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The effect of ankle bracing on landing biomechanics in female netballers

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ABSTRACT

Objectives: Investigate the impact of lace-up ankle braces on landing biomechanics.
Design: Within-subject repeated measures. Participants completed a drop jump, drop land, and netball-specific task in braced and unbraced conditions.
Setting: Biomechanical research laboratory.
Participants: Twenty female high school netballers.
Main outcome measures: Leg, knee, and ankle stiffness, knee/ankle stiffness ratio, knee and ankle sagittal excursion, peak vertical ground reaction force, time-to-peak vertical ground reaction force, and loading rate.
Results: In the brace condition leg stiffness increased bilaterally during the drop land (ES = 0.21, 0.22), ankle stiffness increased bilaterally during the drop jump (ES = 0.37, 0.29) and drop land (ES = 0.40, 0.60), and knee/ankle stiffness ratio decreased in all three tasks (ES = −0.22 to −0.45). Ankle sagittal excursion decreased bilaterally during the drop jump (ES = −0.35, −0.53) and drop land (ES = −0.23, −0.46), and decreased in the lead limb during the netball jump (ES = −0.36). Knee excursion decreased bilaterally during the drop jump (ES = −0.36, −0.40) and in the lead limb during netball task (ES = −0.59). Lead limb TTP was greater during the netball jump (ES = 0.41).
Conclusions: Lace-up ankle braces may increase leg and joint stiffness and reduce joint excursion during landing but do not appear to affect landing forces. The observed effect on landing biomechanics may predispose young netballers to injury.

1. Introduction

Netball is a popular international game and the leading women's sport in Australia, England, and New Zealand. The most common lower-extremity injuries incurred during netball include knee and ankle sprains, calf strains, and Achilles tendon injury (Otago & Peake, 2006). Poor landing technique such as excessive stiffness, and low hip, knee, and ankle excursion, combined with high ground-reaction forces (GRFs) incurred during sudden stop-landings (a common task in netball due to the rules) may contribute to netball injury (Mothersole, Cronin, & Harris, 2013). Due to the high prevalence of ankle sprains in netball, ankle braces may be worn to both support and prevent ankle injury (Sports Medicine Australia; Vanwanseele, Stuelcken, Greene, & Smith, 2013). Although braces have been found to be effective in reducing the risk of ankle injury (Papadopulos, Nicolopoulos, Anderson, Curran, & Athanasopoulos, 2005) lace-up ankle braces may restrict dorsiflexion (DF) range of motion (ROM) (Parsley, Chinn, Lee, Ingersoll, & Hertel, 2013) subsequently restricting knee and hip sagittal excursion on landing (Fong, Blackburn, Norcross, McGrath, & Padua, 2011). Reduced excursion may result in a stiffer landing style and greater GRFs and loading rates (LRs) (Bisseling, Hof, Bredeweg, Zwerver, & Mulder, 2008; Fong et al., 2011) which have been associated with increased injury risk (Mothersole et al., 2013). The purpose of this study was to investigate the impact of lace-up ankle braces on landing biomechanics. We hypothesised that ankle bracing would increase leg and joint stiffness, decrease knee/ankle stiffness ratio, decrease ankle and

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knee sagittal excursion, increase vertical ground-reaction forces and loading rate, and decrease time-to-peak force.

2. Methods

Twenty-six, uninjured female high school netball players from a local secondary school were recruited. Participants were considered uninjured if they were fully participating in training and games at the time of testing. Informed consent was obtained from participants and legal guardians prior to testing and ethical approval was granted by a university ethics committee. Sample size calculations were made using an Excel spreadsheet for estimating sample size (Hopkins, 2006a). Based on a standardised smallest important difference (Cohen's d) of 0.2 and the standard error of measurement for leg stiffness during running reported by Lorimer (2013) we estimated 13 participants were required to achieve 80% power.

Participants' height, weight, and bilateral trochanterian height were measured by a researcher trained in International Society for the Advancement of Kinanthropometry (ISAK) protocols. Retroreflective markers (10 mm) were placed bilaterally at anatomical landmarks using a modification of previously described three dimensional models (Besier, Sturnieks, Alderson, & Lloyd, 2003) (Supplementary figure online). Clusters of four retroreflective markers on thermo-moulded plastic shells were placed at the sacrum, mid-thigh, and mid-shank. Individual markers were placed bilaterally on the ASIS, greater trochanter, medial and lateral femoral condyles and malleoli, proximal and distal mid-line posterior calcaneus, medial and lateral anterior calcaneus, 1st and 5th metatarsal heads, and centre line of the forefoot between 2nd and 3rd metatarsal heads. Foot markers were placed over the shoes with landmarks palpated through the shoes. The same physiotherapist palpated for anatomical landmarks and attached markers for all participants.

