery or fracture in the lower limbs or any vestibular, neurological or musculoskeletal disease that could interfere with the procedures of the study. A lateral ankle sprain was defined as an inversion movement beyond the physiological limit followed by: 1- persistent pain for more than one day or; 2- edema for more than one day or; 3- hematoma for more than one day or; 4- inability to take part in physical activity for more than one day (Fong, Chan, Mok, Yung, & Chan, 2009; Hiller, Refshauge, Herbert, & Kilbreath, 2008).

2.3. Procedures

To ensure that the assessor was blinded throughout the study, the CAIT-P scores were not revealed and all assessments were taken for both ankles in all participants; however only one ankle of each participant was considered in all analyses. For the CAI group, the ankle with the lowest CAIT-P score was used for analyses and for the control group, the ankle included in the analyses were chosen by pairing it according to side dominance from the CAI group. The order of sides and sequence of assessments were decided via randomization. All assessments were performed with participants wearing sports clothes and barefoot. Participants were instructed to refrain from any sports activity 48 h prior to the assessment sessions.

2.4. Assessments

For data collection, we used a force platform Biomec 400 (EMG System do Brasil Ltda., Brazil) and its software to record vertical ground reaction force at 500 Hz. Data were analysed in Matlab (Mathworks, Natick, MA) and filtered with a second-order Butterworth low-pass filter with cutoff frequency of 35 Hz.

2.4.1. Vertical jump

Participants were instructed to position themselves in single-leg stance on the force platform and to maintain their hands on their waist during the entire test. Data collection was then initiated from the moment the participants informed the researcher that they felt balanced. The participants remained in this position for 5 s and were instructed to perform a counter-movement maximum vertical jump (VJ) and regain balance as fast as possible and remain in that position until the end of data collection (25 s). The landing happened on the same leg of the jump (Meylan et al., 2009; Nunes, de Noronha, Cunha, Ruschel, & Borges, 2013). Data were collected from three valid trials for each limb, with a minimum interval of 30 s between trials. For all trials, the participants received a standard verbal stimulus to reach the highest possible jump.

2.4.2. Single-leg stance (SLS)

Again, participants were instructed to position themselves in single-leg stance on the force platform with hands on their waist and data collection was initiated from the moment the participants informed the researcher that they felt balanced. They remained in SLS for 30 s and data were collected for three valid trials, with a minimum interval of 1 min between trials (Fig. 1).

For both assessments (VJ and SLS), a test was considered a “fail” and discarded if the participant lost balance during data collection,