Clinical Biomechanics 38 (2016) 63–67

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

The influence of foot posture on dorsiflexion range of motion and postural control in those with chronic ankle instability☆

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ARTICLE INFO

Article history:
Received 14 December 2015
Accepted 21 August 2016

Keywords:
Chronic ankle instability
Foot posture
Postural control
Dorsiflexion

ABSTRACT

Background: To investigate the effect of foot posture on postural control and dorsiflexion range of motion in individuals with chronic ankle instability.

Methods: The study employed a cross-sectional, single-blinded design. Twenty-one individuals with self-reported chronic ankle instability (male = 5; age = 23.76(4.18)years; height = 169.27(11.46)cm; weight = 73.65(13.37)kg; number of past ankle sprains = 4.71(4.10); episode of giving way = 17.00(18.20); Cumberland Ankle Instability Score = 18.24(4.52); Ankle Instability Index = 5.86(1.39)) participated. The foot posture index was used to categorize subjects into pronated ($n = 8$; Foot Posture Index = 7.50(0.93)) and neutral ($n = 13$; Foot Posture Index = 3.08(1.93)) groups. The dependent variables of dorsiflexion ROM and dynamic and static postural control were collected for both groups at a single session.

Findings: There were no significant differences in dorsiflexion range of motion between groups ($p = 0.22$) or any of the eyes open time-to-boundary variables ($p > 0.13$). The pronated group had significantly less dynamic postural control than the neutral group as assessed by the anterior direction of the Star Excursion Balance Test ($p < 0.04$). However, the pronated group had significantly higher time-to-boundary values than the neutral group for all eyes closed time-to-boundary variables ($p \le 0.05$), which indicates better eyes closed static postural control.

Interpretation: Foot posture had a significant effect on dynamic postural control and eyes closed static postural control in individuals with chronic ankle instability. These findings suggest that foot posture may influence postural control in those with chronic ankle instability.

1. Introduction

Lateral ankle sprains are among the most common injuries sustained by physically active populations (Beynnon et al., 2001; Hootman et al., 2007). Injury epidemiology studies have determined that approximately 12 ankle sprains occur per 1000 exposures to sport related activity (Doherty et al., 2014). Additionally, ankle sprains represent 15% to 44% of all injuries reported in collegiate and high school athletics, respectively (Agel et al., 2007; Kannus and Renstrom, 1991). Ankle sprains can create immediate as well as long-term disability that can affect recreational and occupational activity (Hiller et al., 2012; Verhagen et al., 1995). Up to 70% of those who sustain an ankle sprain will experience lingering symptoms of pain, swelling, ankle instability, and repetitive ankle sprains (Anandacoomarasamy and Barnsley, 2005). These recurrent symptoms are the primary characteristics of a condition known as chronic ankle instability (CAI) (Hertel, 2002).

CAI has been associated with several contributing factors, which are broadly categorized as mechanical or functional impairments (Hertel, 2000). Several mechanical impairments; such as arthrokinematic restrictions, commonly manifest clinically as decreased dorsiflexion range of motion (ROM) (Hoch et al., 2012b). The functional impairments detected in individuals with CAI are alterations in proprioception and neuromuscular control (Hertel, 2002). The functional impairments associated with CAI commonly present as deficits in postural control (Arnold et al., 2009). In those with CAI, decreased dorsiflexion ROM has been shown to negatively affect gait, dynamic postural control, and landing suggesting there is an interaction between mechanical and functional impairments for many individuals (Drewes et al., 2009; Hoch et al., 2011). Although people with CAI commonly exhibit dorsiflexion and postural control deficits, it is unclear if there are additional factors that may influence these insufficiencies.

There is evidence to suggest foot posture may influence several of the postural control and dorsiflexion ROM measurements used to

☆ Acknowledgements: There were no funding sources or help outside of the authors on this project.

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http://dx.doi.org/10.1016/j.clinbiomech.2016.08.010
0268-0033/

examine individuals with CAI (Cote et al., 2005; Hertel et al., 2002; Tsai et al., 2006). Recent studies have demonstrated that healthy individuals with varying foot postures display differences in static and dynamic postural control (Cote et al., 2005; Hertel et al., 2002; Tsai et al., 2006). These differences in postural control may be due to variances in somatosensory feedback associated with different foot postures. Foot posture may also influence weight-bearing dorsiflexion ROM because of the involvement of the entire foot and ankle complex when performing this measurement (Burns, 2005). Currently there has been no published research that has examined the effect of foot posture on postural control or dorsiflexion ROM in individuals with CAI. It is important to investigate the role of foot posture on these measures because it could influence how we interpret these outcomes and plan rehabilitation for people with CAI. Therefore, the purpose of this study was to investigate the effect of foot posture on postural control and dorsiflexion ROM in individuals with CAI. It was hypothesized that deviations in foot posture would influence postural control and dorsiflexion ROM in individuals with CAI.

2. Methods

2.1. Design

This study employed a blinded, cross-sectional design. The independent variable was foot posture and the dependent variables were dorsiflexion ROM, dynamic postural control, and static postural control. The Foot Posture Index-6 (FPI) categorized participants into the pronated or neutral groups. Dorsiflexion ROM was measured through the Weight-Bearing Lunge Test (WBLT). Dynamic postural control was measured using the anterior reach of the Star Excursion Balance Test (SEBT-ANT). Single-limb stance static postural control was measured using instrumented measures of center of pressure known as time-to-boundary (TTB).

