Journal of Electromyography and Kinesiology 25 (2015) 253–259

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

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

Fibular taping does not alter lower extremity spinal reflex excitability in individuals with chronic ankle instability ☆

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ARTICLE INFO

Article history:
Received 1 August 2014
Received in revised form 26 January 2015
Accepted 27 January 2015

Keywords:
Ankle sprain
Electromyography
H-reflex
Prophylactic

ABSTRACT

Objective: To determine changes in spinal reflex excitability of the soleus and fibularis longus muscles before and after fibular taping intervention.

Methods: Twenty-one individuals (age = 23.4 ± 2.7 y, height = 171.0 ± 12.8 cm, mass = 69.7 ± 11.8 kg) with chronic ankle instability (CAI) and at least 5° ankle dorsiflexion asymmetry volunteered for this randomised crossover design study. Each participant received a fibular taping with tension or fibular taping without tension during separate sessions. Spinal reflex excitability of the soleus and fibularis longus was determined by obtaining maximum values for H-reflex (Hoffmann reflex) and maximum compound muscle action potential (Mmax), which was expressed as a ratio (H/M ratio). Measures were obtained immediately before and after a fibular taping intervention.

Results: The application of tape to the fibula, regardless of tension, did not produce a change in spinal reflex excitability for the soleus ($F1,39 = .01$, $P = .91$) or fibularis longus ($F1,39 = .001$, $P = .99$).

Conclusions: Fibular taping with and without tension did not result in an immediate change in spinal reflex excitability of the soleus or fibularis longus in individuals with CAI. Although fibular taping has been shown to reduce recurrent ankle sprains in individuals with CAI, the mechanism of effectiveness may not involve an immediate increase in spinal reflex excitability.

1. Introduction

Lateral ankle sprains are one of the most common orthopedic injuries (Hootman et al., 2007), with almost one-third of individuals incurring a sprain reporting bouts of recurrent injury (van Rijn et al., 2008). Chronic ankle instability (CAI) describes the subsequent repetitive sprains and decreased function (Hertel, 2000). Contributing factors for CAI include deficits in dorsiflexion range of motion (ROM), proprioception, balance, and muscle activation (Hertel, 2000; Hiller et al., 2011; Holmes and Delahunt, 2009; Lin et al., 2010). Both the soleus and fibularis longus have been shown to demonstrates decreased spinal reflex excitability in individuals with ankle instability (Klykken et al., 2011; McVey et al., 2005; Palmieri-Smith et al., 2009; Sefton et al., 2008). The soleus is a key muscle associated with balance and a role of the fibularis longus is to counteract inversion moments at the ankle. Changes in spinal reflex excitability following injury are thought to be due to altered afferent sensory signals from the injured joint which impacts efferent motor output (spinal reflex excitability) to muscles surrounding the joint (Hopkins and Ingersoll, 2000; Pietrosimone et al., 2012).

Ankle taping is a common intervention for the prevention of recurrent ankle sprains. While traditional ankle taping provides mechanical support and limits joint motion, the mechanical benefits are relatively short-lived (<45 min) (Best et al., 2014; Rarick et al., 1962). The mechanism of effectiveness for preventing subsequent sprain is thought to be related to changes in sensorimotor function (Delahunt et al., 2010), including increased joint position sense and balance (Hopper et al., 2009; Miralles et al., 2010). Fibular taping is a relatively minimalistic taping technique that likely offers far less mechanical support than traditional ankle taping interventions. Although fibular taping has been shown to reduce recurrent ankle sprains (Moiler et al., 2006) and improve perceived confidence (Delahunt et al., 2010), little is known regarding the underlying mechanism of effectiveness. Simply applying tape to

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☆ Study approval was granted by the Institutional Review Board at Creighton University (IRB 11-16018). This trial was registered on ClinicalTrials.gov (NCT01423513).

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http://dx.doi.org/10.1016/j.jelekin.2015.01.009
1050-6411/

the skin overlying the calf musculature can alter spinal reflex excitability of the gastrocnemius and soleus (Alexander et al., 2008; Firth et al., 2010). Clinically, fibular taping is applied with tension in an attempt to provide a posterior glide of the fibula on the tibia. This is similar to a distal tibiofibular joint mobilisation, used to address altered joint arthrokinematics (Denegar et al., 2002; Whitman et al., 2009). Joint mobilisation is thought to stimulate joint mechanoreceptors and has been shown to increase spinal reflex excitability of the soleus (Grindstaff et al., 2011) as well as increase ankle dorsiflexion ROM and improve balance (Hoch and Grindstaff, 2012). This highlights the potential for both sensorimotor and mechanical effects following joint mobilisation intervention. Fibular taping has also been shown to increase spinal reflex excitability of the soleus (Chou et al., 2013) without changes in spinal reflex excitability when fibular taping was applied without tension. This indicates increased spinal reflex excitability was likely due to stimulation of joint mechanoreceptors versus more superficial receptors sensitive to light touch. A limitation of the previous study (Chou et al., 2013) is that it was not clear whether changes were due to tape application or participant repositioning. Changes in body position (side lying to prone) has been shown to influence spinal reflex excitability (Dishman et al., 2005). Therefore, the purpose of this study was to examine changes in spinal reflex excitability before and after a fibular taping intervention in participants with CAI. Our hypothesis was that fibular taping with tension would result in a greater increase in spinal reflex excitability of the soleus and fibularis longus muscles compared to tape application without tension. This study was part of a larger trial with data related to changes in range of motion and balance previously published (Wheeler et al., 2013).

