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The effect of textured ballet shoe insoles on ankle proprioception in dancers

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ABSTRACT

Background: Impaired ankle inversion movement discrimination (AIMD) can lead to ankle sprain injuries. The aim of this study was to explore whether wearing textured insoles improved AIMD compared with barefoot, ballet shoes and smooth insoles, among dancers.
Methods: Forty-four adolescent male and female dancers, aged 13–19, from The Australian Ballet School were tested for AIMD while barefoot, wearing ballet shoes, smooth insoles, and textured insoles.
Results: No interaction was found between the four different footwear conditions, the two genders, or the two levels of dancers in AIMD ($p > .05$). An interaction was found between the four different footwear conditions and the three tertiles when tested in ballet shoes ($p = .006$). Although significant differences were found between the upper tertiles and the lower tertiles when tested with ballet shoes, barefoot and with smooth insoles ($p < .001$; $p < .001$; $p = .047$, respectively), when testing with textured insoles dancers in the lower tertile obtained similar scores to those obtained by dancers in the upper tertile ($p = .911$).
Conclusion: Textured insoles improved the discrimination scores of dancers with low AIMD, suggesting that textured insoles may trigger the cutaneous receptors in the plantar surface, increasing the awareness of ankle positioning, which in turn might decrease the chance of ankle injury.

1. Introduction

Ballet dancers require high levels of postural and balance control to achieve better performance (Bronner, 2012; Kiefer et al., 2011; Lobo da Costa, Azevedo Nora, Vieira, Bosch, & Rosenbaum, 2013). Postural balance can be defined as the ability to maintain the body's center of mass within its base of support, with the mechanisms controlling postural control consisting of visual, vestibular and somatosensory/proprioceptive feedback (Hrysomallis, 2007). Somatosensory feedback refers to the proprioceptors located at the skin, muscles, tendons, ligaments, and joint capsules (Höhne, Stark, Brüggemann, & Arampatzis, 2011; Li, Xu, & Hoshizaki, 2009; McKeon & Hertel, 2007), which are integrated to determine the body position and movements in space. The sensory information from the proprioceptors contributes to providing feedback to the central nervous system regarding any change in foot position, in order to maintain balance and prevent loss of balance and potential injuries (Höhne et al., 2011).

To achieve excellence in a dance performance, dancers must have an outstanding proprioceptive ability to optimally represent limb position in space (Jola, Davis, & Haggard, 2011; Kiefer et al., 2013). Enhanced proprioceptive feedback may allow for improved movement smoothness, with better coordination and accuracy, which reflect the aesthetical values of dance (Smitt & Bird, 2013). Moreover, as professional dancers depend on the reliable functional stability of their ankle and foot joints to exercise their profession, better ankle and foot proprioception has been attributed to prolonged periods of training and decreased risk of injuries (Arnold, Linens, de la Motte, & Ross, 2009; Han, Anson, Waddington, & Adams, 2013; Hertel, Gay, & Denegar, 2002; Hutt & Redding, 2014; Li et al., 2009; Lin, Lee, Liao, Wu, & Su, 2011; Marmeleira, Pereira, Cruz-Ferreira, Fretes, Pisco, &

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Fernandes, 2009; Muaidi, Nicholson, & Refshauge, 2009; Rein, Fabian, Zwipp, Rammelt, & Weindel, 2011).

Any disruption of the proprioceptive system at the ankle may result in the generation of postural instability, ineffective application of muscle force, decreased detection of inversion movements, or a delay in the motor response of the peroneal muscles. Poor ankle movement control, especially over the medial-lateral direction, may place the ankle joint in inversion positions at increased risk for ankle and foot injuries (Batson, 2009; Corbin, Hart, McKeon, Ingersoll, & Hertel, 2007; Hiller, Refshauge, & Beard, 2004; Hrysomallis, 2007; Hrysomallis, 2011; Lin et al., 2011).

Previous studies have already attempted to increase plantar sensory and proprioceptive feedback, with the aim of protecting the athlete/dancer from injury (e.g., Batson, 2009; Li et al., 2009; Muaidi et al., 2009; Witchalls, Waddington, Adams, & Blanch, 2014). Since the plantar sole of the foot has previously been shown to provide important information about the disposition and movement of the body (Waddington & Adams, 2003), the rationale for inserting textured insoles into athletes' shoes was that performance might be improved by enhancing afferent information from the plantar sole to the central nervous system (Cameron, Adams, & Maher, 2008; Pearson & Whitaker, 2012; Waddington & Adams, 2003). The ability of textured insoles to improve the proprioception feedback from the sole of the foot and to provide an avenue for further reducing lower limb injuries, has been measured previously in athletes such as soccer and netball players, but not among dancers wearing ballet shoes (Salles & Gyi, 2013; Waddington & Adams, 2000, 2003).

