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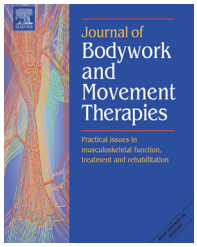

Effects of Achilles tendon vibration, surface and visual conditions on lower leg electromyography in young adults with and without recurrent ankle sprains

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Summary Functional ankle instability is associated with decreased ankle muscle function. Compliant surfaces and eyes-closed training are commonly used for rehabilitation and prevention of ankle sprains. Brief Achilles tendon vibration is commonly used in the study of postural control. To test the level of activation of tibialis anterior (TIB) and fibularis longus (FIB), bilateral Achilles tendon vibration was applied for the middle 20 s in a series of 60-s trials, when 10 healthy young adults and 10 adults with history of repeated ankle sprains were standing bipedal: on floor, on memory foam, or on a Both Sides Up (BOSU) ball, with eyes open, and on floor and foam with eyes closed. Differences in Integrated surface electromyography (IEMG) of TIB and FIB were significant for both groups pre, during, and post vibration (Friedman Tests, $p < 0.001$ for all). In both groups, the highest IEMG for TIB was obtained during vibration when standing on foam with eyes closed, whereas the highest IEMG for FIB was obtained during vibration when standing on the BOSU. Bipedal stance on BOSU and brief Achilles tendon vibration may be a useful intervention when a session's goal is to facilitate lower leg muscles activation. Future research should explore training effects as well as the effect of FIB tendon vibration.

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Introduction

Ankle sprain is one of the most commonly occurring sports-related trauma, accounting for up to 30% of all sports injuries (Mascaro and Swanson, 1994). Surveillance data from women's gymnastics National Collegiate Athletic Association and men's National Basketball Association consistently listed the ankle as the most common injury site and a ligament sprain as the most common injury type (Kerr et al., 2015; Starkey, 2000). Freeman et al. (1965) originally described functional instability of the foot as repeated tripping and spraining typically ascribed to sensorimotor deficits which may occur in 40% of lateral ankle sprains. Between 55% and 72% of patients with ankle sprains report residual symptoms six to 18 months after injury (Braun, 1999).

Functional ankle instability (FAI) is thought to be associated with deficits in proprioceptive (joint position sense) input (Freeman et al., 1965) and sensory processing (Hertel, 2002; Schiftan et al., 2014). Additional underlying mechanisms have been suggested to explain the development of FAI following some lateral sprains (Hertel, 2008). One potential explanation is decreased muscle function around the ankle, invertors and evertors specifically (Hertel, 2000; McVey et al., 2005). A group of 10 collegiate basketball players with FAI displayed reduced postural control and longer reaction time of the fibularis longus (FIB) and tibialis anterior (TIB) muscles as compared to basketball players without FAI and to healthy controls (Méndez-Rebolledo et al., 2014). Increased level of TIB activation was also demonstrated via electromyography (EMG) in nine young adults with history of ankle sprains but no persistent instability as compared to 11 adults with chronic ankle instability (CAI) during stepping down from a curb (Dundas et al., 2014). These studies suggest that weight-bearing function of TIB and FIB muscles should be targeted in rehabilitation programs post ankle sprains.

Standing on compliant surfaces is a commonly used rehabilitation exercise in balance interventions (Hupperets et al., 2009; Riva et al., 2015). In sports and orthopedic rehabilitation, unstable and compliant surfaces are used as a method to enhance proprioceptive input. This 'sensorimotor training,' as it is often referred to, is commonly used to improve standing balance for people with specific somatosensory deficits such as those that occur with FAI (Braun Ferreira et al., 2011; Sefton et al., 2011). Despite the fact that postural control exercises have been shown to be beneficial for people post ankle sprains, the idea of improving proprioception via static-stance postural control exercises has been invalidated (Ashton-Miller et al., 2001; Hertel, 2008). It is possible that unstable and compliant surface exercises improve postural control (Martínez-Amat et al., 2013; Romero-Franco et al., 2014, 2012; Yaggie and Campbell, 2006) via increased weight-bearing activation of lower leg muscles. Indeed, increased activation of TIB and FIB during single-leg stance on various unstable surfaces has been reported in several studies (Braun Ferreira et al., 2011; Cimadoro et al., 2013; De Ridder et al., 2015). However, individuals with ankle instability might have difficulty in performing single-leg stance tasks on challenging surfaces, especially during early stages of rehabilitation. Hence, the level of muscle activation during bipedal balance tasks should be investigated.

In order to identify an optimal way of activating TIB and FIB muscles we studied surfaces and positions that are commonly used in the clinic (Both Sides Up [BOSU; Fitness Quest, Canton, OH)] ball, memory foam, feet-together stance, and eyes open or closed). We also explored the potential clinical application of tendon vibration. Brief Achilles tendon vibration during standing in healthy adults increases postural sway (Thompson et al., 2007) and gastrocnemius/tibialis anterior activation (Spiliopoulou et al., 2012). Achilles tendon vibration has been used in numerous studies as a method of perturbing the somatosensory system (Abrahámová et al., 2009; Eklund, 1972; Thompson et al., 2011). It is possible that combining Achilles tendon vibration with other balance tasks can create perturbation exercises that increase activation of the dynamic stabilizers of the ankle joint and might be useful in the clinic. Therefore, the purpose of this study was to test the level of activation of TIB and FIB in healthy young adults, with and without history of repeated ankle sprains, during bipedal stance under various surface and visual conditions, combined with brief tendon vibration.

Methods

This study was a laboratory randomized block design. The independent variables were group (healthy young adults [HEALTHY] or young adults with history of repeated ankle sprain [SPRAIN]); task (surface and visual conditions), and time (pre, during, and post vibration). The dependent variables were integrated electromyography (IEMG) activity from the mean of both legs of TIB and FIB as measured by surface EMG.

Participants

Flyers were posted around the university and surrounding community and a volunteer sample of convenience was recruited. Twenty young adults participated in this study: 10 healthy young adults (HEALTHY) with no lower extremity or back injury within the 12 months prior to the study and 10 young adults with history of repeated ankle sprains (SPRAIN). Inclusion criteria for both groups were: men or women, aged 18–40 years, of any race or ethnic background, and with normal or corrected to normal vision. HEALTHY participants were excluded for somatosensory, vestibular, or ankle range of motion deficits based on a clinical screening. SPRAIN participants reported three or more sprains in the past five years, a previous diagnosis of a moderate inversion ankle sprain, and at least one episode of the ankle 'giving way' in the past 12 months (Docherty et al., 1998). Description of the sample appears in Table 1. The groups were comparable on most demographic factors, with the exception that within the narrow age range we sampled, the SPRAIN group was significantly younger (mean of 22.2 vs. 27). In addition, the SPRAIN group had five participants who were Asian-American as compared to none in the HEALTHY group. The HEALTHY group performed significantly better on the single-leg-eyes-closed conditions of the Balance Error Scoring System (BESS) test (Bell et al.,