Participants wore tight-fitting shorts and t-shirts or singlet's which allowed easy palpation of bony landmarks and secure marker application. The McDavid lace-up 195-R brace was selected as it is commonly used by netball players. Braces were fitted as per manufacturer's instructions by the same physiotherapist. All participants wore standard sports shoes of the same brand and style (Asics Gel-Kurow).

Participants completed a warm-up consisting of 3 min on a stationary bike at a self-selected pace, five squats, and ten walking lunges. Braces were then fitted and tasks were practiced 3–5 times to allow familiarisation with tasks and braces. Participants then completed three trials of three landing tasks in braced and unbraced conditions with a 30 s rest between trials. Task order was randomised and brace condition order alternated with each consecutive participant.

Landing tasks included a drop jump, drop land, and a netball-specific task in which participants landed instinctively with minimal instructions or restrictions. The drop jump and drop land were performed from a 30 cm box with participants resting their preferred heel on the edge of the box before dropping down. During the drop jump participants were instructed to perform a vertical jump for maximal height immediately upon landing. Participants approached the netball jump at a 3–4 m long run (distance determined by participant comfort), jumped forward off their preferred limb and landed with a one-to-two landing style coming to a complete stop as per netball rules. During the jump, participants received a chest-pass delivered at a flat trajectory by a researcher standing 4 m from the far edge of the force plate at a 5° angle to the line of approach. The majority of passes in netball are received bilaterally between chest and head-height while leaping or hopping forward and do not require players to reach (Hopper, Lo, Kirkham, & Elliott, 1992). For these reasons trials were considered unsuccessful if the pass was caught above the head or below the chest, required participants to reach further than arm-length, caught one-handed, or dropped.

Variables included ankle and knee sagittal excursion (peak angle minus the initial contact (IC) angle), leg, knee, and ankle stiffness, knee/ankle stiffness ratio, peak vertical ground reaction force (vGRF), time-to-peak vGRF (TTP), and loading rate (LR). Kinematic data was collected via a 9-camera (200 Hz) VICON motion analysis system (Oxford Metrics Ltd., Oxford, UK). A Bertec treadmill (BERTEC Corp, Worthington, OH, USA) set flush with the floor and locked to act as a force plate (1000 Hz) was used to collect kinetic data. Functional joint positions were determined using a custom built, MATLAB constrained optimization program (*Optimization Toolbox*, Mathworks Inc.; Natick, MA) (Besier et al., 2003). Visual3D software (*Visual 3D*, C-motion, Inc.; Germantown, MD) was used to calculate joint moments and foot centre of pressure locations via inverse dynamics. Anatomical co-ordinate systems were determined as described by Besier et al. (2003). The foot was modelled as a single-segment with the x-axis forming a line joining the two calcaneal markers, and y-axis forming a line from the proximal calcaneal marker to the forefoot midline marker. The z-axis was orthogonal to the x and y axes. Leg and joint stiffness were calculated from kinetic and kinematic data based on the validated mass-spring model (Schmitz & Shultz, 2010). Stiffness was calculated using the most reliable equations identified in previous research (Supplementary table online) (Lorimer, 2013). Knee/ankle stiffness ratio was also calculated as it has been associated with injury (Lorimer, 2013).

Normality was tested via the Shapiro–Wilk test and visual inspection of histograms using SPSS version 22. Extreme outliers were defined as any data points lying more than three times the interquartile range away from the interquartile range and three were removed prior to analysis. The mean of three trials was taken and as the data was not normally distributed it was log-transformed prior to analysis. A spreadsheet for analysing outcomes in a crossover study with a single group was used to derive magnitude based qualitative inferences as to the true effect of the ankle brace on dependant variables (Hopkins, 2006b). Cohen's d effect sizes (ES) of 0.20 were used as the threshold for substantial change (Hopkins, Batterham, Marshall, & Hanin, 2009). Where the effect had a >5% probability of being substantially positive or substantially negative the inference was stated as 'unclear'. Otherwise the outcome was clear and the inference was based on the likelihood the true value of the ES was greater than 0.20 using the following scale: 25–75%, possibly; >75%, likely; >95%, very likely; >99.5%, most likely (Hopkins et al., 2009). Magnitudes of observed ES's were interpreted based on the following scale: 0.2–0.59 (small), 0.6–1.19 (moderate), 1.2–1.99 (large), 2.0–3.99 (very large), ≥4.0 (extremely large) and their inverse (Hopkins et al., 2009).

3. Results

Prior to data collection three participants withdrew due to injury and one was unavailable. Technical issues during data collection resulted in the exclusion of two further participants. Analysis was therefore conducted with 20 participants (mean ± SD, age = 15.9 ± 1.2 y; mass = 65.5 ± 6.5 kg; height = 171.5 ± 5.0 cm).

Technical issues during data collection resulted in the exclusion of all drop-land trials for one participant. A second participant switched leading limbs between braced and unbraced conditions during the netball jump and this data was also excluded.

Raw outcomes, ESs, and inferences for the effect of ankle bracing on stiffness, sagittal excursion, and kinetics are reported in