In the current study, we hypothesized that proprioceptive insoles inserted in the ballet shoes would enhance proprioceptive feedback, providing more accurate information about foot position. This hypothesis was based on the assumption that wearing textured insoles would increase afferent information and improve ankle discrimination ability (Corbin et al., 2007). Furthermore, insoles have been shown to be well tolerated by athletes/dancers as an intervention for balance improvement and injury prevention (Salles & Gyi, 2013; Waddington & Adams, 2000).

An accurate way to evaluate the ability of the somatosensory system around the ankle joint to detect changes in foot position, is by measuring the ankle inversion movement discrimination ability (Waddington & Adams, 2003). It should be noted that although inversion movement occurs anatomically at the sub-talar joint, most ankle injuries have been found to be associated with false functional inversion movement at the ankle joint (Ashton-Miller, 2000; Waddington & Adams, 2003). Hence, in the current study ankle discrimination refers to inversion movement at the ankle joint.

There is a general consensus in the dance literature that proprioception and postural balance vary between dancers and non-dancers, between different dance levels (e.g., professional vs. amateur dancers), and when tested with different types of dance shoes (e.g., pointe shoes vs. demi-pointe shoes) (Fong Yan, Hiller, Smith, & Vanwanseele, 2011; Hopper, Grisbrook, Newnham, & Edwards, 2014; Hutt & Redding, 2014; Kiefer et al., 2013; Nunes, Haddad, Bartlett, & Obright, 2002; Rein et al., 2011; Smitt & Bird, 2013; Wyon, Cloak, Lucas, & Clarke, 2013); No previous study has examined the effect of the different construction of dance shoe linings on enhancing proprioception that may contribute to injury prevention. Therefore, the purpose of the current study was:

1) To examine the influence of textured insoles inserted into the ballet shoes compared to other conditions (barefoot, ballet shoes without insoles, and smooth insoles inserted into the ballet shoes) on AIMD among adolescents and mature dancers of both genders.
2) To determine whether AIMD in dancers with different footwear conditions changes over time.

2. Methods

A group of 44 dancers, aged 13–19 years (mean age = 16.32 ± 1.625), from the Australian Ballet School (ABS), were included in the current study. The study was approved by the Ethics Committee of Victoria University, Australia. All dancers and one of their parents (for dancers under the age of 18) provided written informed consent for participation.

All participants were full-time elite classical ballet students at the ABS. Their ages ranged from 13 to 19 and their dance levels ranged between Levels 4–5 (adolescent dancers aged 13–16) and 6–7 (mature dancers aged 17–19) (Table 1). ABS students are selected by an extensive audition process. Students are predominantly from throughout Australia and New Zealand and from Asian countries, particularly Japan and China.

For inclusion in the present study, participants had to be students that were participating in a full-time programme of vocational dance training at the ABS. Participants were excluded from the study if they were suffering from any current lower extremity or lower back injury.

2.1. Equipment

2.1.1. Ankle movement extent discrimination apparatus (AMEDA)

The AMEDA provides discrimination scores representing each participant's sensitivity to small differences in the degree of ankle inversion (Waddington & Adams, 1999) (Fig. 1).

The AMEDA device consists of a hinged plate which rotates around an axle under the long axis of the foot being tested. With their feet placed shoulder-width apart, standing with both legs in a weight bearing position, subjects were asked to stand in a relaxed posture on the platform of the AMEDA, with the foot of the limb being tested centered over the axis of movement of the movable base plate. The participant made an active inversion movement which moved the plate and the outer side of the foot down until contact was made by the rim of the plate on an adjustable metal stop. The participant then returned the plate to the horizontal stopped position at the same steady pace, and made a judgment as to the degree of inversion achieved during the movement.

The AMEDA uses a set of 5 predetermined available end positions for ankle inversion movements. The 5 predetermined displacements, from smallest to largest, were: 10.49°, 11.84°, 12.55°, 13.27° and 14.52° from the horizontal position. A position number (1, 2, 3, 4 or 5) was assigned to each movement displacement in order from the smallest/shallowest angle (10.49°- position number 1) to the largest/deepest angle (14.52°- position number 5). Participants were provided with three familiarization trials during which they experienced all of the available movement degrees in sequence. A trial consists of each of the 5 movement degrees being presented to the participant 10 times in a random order (a total of 50 ankle movements), with the participant judging each movement degree as it is undertaken and reporting the appropriate position number.

2.1.2. Four footwear conditions

The ability to discriminate differences in the degree of ankle inversion movements was measured in four different footwear conditions.

The order in which each dancer was tested with the four different types of footwear was randomized using a Latin square.

1. Ballet shoes: Each dancer was tested using his/her personal ballet shoes.
2. Barefoot: The dancers were tested standing barefoot on the AMEDA device.