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Acute response to barefoot running in habitually shod males

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ABSTRACT

The aim of this study was to examine the immediate effects of barefoot (BF) running on lower limb kinematics and muscle activity in a group of habitually shod runners. Ten male runners with no prior BF or minimalist running experience performed 1-min bouts of treadmill running at 3 velocities in both shod and BF conditions. 2D video data were recorded in order to quantify ankle, knee and hip kinematics. Synchronous kinetic data were recorded from a force plate supporting the treadmill in order to quantify spatiotemporal variables. EMG data were collected from 6 lower limb muscles, quantifying recruitment patterns during discrete phases of the gait cycle. BF running resulted in significantly higher stride frequency and shorter ground contact times ($P < .001$). Additionally, BF running significantly reduced knee and hip range of motion but increased ankle range of motion during the absorptive phase of the stance. Alterations in ankle kinematics during BF running resulted from increased pre-activation of the *medial* ($P < .05$) and *lateral* ($P < .01$) *gastrocnemius* in addition to reductions in pre-activation of the *tibialis anterior* ($P < .05$). The results highlight that recruitment patterns and kinematics can change in as little as 30-s of BF running in individuals with no previous BF running experience.

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1. Introduction

The last decade has seen a remarkable increase in the interest and participation in barefoot (BF) or minimalist running. This interest was primarily driven by claims that BF running alters stride mechanics, resulting in a more forefoot strike pattern which attenuates impact forces and may ultimately reduce the risk of long-term injury (Daoud et al., 2012; Lieberman et al., 2010; Robbins & Hanna, 1987). However, recent studies examining the effects of transitioning to minimalist running have reported increased rates of injury (Ryan, Elashi, Newsham-West, & Taunton, 2014) and metatarsal stress reactions (Ridge et al., 2013), following 12 and 10 week transitions, respectively. Other studies which have examined transitioning away from cushioned running shoes have reported no difference in injury rates (McCarthy, Fleming, Donne, & Blanksby, 2014; Warne et al., 2014). Despite the lack of agreement, it is generally accepted that changing footwear or running surface increases the risk of injury (Warden, Burr, & Brukner, 2006). A more detailed examination of the acute response to a transition away from shod running is therefore warranted, in order to better understand the natural adaptive process and minimize potential risk of injury.

A significant body of research has previously described the acute effects of BF or minimalist running on stance kinetics (Braunstein, Arampatzis, Eysel, & Bruggemann, 2010; De Wit, De Clercq, & Aerts, 2000; Squadrone & Gallozzi, 2009), foot strike pattern (Lieberman et al., 2010), and more recently 3D joint kinematics (Bonacci et al., 2013) and running economy (Perl, Daoud, & Lieberman, 2012). However, much of this published research used habitually BF runners (Lieberman et al., 2010; Perl et al., 2012; Squadrone & Gallozzi, 2009) and therefore does not directly apply to the general running population. Other studies using habitually shod participants have performed pre-trial familiarization periods in order to provide sufficient time for runners to alter their recruitment patterns and running mechanics (Bonacci et al., 2013; De Wit et al., 2000) or instructed the participants to run with specific foot strike patterns (Lieberman et al., 2010; Perl et al., 2012). There is therefore a lack of literature examining the naturally occurring acute response to BF running in habitually shod runners.

While there is general agreement that BF running alters joint kinematics, resulting in greater plantar flexion at initial contact (Bishop, Fiolkowski, Conrad, Brunt, & Horodyski, 2006; De Wit et al., 2000) and a more forefoot strike pattern (Lieberman et al., 2010), it remains unclear if these alterations occur immediately or if they develop following a longer period of neuromuscular adaptation. Furthermore, despite general agreement in the literature regarding the kinematic changes associated with BF running, there is still some disagreement as to the neuromuscular recruitment patterns underlying those changes. Two studies have reported increased activity of the *triceps surae* (Divert, Mornieux, Baur, Mayer, & Belli, 2005; Olin & Gutierrez, 2013) which in part explains the increased plantar flexion reported by many authors. However, there remains lack of agreement regarding the activity of *tibialis anterior* in BF. While Olin and Gutierrez (2013) and von Tscharner, Goepfert, and Nigg (2003) reported significantly lower *tibialis anterior* activity, Divert et al. (2005) reported no differences between BF and shod conditions. Additionally, despite several authors reporting reduced knee range of motion (ROM) during BF running (Bonacci et al., 2013; De Wit et al., 2000), the contribution of knee extensor and flexor muscle activity to these changes remains unknown. Recent studies examining the effect of altering footwear and stride mechanics on impact through the shank have reported conflicting effects. Gruber, Boyer, Derrick, and Hamill (2014) reported that running with a forefoot strike pattern significantly reduced tibial shock, measured using triaxial accelerometry. However, Olin and Gutierrez (2013) observed that barefoot running significantly increased tibial shock compared to shod running, regardless of whether a forefoot or rearfoot strike pattern was adopted.

Understanding both the timing and neuromuscular mechanisms underlying kinematic and kinetic alterations is of importance, in order to more safely transition habitually shod runners into minimalist or barefoot running and reduce the risk of injury. Therefore, the primary objective of this study was to examine the acute effect of BF running on lower limb recruitment, kinematics in a group of habitually shod runners. A secondary aim was to compare the effect of velocity across shod and BF conditions.