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Effects of textured socks on balance control during single-leg standing in healthy adults

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Abstract

Balance is important in many activities of daily living and sports movements. Texture, added to shoe insole material, has been shown to improve balance in young, older and pathological populations. The aim of this study was to develop and test textured socks, which might have several potential benefits over insole use including: they can be worn without, or transferred between, shoes, and texture can be applied to areas of the foot other than the plantar surface. Prototypes socks were made with nodules (5 mm diameter) sewn onto socks on: 1) the plantar surface, 2) the dorsal surface, 3) sides of the foot and 4) covering the entire surface. Participants (n=13) performed three single-legged stance trials, standing on a force platform. with eyes open and eyes closed, whilst wearing each of the prototype socks and a control sock. Balance was quantified using the postural time-to-boundary measure. Results revealed a trend towards improved balance in the *Sides sock* condition (eyes open d = 0.62, eyes closed d = 0.51) conditions. This finding supported previous data from studies showing benefits of wearing insoles with plastic tubing around the perimeter of the foot, suggesting that textured socks might be useful as an intervention to improve balance.

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1. Introduction

Maintaining balance requires refined postural control which can be enhanced by perception of information from the environment and exploiting adaptive compensation tendencies in relevant muscle groups to constantly adjust

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for changes in body motion and position (Maki et al., 2008). Augmenting somatosensory information has been shown to enhance balance and postural control (Maki et al. 1999; Qiu et al., 2012). Populations that could benefit from improved balance include older adults, those with medical conditions, and athletes. In essence, performing standing goal-directed behaviors as simple as reaching for an object or as complex as an athletic performance requires proper balance control (Riccio, 1993).

Multiple exercise-based interventions, including balance-board training (Verhagen et al., 2005), Tai Chi (Tsang & Hui-Chan, 2004) and computer games-based training (Betker et al., 2006), have been investigated to improve balance. However, these programs can be difficult to administer and are heavily dependent on participant compliance (Campbell et al., 2005). Alternative approaches have involved the development of ankle and foot appliances (AFAs) - physical devices which interact with the foot or ankle to enhance somatosensory system feedback. AFAs have been used to apply sub-sensory mechanical vibrations to the feet, benefitting balance in older and pathological populations (Priplata et al., 2006; Priplata et al., 2003). However, vibrating insoles require a power source, are bulky and costly to produce and maintain. An alternative type of AFA, which improved proprioception in a sample of athletes, involves the addition of texture to the plantar surface of the foot (Waddington & Adams, 2003). Waddington and Adams (2003) demonstrated that male soccer players exhibited better discrimination between different extents of subtalar inversion when a textured insole was placed in their shoe. In a recent systematic review, Orth et al (2013) concluded that there is clear support for using textured materials to improve perceptual-motor performance. For example, textured insoles have been shown to decrease postural sway, and enhance balance, in older people (Qiu et al., 2012).

Previous investigations have added texture to shoe insoles or required participants to stand on a textured surface. However, only approximately 62% of the foot outline is in contact with the ground during stance (Low et al., 1993), suggesting that texture added to insoles might not be applied to a significant proportion of the plantar foot surface. We sought to investigate the role of socks in providing a more functional application of texture to a greater area of the foot plantar surface. Indeed, textured socks might offer additional benefits. First, they would be easily transferred between different shoes. Furthermore, socks could be worn without footwear in dwellings, or in slippers and gym shoes. Second, socks offer the potential to apply texture to areas of the foot other than the plantar surface. For example, texture could be added to the sides of the feet, which might be beneficial according to data reported by Maki and colleagues in the development of an AFA. A raised ridge was placed on an insole around the perimeter of the foot which was shown to improve balance by providing increased stimulation of sensory receptors when loss of balance was imminent (Maki et al., 1999; Perry et al., 2008).

Therefore, the aim of this exploratory study was to design and test textured socks to determine their effects on balance in young healthy adults performing a single-leg standing task. We hypothesised that wearing textured socks would improve balance. We also expected that enhanced somatosensory feedback would be more beneficial when visual information was not available to regulate postural control (i.e. eyes closed condition).

2. Methods

2.1. Sock Development

Four preliminary prototype textured socks were designed and developed. Craft pom-poms served as nodules and were sewn to commercially-available athletic socks. Three different socks had nodules sewn on the bottom, sized 5mm, 10mm and 12mm, respectively. The fourth sock had 12mm nodules around the circumference of the foot, to simulate the balance-facilitating insole of Maki et al. (1999). Seven adults – with no neuromuscular pathologies that could affect balance - participated in a focus group to evaluate the socks for comfort and fit. Results from the focus group guided the development and construction of five prototype textured sock models for testing. Socks, for which 5 mm nodules were added to the: 1) plantar surface, 2) sides, 3) dorsal surface and 4), entire surface of the foot (Fig. 1) were developed. In addition a sock designed to be most comfortable - based on focus-group feedback– was also developed with 10 mm nodules on the dorsal surface and sides of the feet, together with 5 mm nodules on the plantar surface. In all socks, the inter-nodule distance was approximately 200 mm.