Physical Therapy in Sport 16 (2015) 16–21

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Original research

Effect of lace-up ankle braces on electromyography measures during walking in adults with chronic ankle instability

Greg Barlow [1], Luke Donovan*, Joseph M. Hart [2], Jay Hertel [3]

University of Virginia, 210 Emmet St. South, Charlottesville, VA 22904, USA

ARTICLE INFO

Article history:
Received 9 November 2013
Received in revised form
29 January 2014
Accepted 11 February 2014

Keywords:
Ankle sprain
Muscle activation
Neuromuscular control

ABSTRACT

Background: Lace-up ankle braces reduce the incidence of ankle sprains and have been hypothesized to do so through both mechanical and neuromuscular mechanisms.
Objective: To determine the effect of lace-up ankle braces on surface electromyography (sEMG) measures during walking in adults with chronic ankle instability (CAI).
Design: Randomized crossover.
Setting: Laboratory.
Participants: Fifteen adults with CAI.
Main outcome measures: Surface EMG activity was recorded from the anterior tibialis, peroneus longus, lateral gastrocnemius, rectus femoris, biceps femoris and gluteus medius during treadmill walking with and without lace-up ankle braces. The dependent variables were sEMG amplitude 100 ms pre- and 200 ms post-initial contact, time of activation relative to initial contact, and percent of activation across the stride cycle.
Results: When compared to no brace, ankle bracing resulted in lower pre-contact amplitude of the peroneus longus ($p = 0.02$). The anterior tibialis, peroneus longus, rectus femoris, and gluteus medius were activated later relative to initial contact ($p < 0.03$). The peroneus longus and rectus femoris were activated for a shorter percentage of the stride cycle ($p < 0.05$).
Conclusion: Braces cause a change in neuromuscular activity during walking. Clinicians should be aware of these changes when prescribing braces, as it may relate to the mechanism in which braces decrease sprains.

1. Introduction

Injuries to the ankle are one of the most common musculoskeletal injuries in athletics (Hootman, Dick, & Agel, 2007; Waterman, Owens, Davey, Zacchilli, & Belmont, 2010). People who sprain their ankle will remain about 5 times more likely to re-injure their ankle (McKay, Goldie, Payne, & Oakes, 2001). It is common for individuals who sprain their ankle to have prolonged symptoms and perceived instability that lasts greater than a year (van Rijn, van Os, Bernsen, Luijsterburg, Koes, & Bierma-Zeinstra, 2008). This condition is commonly known as chronic ankle instability (CAI) (Delahunt, Coughlan, Caulfield, Nightingale, Lin, & Hiller, 2010; Hertel, 2002). These symptoms can lead to decreased athletic performance, prolonged removal from participation and a lowered quality of life (van Rijn et al., 2008).

It can be a challenge for clinicians to improve function in people with CAI because of the complexity of the characteristics. Past studies have shown individuals with CAI to have deficits in proprioception (Munn, Sullivan, & Schneiders, 2010), postural control (Docherty, Valovich McLeod, & Shultz, 2006; Evans, Hertel, & Sebastianelli, 2004), lower extremity muscle activity (Delahunt, Monaghan, & Caulfield, 2006a; Feger, Donovan, Hart, & Hertel, 2014) and have been found to have alterations in gait (Chinn, Dicharry, & Hertel, 2013; Delahunt et al., 2006a) and landing activities (Delahunt, Monaghan, & Caulfield, 2006b). The etiology of CAI is clearly a multifactorial issue (Freeman, Dean, & Hanham, 1965; Hertel, 2008; Hiller, Kilbreath, & Refshauge, 2011).

Prophylactic ankle bracing has been used to prevent initial and recurrent injuries to the lateral ankle ligaments and is often used by individuals with CAI to enhance ankle stability. Recent studies have shown the use ankle braces caused a 70% reduction in acute ankle

* Corresponding author. Tel.: +1 434 924 6184; fax: +1 434 924 1389.
E-mail addresses: gbarlow39@gmail.com (G. Barlow), ltd2r@virginia.edu (L. Donovan), jmh3zf@virginia.edu (J.M. Hart), jnh7g@virginia.edu (J. Hertel).
[1] Tel.: +1 434 924 6184; fax: +1 434 924 1389.
[2] Tel.: +1 434 924 6187; fax: +1 434 924 1389.
[3] Tel.: +1 434 243 8673; fax: +1 434 924 1389.

http://dx.doi.org/10.1016/j.ptsp.2014.02.002
1466-853X/

injuries among those with previous ankle injury and a 57% reduction among those with no history of ankle injury in high school athletes (McGuine, Brooks, & Hetzel, 2011; McGuine, Hetzel, Wilson, & Brooks, 2012). An interesting finding from these studies (McGuine et al., 2011, 2012) is that the severity of the ankle sprains that occurred did not change with the application of a brace.

