Human Movement Science 51 (2017) 138–145

Contents lists available at ScienceDirect

Human Movement Science

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

Full Length Article

# Quantifying knee mechanics during balance training exercises

Lauren C. Benson *, Thomas G. Almonroeder, Kristian M. O'Connor

*University of Wisconsin-Milwaukee, 2400 E. Hartford Ave. Milwaukee, WI, USA*

ARTICLE INFO

*Article history:*
Received 28 January 2016
Revised 13 December 2016
Accepted 13 December 2016
Available online 26 December 2016

*Keywords:*
Balance
Rehabilitation
Knee abduction moment
Vastus medialis oblique
Vastus lateralis

ABSTRACT

Patellofemoral pain (PFP) is common among runners and those recovering from anterior cruciate ligament reconstruction. Training programs designed to prevent or treat injuries often include balance training, although balance interventions have been reported to coincide with more knee injuries. Knowledge of the effect of balance exercises on knee mechanics may be useful when designing training programs. High knee abduction moment has been implicated in the development of PFP, and imbalance between vastus lateralis (VL) and vastus medialis oblique (VMO) may contribute to patellofemoral stress. The purpose was to quantify knee abduction moment and vasti muscle activity during balance exercises. Muscle activity of VMO and VL, three-dimensional lower-extremity kinematics, and ground reaction forces of healthy recreational athletes (12M, 13F) were recorded during five exercises. Peak knee abduction moment, ratio of VMO:VL activity, and delay in onset of VMO relative to VL were quantified for each exercise. The influence of sex and exercise on each variable was determined using a mixed-model ANOVA. All analyses indicated a significant main effect of exercise, $p < 0.05$. Follow-up comparisons showed low peak knee abduction moment and high VMO:VL ratio for the task with anterior-posterior motion. Delay of VMO relative to VL was similar among balance board tasks.

© 2016 Elsevier B.V. All rights reserved.

## 1. Introduction

Almost 40% of sports injuries involve the knee (Majewski, Susanne, & Klaus, 2006), and can be due to an acute event or repetitive stress causing an overuse injury. In general, prevention and treatment programs for sports injuries are designed to improve neuromuscular control of the lower extremity during dynamic tasks (e.g. running, landing, etc.) (Earl & Hoch, 2011; Hootman, Dick, & Agel, 2007; Peters & Tyson, 2013; Wouters et al., 2012). Balance training is often a key component of these programs and has been shown to result in changes in the mechanics of the lower extremity during landing tasks (Barendrecht, Lezeman, Duysens, & Smits-Engelsman, 2011; Myer, Ford, McLean, & Hewett, 2006; Myer, Ford, Palumbo, & Hewett, 2005). However, conflicting results have been reported in regard to the effect of balance training on the incidence of acute knee injury (Caraffa, Cerulli, Projetti, Aisa, & Rizzo, 1996; Soderman, Werner, Pietila, Engstrom, & Alfredson, 2000). Additionally, Verhagen et al. (2004) reported a significant increase in the incidence of overuse knee injury following a balance training program featuring the use of a balance board.

Ambiguity related to the effectiveness of using balance training to prevent injuries at the knee may be due to the variety of possible balance exercises (i.e. single vs. double limb, rigid vs. moveable surface, eyes open vs. closed). It is reasonable to expect that different balance exercises would elicit different mechanical responses, and so the outcome of balance training

* Corresponding author.
*E-mail addresses:* lauren.benson@ucalgary.ca (L.C. Benson), tga@uwm.edu (T.G. Almonroeder), krisocon@uwm.edu (K.M. O'Connor).

http://dx.doi.org/10.1016/j.humov.2016.12.005
0167-9457/© 2016 Elsevier B.V. All rights reserved.

may be reliant on the type of exercises employed. Different individuals may require different training/rehabilitation programs; therefore, it is important to know how different balance exercises affect joint mechanics during the exercise. Developing this understanding will inform clinical decision making regarding when it is appropriate to use balance training in the treatment or prevention of knee injuries and will help to optimize exercise prescription.

Patellofemoral pain (PFP) is the most common running-related injury reported within a sports medicine setting (Taunton et al., 2002; Taunton et al., 2003). Additionally, PFP is common among athletes recovering from ACL reconstruction (Culvenor et al., 2016), indicating that PFP may be a concern for athletes participating in rehabilitation programs. Increased loading of the knee in the frontal plane has been identified as a primary etiological factor in the development of PFP (Myer et al., 2015; Stefanyshyn, Stergiou, Lun, Meeuwisse, & Worobets, 2006). It is thought that greater internal knee abduction moments result in increased lateral patellofemoral joint contact forces (Scott & Winter, 1990; Willson & Davis, 2008). MRI findings support this premise as subjects with PFP demonstrate degenerative changes of the lateral patellofemoral joint that are consistent with early osteoarthritis (Thuillier et al., 2013; Utting, Davies, & Newman, 2005), suggesting that interventions designed to treat or prevent injury to the knee should consider the loading of the knee in the frontal plane.

