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The effect of ankle bracing on lower extremity biomechanics during landing: A systematic review

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ABSTRACT

Objectives: To examine the evidence for effect of ankle bracing on lower-extremity landing biomechanics.
Design: Literature review.
Methods: Systematic search of the literature on EBSCO health databases. Articles critiqued by two reviewers.
Results: Ten studies were identified which investigated the effect of ankle bracing on landing biomechanics. Overall results suggest that landing biomechanics are altered with some brace types but studies disagree as to the particular variables affected.
Conclusions: There is evidence that ankle bracing may alter lower-extremity landing biomechanics in a manner which predisposes athletes to injury. The focus of studies on specific biomechanical variables rather than biomechanical patterns, analysis of pooled data means in the presence of differing landing styles between participants, variation in landing-tasks investigated in different studies, and lack of studies investigating goal-directed sport-specific landing tasks creates difficulty in interpreting results. These areas require further research.

1. Introduction

Ankle braces are commonly worn during sport to support or prevent ankle injury.[1] Some common brace types may restrict ankle dorsiflexion (DF) range of motion (ROM)[2,3] which in turn may alter lower-extremity biomechanics during landing tasks in a manner which predisposes the athlete to injury.[4,5] Reduced DF ROM has been reported with lace-up braces[2,3] and Aircast-stirrup braces.[2,6] However these studies measured DF range goniometrically in non-functional positions which has been shown to underestimate true maximal range.[7] Therefore, although bracing appears to reduce available range during passive testing this effect may be different during landing tasks where greater forces may be needed to overcome the resistance of the brace.

Restricted DF ROM has been linked to a number of acute and chronic lower-extremity injuries.[8–16] The biomechanical reasons for these associations remain unclear but it has been theorised that DF restriction limits the ability to pass the leg forwards over the foot[15,17–19] and to lower the centre of mass during squatting movements.[5] This may be compensated for with subtalar and mid-foot pronation[15,17,18] or knee valgus,[15,20] increasing the risk of associated injuries such as ACL injury,[7] Achilles injury,[4] and patellar tendon injury.[1,8] The restricted sagittal excursion may also reduce time to attenuate landing-forces leading to increased loading-rates (LRs) and ground-reaction forces (GRFs).[4,21,22] Furthermore, reduced sagittal excursion may increase lower-extremity stiffness which is also associated with increased GRFs and LRs[4,21–23] and is speculated to increase injury-risk.[24,25]

The link between reduced DF ROM and injury and the potential for braces to restrict DF suggests that ankle bracing may result in biomechanical compensations which predispose athletes to injury. Thus the purpose of this review is to examine the evidence for the effect of ankle bracing on lower extremity biomechanics during landing tasks.

2. Methods

The following search was conducted on EBSCO Health Databases on 1/09/2014: (brac* AND (ankle OR talocrural) AND (mechanic* OR biomechanic* OR kinetic* OR kinematic* OR move OR "ground-reaction-force*" OR GRF* OR (force* AND (land* OR load)) OR stiff*)

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AND (jump* OR land* OR hop*). Reference lists were scanned to identify further articles.

Studies were included if they compared biomechanical variables in braced and unbraced conditions with at least one of the following outcome measures: GRF, LR, time-to-peak (TTP) GRF, stiffness, or lower-extremity kinematics during a landing task. Studies were excluded if they included injured participants, or compared between genders, different landing-tasks, or in varying states of fatigue. Articles were restricted to full text in the English language, no publication date restrictions were imposed.

Data was tabulated (Table 1) with dependent variables which were not a focus of the review excluded (e.g. effect of ankle strapping). Where the foot model used was not stated and markers were placed at the malleoli, calcaneus, and metatarsal heads, it was assumed that a single-segment foot model was used. Where possible 90% confidence intervals (CIs) were calculated[26] with threshold P-values used (e.g. $P \leq 0.05$) where exact P-values were not reported. Soft braces which used laces to secure the brace to the ankle were classified as 'lace-up', those using air-cells to splint the ankle were classified as 'Aircast-stirrup' braces, and those constructed from rigid or semi-rigid plastic with a hinge on the horizontal axis were classified as 'rigid-stirrup' braces.

Articles were critiqued by two reviewers using the modified Downs and Black checklist[27] (Table 2). Question 27 of the checklist was altered to score 1 for sufficient sample size based on power calculation and score 0 for insufficient sample size or power not calculated.