2. Methods

2.1. Participants

Twenty-three individuals (8 males, 15 females; age = 23.4 ± 2.5 y, height = 171.6 ± 12.4 cm, mass = 71.5 ± 13.1 kg, Foot and Ankle Ability Measure (FAAM) Sport 71.0 ± 16.3%, AII 6.2 ± 1.7 points, history of 3.2 ± 4.1 sprains) with CAI qualified for and participated in this study (Fig. 1). Participants responded to advertisements posted throughout the university and surrounding community. Inclusion criteria for CAI was defined as recurrent episodes of ankle instability following at least a single lateral ankle sprain and decreased patient reported function, defined as either a FAAM Sport measure less than 85% (Martin et al., 2005) or scoring 3 or greater on the Ankle Instability Instrument (Docherty et al., 2006). Both forms are often used to discriminate between individuals with and without CAI (Gribble et al., 2013). Lower FAAM Sport scores are indicative of decreased self-reported function while higher Ankle Instability Instrument scores indicate likelihood of ankle instability. Participants were also required to present with a minimum of a 5° deficit in dorsiflexion ROM of the involved ankle compared to the contralateral limb. Exclusion criteria were lower extremity injury or surgery within the past six months, self-reported ankle osteoarthritis, history of ankle surgery involving intra-articular fixation, current pregnancy, or neuromuscular disease that might limit or alter lower extremity strength or reflexes.

2.2. Procedures

The study protocol was approved by the Creighton University Institutional Review Board (IRB 11-16018) and is compliant with the Declaration of Helsinki. All participants read, understood, and signed an approved informed consent form. To determine whether participants met study inclusion criteria, each participant also completed a standardised health history form, the FAAM Sport (Martin et al., 2005) and Ankle Instability Instrument (Docherty et al., 2006). Weight-bearing ankle dorsiflexion ROM was assessed using a digital inclinometer with the participant barefoot (Konor et al., 2012; Wheeler et al., 2013). In the event of bilateral CAI (13 of the 21 participants), the limb with the greatest ankle dorsiflexion ROM restriction was selected for measurement and intervention. Baseline measures of spinal reflex excitability were obtained prior to the randomised intervention (Fig. 1). Spinal reflex excitability measures were obtained immediately following tape application to avoid confounding the effects of taping on spinal reflex excitability with the effects of changes in position (Dishman et al., 2005; Kim et al., 2012). Each participant returned for a second visit a minimum of 24 h later to undergo the same protocol with the alternative taping intervention.

2.3. Instrumentation

Hoffmann reflex (H-reflex) and compound muscle action potential (M-response) measurements were collected using surface electromyography (EMG) (MP150, BIOPAC Systems Inc., Santa Barbara, CA, USA). The signal was amplified (EMG100C, BIOPAC Systems Inc.), with gain initially set at 1000 and further optimised (Gain 500–2000) as necessary to best maximise the EMG signal for each participant. EMG signals were sampled at 2000 Hz with a common-mode rejection ratio of 110 dB and band-pass filtered (10–500 Hz). Spinal reflex excitability measures were elicited using a 200-V (maximum) stimulator module and isolation unit (STM100A and STMISOC, BIOPAC Systems Inc., Santa Barbara, CA, USA).

2.4. Spinal reflex excitability

Skin preparation and electrode placement on the fibularis longus and soleus muscles were consistent with previously published methods (Grindstaff et al., 2011). The area was shaved, abraded with fine sandpaper, and cleaned with isopropyl alcohol. Surface EMG electrodes (EL503, BIOPAC Systems Inc.) were placed approximately 2 cm apart center-to-center on the fibularis longus and soleus musculature. The fibularis longus surface electrodes were positioned 2–3 cm distal to the head of the fibula. Soleus surface electrodes were positioned 2–3 cm distal to the medial head of the gastrocnemius. A ground electrode was placed on the contralateral lateral malleolus. A stimulating electrode (2 mm, EL254S, BIOPAC Systems Inc.) was placed superficial to the sciatic nerve, identified via palpation, in the superior portion of the popliteal fossa. The sciatic nerve was selected as this is the common nerve prior to bifurcation into the common fibular and tibial nerves. An electrical stimulus capable of eliciting a motor response in both the fibularis longus and soleus muscles was utilised to confirm accurate placement of the stimulating electrode. A dispersive electrode (7 cm diameter rubber carbon electrode) was placed superior to the patella.

Participants were tested in a supine position with the knee in approximately 15° of flexion and supported by a foam bolster. A 1-ms square wave pulse was used to stimulate the sciatic nerve. Stimuli were delivered with an incremental intensity (0.1 V) in order to obtain the peak-to-peak amplitude of the maximum H-reflex (Hmax) and maximum compound muscle action potential (Mmax) (Grindstaff et al., 2011). Although muscles were stimulated at the same time, independent Hmax and Mmax measures were obtained for the fibularis longus and soleus muscles. Stimuli were given with 10-seconid rest intervals in between to ensure that post-activation depression did not interfere with the H-reflex amplitude (Pierrot-Deseilligny and Mazevet, 2000). Three measurements were obtained for the Hmax and Mmax, and the average