2.2. Subjects

A convenience sample of twenty-one subjects was recruited through word of mouth and flyers around a large public university. All subjects provided written informed consent in compliance with the University's institutional review board. Subjects were included if they were between 18 and 45 years of age, had a history of ≥1 significant ankle sprain, had ≥2 episodes of giving way in the past three months, answered “yes” to ≥6 questions on the Ankle Instability Instrument (AII) (Redmond et al., 2006), ≤26 on the Cumberland Ankle Instability Tool (CAIT) (Hiller et al., 2006), and ≥15 on the Godin Leisure-Time Exercise Questionnaire (Godin and Shephard, 1985; Gribble et al., 2014). Subjects were excluded if they had an ankle sprain within the past six months, lower extremity injury within the past six months, lower extremity surgery, or had any health conditions known to affect balance. If a subject had bilateral CAI, the ankle with the lower CAIT score was included. After inclusion, the FPI categorized 13 subjects into the neutral group and eight into the pronated group (Table 1).

2.3. Procedures

All data were collected during a single session. After inclusion was determined, a single investigator completed the FPI on the involved limb. Following foot posture assessment, dorsiflexion ROM, dynamic postural control, and static postural control were collected in a counterbalanced order. The investigator assessing foot posture was blinded to all other measures, while the investigators collecting dorsiflexion ROM and postural control measures were blinded to the group assignments throughout the study.

Table 1
Means and standard deviations of subject characteristics.

	Neutral ($n = 13$)	Pronated ($n = 8$)	p-Value
FPI	3.08 (1.93)	7.50 (0.93)	–
Males/Females	3/10	2/6	–
Age (years)	24.85 (4.78)	22.00 (2.27)	0.13
Height (cm)	168.13 (10.07)	171.13 (13.96)	0.57
Weight (kg)	73.69 (13.99)	73.60 (13.25)	0.99
“Yes” on AII	6.0 (1.53)	5.63 (1.19)	0.56
Previous ankles sprains	5.69 (4.94)	3.13 (1.25)	0.17
CAIT	17.85 (5.15)	18.88 (3.52)	0.63
GLEQ	71.15 (54.08)	66.50 (25.43)	0.82

FPI = Foot Posture Index; AII = Ankle Instability tool; CAIT = Cumberland Ankle Instability Instrument; GLEQ = Godin Leisure time-Exercise Questionnaire.

2.4. Foot posture

A single FPI assessment with the subject standing in a relaxed double limb stance was used to assess foot posture. This technique has demonstrated excellent intra-rater reliability (ICC = 0.90) (Cornwall et al., 2008). The FPI is a scoring system that measures foot posture using a multifactorial approach. It incorporates the following six criteria: talar head palpation, supra and infra lateral malleolar curvature, calcaneal frontal plane position, prominence in the region of the talonavicular joint, congruence of the medial longitudinal arch, and abduction/adduction of the forefoot on the rearfoot which are scored individually (Cornwall et al., 2008; Redmond et al., 2006). Each of these criteria were scored individually based on a 5 point likert-type scale ranging from −2 to 2 which are summed for a total score between 12 and −12 (Redmond et al., 2006). Total scores are typically categorized into 5 categories: normal, 0 to +5; pronated (+6 to +9), highly pronated (+10 and above), supinated (−1 to −4), and highly supinated (−5 to −12) (Redmond, 1998). For this study, subjects were more broadly categorized into 3 categories: normal (0 to +5), pronated (+6 to +12), and supinated (−1 to −12). We chose to use a broad classification system due to the exploratory nature of this investigation.

2.5. Weight-bearing dorsiflexion ROM

The WBLT was used to assess maximum weight-bearing dorsiflexion ROM (Fig. 1). This test has demonstrated excellent inter-rater reliability (ICC = 0.99) (Bennell et al., 1998). The WBLT involves subjects performing a modified knee to wall lunge. Each subject performed three practice trials followed by three trials recorded for analysis. During each trial, subjects were instructed to lunge forward until their knee contacted the wall while the heel remained in contact with the floor. Subjects were permitted to place their non-test limb in any comfortable position while having their hands lightly against the wall in front of them for balance. All subjects started with their great toe on a tape measure about three centimeters from the wall and were incrementally progressed further along the tape measure until their heel lifted or their knee did not contact the wall. Therefore, maximal dorsiflexion was considered the furthest point at which the subject was able to make knee contact with the wall while keeping their heel in contact with the ground. These methods were adapted from previous studies (Hoch, 2011).

2.6. Dynamic postural control

The SEBT-ANT was used to assess dynamic postural control and has demonstrated excellent inter-rater reliability (ICC = 0.88) (Gribble et al., 2013). Subjects performed four practice trials and three collection trials of SEBT-ANT. The SEBT-ANT was measured in centimeters by a tape measure secured to the floor. Foot length was measured on the involved limb and the second toe was placed on the tape measure at half the length of the foot. This position was recorded in the event the foot