



Impacts of different types of insoles on postural stability in older adults

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ABSTRACT

The objective of this study was to examine the effects of different types of insoles on postural stability in older adults. Four types of commercially available insoles were selected including the cupped insoles, textured insoles, rigid insoles, and soft insoles. The experiment included a static stance session and a walking session. In the static stance session, the participants stood upright on a force platform as still as possible, with feet together, arms by the side and looking straight ahead. The mean velocity of center-of-pressure time series obtained from the force platform was used to assess static postural stability. In the walking session, the participants walked on a treadmill at their self-selected comfortable speed for 4.5 min in each insole condition. Dynamic postural stability was assessed using the margin of stability. It was found that static postural stability was not affected by insoles, but cupped insoles improved dynamic postural stability, and rigid insole was associated with better dynamic postural stability compared to soft insoles. These findings can aid in better understanding the insole design features associated with improved postural stability in older adults.

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1. Introduction

Maintaining postural stability is a fundamental functional ability of humans to manage activities of daily living. Aging is often associated with decreased postural stability (Du Pasquier et al., 2003) that has adverse effects on older adults' function and quality of life. In fact, postural instability has been recognized a major risk factor for frequent falls among older people (Rubenstein, 2006). Maintenance of postural stability depends on the integration of musculoskeletal, neural, kinesthetic, cognitive, motor control, and diverse afferent (sensory) inputs. The somatosensory information from afferent receptors from the skin, joints, muscles, and tendons is critical to maintaining postural stability (Manchester et al., 1989). Meyer et al. (2004) used intradermal injections of local anesthetic into the entire weight-bearing surface of the foot soles to attenuate the somatosensory feedback from the plantar cutaneous surface of the feet, and found that such attenuation was associated with decreased postural stability. Thus, interventions have been designed to improve postural stability by enhancing the somatosensory feedback (Dickstein et al., 2001; Qu, 2010; Singh et al., 2009).

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Insole interventions were suggested able to alter somatosensory information from plantar cutaneous receptors (Maki et al., 1999). In addition, insole interventions also play a role in the control of postures by providing mechanical support to the body (Perry et al., 2007). Therefore, many recent studies have examined the effects of insole interventions on postural stability (Iglesias et al., 2012; Simeonov et al., 2011). Based on the theory of stochastic resonance, vibrating insoles have been proposed as an intervention for improving postural stability (Galica et al., 2009; Priplata et al., 2003; Simeonov et al., 2011). Priplata et al. (2003), for example, found that wearing vibrating insoles can lead to a reduction of standing postural sway. More recently, Galica et al. (2009) have reported that vibrating insoles could reduce gait variability and such reductions were similar between older recurrent fallers and older non-fallers. Limitations of using vibrating insoles as an intervention for improving postural stability are that it is expensive and requires an external power supply to activate vibration. Thus, vibrating insoles may not be a feasible solution to improving postural stability in practice.

Some studies investigated the effects of textured insoles on postural stability. It was generally reported that textured insoles can increase standing postural stability of both younger and older people in the eye-closed condition (Corbin et al., 2007; Qiu et al., 2012). However, in the eye-open condition, textured insoles made no differences (Corbin et al., 2007). Postural stability was also found



Fig. 1. Examined insoles in the present study. (a) Cupped insoles; (b) Textured insoles; (c) Rigid insoles; (d) Soft insoles.

to be affected by insole material hardness (Iglesias et al., 2012). Iglesias et al. (2012) suggested that more rigid insoles lead to greater postural stability with the underlying mechanism that more rigid insoles are more likely to place the foot in a more neutral position while softer insoles tend to better accommodate foot posture. A common limitation with the current research on textured insoles and insole material hardness is that postural stability was mainly assessed during static stance. Most activities of daily living are dynamic in nature and the mechanisms used to maintain static stability are quite different from those used to maintain dynamic stability (Hyun and Dingwell, 2006). An investigation on the textured insoles effects during dynamic activities was done by Hatton et al. (2012) who reported that wearing textured insoles did not affect gait stability parameters.

Besides the above-mentioned studies, Perry et al. (2008) compared a balance-enhancing insole and a conventional insole in terms of their effects on lateral stability during walking on a simulated uneven terrain. Different from the conventional insole, the balance-enhancing insole had a raised ridge around the perimeter. Perry et al. (2008) found that the balance-enhancing insole improved lateral gait stability over the uneven ground. de Castro et al. (2014) studied the effects of two pressure relief insoles during gait. They found that the insole with corkgel in the rearfoot and forefoot could relieved plantar pressure peaks, while the insole with poron foam in the great toe and lateral forefoot lowered ground reaction forces. de Castro et al. (2014) did not examine how these pressure relief insoles affect postural stability during gait.

The objective of this study was to examine the effects of four different types of insoles on postural stability in older adults. Postural stability was assessed in both static and dynamic conditions. Four types of commercially available insoles were selected

including cupped insoles, textured insoles, rigid insoles and soft insoles. We hypothesized that cupped insoles, textured insoles and rigid insoles would be associated with greater postural stability compared to soft insoles, because of the fact that softer standing surface decreases somatosensory feedback (Patel et al., 2011).

2. Methods

2.1. Participants

Thirteen healthy older adults including five males and eight females were recruited (age: 69.2 ± 7.2 years; height: 160.5 ± 6.8 cm; weight: 60.0 ± 6.9 kg). They were all above 60 years old, living independently in their own home, able to walk without the assistance of another person, and having no medical conditions. All participants provided written informed consent which was approved by the local ethical committee.

2.2. Insoles

Four types of commercially-available insoles were examined in the present study (Fig. 1). These insoles were designed and manufactured by Daiso Japan. The cupped insole is made from polyester and urethane sponge with the heel edge raised by approximately 15 mm (Fig. 1a). The textured insole is made from polyester and EVA (Fig. 1b) and has convex circular patterning with center-to-center distances of approximately 10 mm. The rigid insole and soft insole both have a complete flat surface (Figs. 1c and d). The rigid insole is made from polyurethane and EVA, and the material of the soft insole is slow rebound foam sponge. The insoles with different sizes were available to fit different foot sizes.

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