The mechanics of the patellofemoral joint can be influenced by the actions of the muscles of the quadriceps. The vastus lateralis (VL) is located on the anterolateral thigh and as a result, it promotes lateral tracking of the patella within the femoral groove. If unchecked, this may result in an increase in lateral patellofemoral joint stress. Another muscle of the quadriceps, the vastus medialis, is located on the anteromedial thigh and has obliquely-oriented fibers referred to as the vastus medialis obliquus (VMO) which may effectively limit excessive lateral tracking of the patella. Using a modeling approach, Neptune, Wright, and van den Bogert (2000) showed that just a 5-ms delay in the timing of the activation of the VMO relative to the VL results in a significant increase in the lateral contact force at the patellofemoral joint, and a 10% increase in VMO strength yields a significant reduction in the lateral patellofemoral contact force during running. Additionally, prospective and retrospective studies have shown a delay in the onset of the VMO relative to the VL for individuals with PFP in a variety of tasks (Cowan, Bennell, Hodges, Crossley, & McConnell, 2001; Cowan, Hodges, Bennell, & Crossley, 2002; Van Tiggelen, Cowan, Coorevits, Duvigneaud, & Witvrouw, 2009), and greater activation of the VL relative to the VMO during knee extension contractions (Owings & Grabiner, 2002; Souza & Gross, 1991). As a result, it appears that exercises designed to reduce patellofemoral joint contact forces should attempt to promote increased activity of the VMO relative to the VL.

In theory, the optimal balance training exercise for athletes concerned about PFP would be one which increases the activity of the VMO relative to the VL without promoting excessive loading in the frontal plane. Yet the knee frontal plane moments and the activity of the vasti muscles during various balance exercises have not been reported. Therefore, the purpose of this study was to analyze the knee abduction moments and the ratio of the magnitude and timing of the VMO and VL muscle activity during various balance exercises that are commonly implemented within programs designed to improve neuromuscular control. It was hypothesized that balance tasks that allow motion in the medial-lateral direction would result in the greatest peak knee abduction moment. Differences in the VMO and VL timing and activity ratio across tasks were not anticipated, as it was expected that the activity of these muscles would change concurrently with the balance task. Due to the higher incidence of PFP among females than males, sex was included as a factor in the statistical model (Boling, Padua, Marshall, Guskiewicz, & Pyne, 2009; Taunton et al., 2002).

## 2. Methods

Twenty-five healthy recreational athletes (12 male, 13 female, 24 (5) years, 1.74 (0.11) m, 73.67 (14.74) kg) were recruited. Inclusion criteria were recreationally active (score of five or greater on the Tegner Activity Scale) males and females between the ages of 18–45 (Briggs, Steadman, Hay, & Hines, 2009; Tegner & Lysholm, 1985). Exclusion criteria were lower extremity injuries in the last six months, any history of major lower extremity surgery, pregnancy, medications or medical conditions that impair balance, and functional ankle instability in the dominant leg quantified by a Cumberland Ankle Instability Tool score less than 28 (Hiller, Refshauge, Bundy, Herbert, & Kilbreath, 2006). The dominant leg was defined as the preferred leg used to kick a ball. Informed consent was obtained to ensure that the rights of the subjects were protected. The study procedures were approved by the University of Wisconsin-Milwaukee Institutional Review Board (IRB Protocol Number 15.254).

Participants wore tight-fitting shorts so that wireless EMG receivers (Noraxon, DTS EMG, Scottsdale, AZ, USA) could record activity of the VMO and VL of the dominant leg. Prior to application of the surface electrodes (Vermed, NeuroPlus, Bellows Falls, VT, USA), the skin was shaved, gently abraded, and wiped with alcohol to reduce electrical impedance. Pairs of electrodes were placed on each muscle according to the method outlined in Cowan et al. (2001). Muscle activity was recorded at 1000 Hz as the participant performed a maximum voluntary contraction (MVC) during isometric knee extension with the foot in neutral position and the knee and hip at 90° of flexion (Hassanlouei, Falla, Arendt-Nielsen, & Kersting, 2014). There were three trials for each isometric contraction, lasting five seconds each and with two minutes of rest in between each contraction. Participants wore shoes to protect their feet and were verbally encouraged to give a maximal effort during each contraction.

During movement trials, three-dimensional kinematic data were collected at 200 Hz with a ten-camera Eagle system (Motion Analysis, Inc., EVART 4.6, Santa Rosa, CA, USA) and ground reaction forces were recorded at 1000 Hz using two adjacent Bertec force plates (Bertec Corp., FP4060-NC, Columbus, OH, USA). Retroreflective markers were applied to the partic-

Download English Version:

https://daneshyari.com/en/article/5042029

Download Persian Version:

https://daneshyari.com/article/5042029

Daneshyari.com