Previous literature demonstrating that ankle bracing restricts range of motion measurements (DiStefano, Padua, Brown, & Guskiewicz, 2008; Sefton, Hicks-Little, Koceja, & Cordova, 2007) have been performed in a laboratory and may not directly relate to the ability for an ankle brace to decrease range of motion when a lateral ankle injury mechanism occurs during high velocity functional activities. Neuromuscular adaptations also may have a contributing role in the ability to prevent ankle sprains. Studies utilizing trap door mechanisms (Cordova & Ingersoll, 2003; M. L. Cordova, Cardona, Ingersoll, & Sandrey, 2000; Shima, Maeda, & Hirohashi, 2005) or those measuring H-reflexes (Nishikawa & Grabiner, 1999; Sefton et al., 2007) have found increased peroneal reflex activity and motonueron pool excitability with ankle brace application. Increased cutaneous and joint mechanoreceptor stimulation from braces is thought to improve proprioception (Feuerbach, Grabiner, Koh, & Weiker, 1994). Gait alterations such as increased maximum pronation and pronation velocity (Nishikawa, Kurosaka, Yoshiya, Lundin, & Grabiner, 2002) and decreased plantarflexion at initial contact following a jump task (DiStefano et al., 2008) have also been associated with the use of ankle braces. These loading and biomechanical changes may result in a decreased chance of the foot being in a position more prone to ankle sprain.

The use of surface electromyography (sEMG) allows for non-invasive approximation of muscle activity. Previous literature utilizing sEMG related to ankle dynamics has primarily been focused on peroneus longus activation during an unanticipated perturbation (Cordova, Armstrong, Rankin, & Yeasting, 1998). While this data adds important baseline information, the translation of these results to more dynamic tasks is uncertain. A recent study on individuals with and without CAI found altered lower extremity muscle activation during walking (Feger et al., 2014). Specifically, CAI participants were found to activate lower extremity muscles earlier in the stride cycle and, in regards to the peroneus longus, for a longer percentage of the stride cycle compared to healthy controls (Feger et al., 2014). The ability for ankle braces to affect these alterations, however, is unknown. Therefore, the purpose of this study was to determine what effect lace-up ankle braces had on lower extremity sEMG amplitude and timing during treadmill walking in patients with CAI.

2. Methods

2.1. Design

A controlled laboratory study using a randomized crossover design was performed. The independent variable was condition, brace vs. no brace. Dependent variables were sEMG amplitude before and after initial contact, onset timing relative to initial contact, and percent activation time across the entire stride cycle of the (anterior tibialis (AT), peroneus longus (PL), lateral head of the gastrocnemius (LG), rectus femoris (RF), biceps femoris (BF), and gluteus medius (GM)). The randomization of condition order (brace vs. no brace) was generated by an investigation team member not involved in data collection.

2.2. Participants

Fifteen recreationally active young adults with CAI participated (Table 1). We defined CAI as anybody with a history of a lateral ankle sprain where the initial sprain occurred greater than one year prior and currently has self-reported functional deficits and symptoms of "giving way" or instability. Inclusion criteria included: aged 18–40, recreationally active (20 min or greater of moderate physical activity level at least 3 days per week), initial ankle sprain greater than 1 year prior to starting the study and diminished self-reported function quantified by a Foot and Ankle Ability Measure (FAAM) sport subscale score of less than 85% (Carcia, Martin, & Drouin, 2008). Participants were excluded if they had an ankle sprain within 6 weeks of the study, a history of fracture or surgical intervention to the ankle complex, current self-reported symptoms of other lower extremity injury, or any neurological pathology that could alter our main outcome measures. Measures were obtained unilaterally. In participants with bilateral CAI, data was collected from the participants' more symptomatic limb. The University Institutional Review Board approved this study and all participants provided informed consent prior to participation.

Table 1
Participant demographics.

	CAI mean (standard deviation)
Age (years)	23.0 ± 4.2
Sex	Male: 5, female: 10
Height (cm)	173.3 ± 10.8
Weight (kg)	72.4 ± 14.0
FAAM ADL (%)	87.2 ± 7.1
FAAM sport (%)	68.5 ± 5.7
Godin leisure-time exercise score	94.3 ± 46.6
# of Previous ankle sprains	4.5 ± 3.2
Time since last ankle sprain (months)	15.2 ± 9.3

cm – Centimeter.
kg – Kilogram.

2.3. Instrumentation

Disposable pre-gelled Ag/AgCl electrodes were used to collect sEMG signals. Signals were amplified with a high-gain, differential-input biopotential amplifier with a gain of 1000 and digitized with a 16-bit data acquisition system (MP 150, Biopac Systems, Inc., Goleta, CA) at 2000 Hz with a common-mode rejection ratio of 110 dB, an input impedance of 1.0 MΩ, and a noise voltage of 0.2 mV. Acqknowledge software (v.4.0, Cambridge, England) was used for data collection and processing of sEMG signals. The sEMG data was collected using real-time processing with a 10–500 Hz band pass filter and a 10 sample moving average root mean square algorithm. A foot switch (BIOPAC Systems Inc., Santa Barbara, CA) was used to identify initial contact during walking. Subjects performed walking trials on a treadmill (Biodex, Shirley, NY). The lace-up brace used during testing was the McDavid Ultralight 195 (McDavid Inc., Woodridge, IL). This brace was chosen because it was used in a recent large scale clinical trial that demonstrated injury prevention effects (McGuine et al., 2011). All participants were fitted with the same model of athletic shoe (X755WB New Balance Athletic Shoe, Inc., Boston, MA) for both the braced and no brace conditions. Data was analyzed using Statistical Package for Social Sciences (SPSS) Version 20.0 (SPSS, Inc, Chicago, IL).

2.4. Procedures

Data collection measures, with the exception of ankle bracing, were identical to those previously described by Feger et al. (2014).

2.4.1. Day 1

Participants completed the initial screening process including Godin Leisure-Time Exercise Questionnaire, FAAM activities of daily