ARTICLE IN PRESS

Human Movement Science xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Human Movement Science

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

Foot orientation affects muscle activation levels of ankle stabilizers in a single-legged balance board protocol

Roel De Ridder [a,*], Tine Willems [b], Sophie De Mits [a], Jos Vanrenterghem [c], Philip Roosen [a]

[a] Department of Rehabilitation Sciences and Physiotherapy, Ghent University, Ghent, Belgium
[b] Department of Physiotherapy and Orthopedics, Ghent University, Ghent, Belgium
[c] School of Sport and Exercise Sciences, Faculty of Science, Liverpool John Moores University, Liverpool, UK

ARTICLE INFO

Article history:
Available online xxxx

PsycINFO classification:
3380

Keywords:
Balance training
Uniaxial board
Foot orientation
Muscle activity

ABSTRACT

Context: The main goal of balance training is regaining a normal neuromuscular control to a functional level. Although uniaxial balance boards are commonly used, no research has been done on the effect of foot orientation on muscle activation levels.
Objective: To investigate the effect of foot orientation on muscle activation levels and modulation of the ankle stabilizing muscles in a single-legged balance protocol on a uniaxial balance board.
Methods: Sixty-nine healthy subjects (age: 21.8 ± 1.7 years; mass: 67.5 ± 11.9 kg; body height: 174.7 ± 8.6 cm; BMI: 21.5 ± 3.0) participated in this study. Subjects were asked to keep their balance during a single leg stance on a uniaxial balance board for four different foot orientations, aligning the board's rotation axis with frontal, sagittal, diagonal and subtalar axes of the foot, respectively. Surface electromyography registered muscle activity of peroneus longus, tibialis anterior, medial and lateral gastrocnemius muscles.
Results: Highest muscle activation levels and modulation for the peroneus longus were registered exercising along the frontal axis; for the tibialis anterior along the diagonal axis; for the medial gastrocnemius along the sagittal axis; and for the lateral gastrocnemius along the diagonal axis.

* Corresponding author. Address: De Pintelaan 185, 3B3, 9000 Ghent, Belgium. Tel.: +32 (0)9 332 04 53; fax: +32 (0)9 332 38 11.

E-mail addresses: Roel.DeRidder@ugent.be (R. De Ridder), Tine.Willems@ugent.be (T. Willems), Sophie.DeMits@ugent.be (S. De Mits), J.Vanrenterghem@ljmu.ac.uk (J. Vanrenterghem), Philip.Roosen@ugent.be (P. Roosen).

http://dx.doi.org/10.1016/j.humov.2013.12.008

Conclusion: Foot orientation modifications on a uniaxial balance board allows to differentially target specific ankle stabilizing muscles during balance training.

1. Introduction

Balance protocols are often part of the rehabilitation process of lower leg musculoskeletal injuries. Balance is defined as the capacity of a person to preserve their center of mass within their base of support. The capacity to do this depends on the efficient integration of afferent visual, vestibular and somatosensory inputs to generate an adequate efferent neuromuscular response (Winter, 1995). Musculoskeletal lower leg injuries such as an ankle sprain are believed to affect balance capabilities (Mitchell, Dyson, Hale, & Abraham, 2008b). As a result of an ankle sprain, damage to the mechanoreceptors in the ankle joint has been suggested to lead to partial deafferentiation. (Freeman, Dean, & Hanham, 1965; Lephart, Pincivero, & Rozzi, 1998). Khin-Myo-Hla et al. state that this deafferentiation may suppress gamma motorneuron activity and cause alterations in the muscle spindle sensitivity (Khin, Ishii, Sakane, & Hayashi, 1999). These deficits might lead to impaired balance, an increased risk to resprain, or evolve to chronic functional instability of the ankle joint (Hertel, 2002; Wikstrom, Tillman, Chmielewski, Cauraugh, & Borsa, 2007). Therefore, specific ankle rehabilitation programs involving balance training are common approaches to minimize consequences of ankle injuries and prevent recurrence.

The main goal of balance training is regaining a normal neuromuscular control around the ankle to a functional level, by maximally stimulating the muscle activity levels of the ankle stabilizing muscles. Various studies have shown improvements of postural control through balance training programs (Freeman et al., 1965; Hupperets, Verhagen, & van Mechelen, 2008; Matsusaka, Yokoyama, Tsurusaki, Inokuchi, & Okita, 2001; Michell, Ross, Blackburn, Hirth, & Guskiewicz, 2006; Verhagen et al., 2004). Not only the curative effect of balance training has been demonstrated, but also the preventative effect on overall lower limb injuries and more specifically ankle sprains (Olsen, Myklebust, Engebretsen, Holme, & Bahr, 2005; Verhagen et al., 2004). Consequently, the risk of an ankle sprain is significantly reduced in populations who subsequently undergo balance training (Hupperets et al., 2008; Verhagen et al., 2004). As explanation, it is suggested that long-term balance training results in a higher stimulation of muscle spindles (Ashton-Miller, Wojtys, Huston, & Fry-Welch, 2001). This higher stimulation would improve neuromuscular control and, therefore, contribute to the functional stability of the ankle joint. However, balance protocols differ in duration, frequency, used device, and progression of the exercises (Mattacola & Dwyer, 2002). At this moment, it is not known which exercises best serve the rehabilitation goals.

It has been suggested that higher muscle activity levels during the balance protocol are expected to speed up the rehabilitation process and a quicker return to preinjury functional levels (Cordova, Jutte, & Hopkins, 1999). The magnitude of muscle activity depends on the stability of the used device (Wahl & Behm, 2008). For different multidirectionally unstable devices such as a trampoline, wobble board, swiss ball, dyna disc or BOSU balance trainer, muscle activity levels of ankle stabilizing muscles have been assessed and compared (Laudner & Koschnitzky, 2010; Wahl & Behm, 2008; Wester, Jespersen, Nielsen, & Neumann, 1996). These devices have in common that there is no control over the rotation direction in which the ankle is challenged. Uniaxial balance boards, on the other hand, allow for uniaxial rotational instability which depends on foot orientation on the board. Whilst uniaxial balance boards are commonly used devices for balance training in the clinical practice, to the authors' knowledge no research has been done yet that identified the effect of foot orientation on muscle activation levels of different ankle stabilizing muscles. This may be useful when rehabilitation is meant to target resolving defects of specific ankle stabilizing muscles. Especially in the early stages of rehabilitation, this focus on a specific muscle might be desirable before using a general multiaxial device. The different foot orientations used in the clinical practice are based on the movement they create around the ankle joint. It is believed that depending on foot orientation, muscle activation levels and amount of

Please cite this article in press as: De Ridder, R., et al. Foot orientation affects muscle activation levels of ankle stabilizers in a single-legged balance board protocol. *Human Movement Science* (2014), http://dx.doi.org/10.1016/j.humov.2013.12.008