After critiquing studies were categorised as *poor, limited, moderate*, or *strong* quality (Supplementary Table 1) in a similar manner to other systematic reviews which used the modified Downs and Black checklist.[28–30] Levels of evidence were then determined[31] (Supplementary Table 2). Evidence was classified as 'strong' where there were consistent findings among multiple strong quality RCTs, 'moderate' were there were consistent findings among multiple moderate quality RCTs and/or one strong quality RCT, 'poor' where there were consistent findings among multiple low quality RCTs/CCTs and/or one moderate quality RCT, and 'Limited' were there was support from one low quality RCTs/CCT. Evidence was classified as 'conflicting' where there were inconsistent findings among multiple RCTs/CCTs. Evidence was considered 'consistent' when at least 75% of articles agreed on key outcomes.[32]

3. Results

The database search yielded 100 articles of which ten met the inclusion criteria (Fig. 1). Scores ranged from 16 to 26/28 on the Downs and Black checklist with three articles classified as strong quality and seven as moderate quality (Table 2). The major quality issues were a lack of power calculations, not stating source populations, not stating the percentage of those approached who agreed to participate, and a lack of participant and researcher blinding.

Overall there is strong evidence that lace-up and Aircast-stirrup braces alter landing biomechanics and conflicting evidence regarding rigid-stirrup braces. There is strong evidence for reduced peak DF angle with lace-up braces, moderate evidence for a reduction with Aircast-stirrup braces and moderate evidence for no reduction with rigid-stirrup braces. There is strong evidence for other alterations in ankle kinematics with lace-up braces, moderate evidence with Aircast-stirrup braces, and conflicting evidence regarding rigid-stirrup braces. There is moderate evidence for altered knee kinematics with lace-up braces, and conflicting evidence regarding rigid-stirrup braces. There is poor evidence that lace-up braces do not affect hip kinematics and moderate evidence that rigid-stirrup braces do not affect hip biomechanics. There is conflicting evidence regarding the effect of lace-up and rigid-stirrup braces on vGRF

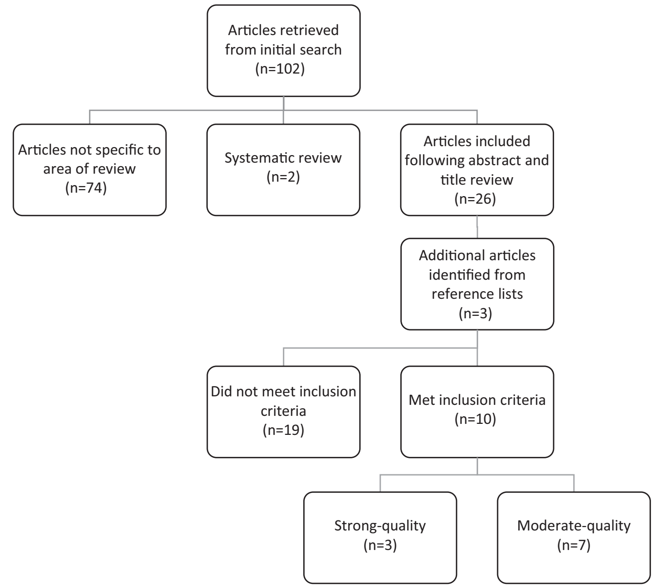

Fig. 1. Search results—Articles reporting on the effect of ankle bracing (≥21 = strong-quality, 14–20 = moderate quality, 7–13 = limited-quality, <7 = poor quality.

and TTP vGRF. There is moderate evidence for no effect of Aircast-stirrup braces on vGRF and poor evidence for reduced TTP vGRF and increased LR. There is conflicting evidence regarding the effect of rigid-stirrup braces on LR. There is poor evidence for no effect of Aircast-stirrup braces on vertical stiffness.

There were 166 participants across all studies (108 female, 58 male) with an age range of 17 to 22.7 years. Participants were involved in a number of sports including basketball, volleyball, netball, and soccer, with one study describing participants as 'recreationally active'[33] and one not stating activity levels or sports.[34]

Kinematics were investigated via 3D motion capture systems, single-camera motion capture, or electromagnetic 3D motion analysis systems. Kinematic variables included ankle, knee, and hip sagittal, frontal, and transverse motion. Two studies[35,36] used single-segment foot models, one[37] used a two-segment model, and four studies[38–41] did not state the foot model used. Four studies[36,39,40,42] measured shoe motion, two[35,37] measured in-shoe foot motion, and another[41] assessed participants barefoot. In one study[38] it was not possible to determine whether foot or shoe motion was measured. Kinetic variables were captured via force plates and included peak vertical GRF (vGRF), first and second peak vGRF (P_1, P_2), time-to-peak (TTP) vGRF, time-to first peak and second vGRF peaks (TTP_1, TTP_2), loading-rate (LR), and LR at P_1 and P_2 (LR_1, LR_2). One study[33] calculated vertical stiffness from vGRF and COM displacement data.

All studies used a within-subject design and within each study all participants completed the same landing-tasks. Landing-tasks included drop-jumps, drop-landings, forward jumps, and sport-specific jumps with a variety of heights, distances, and landing-styles (bilateral, unilateral).

Of the five studies investigating peak DF angle during a landing task three[35,36,40] found reduced peak DF with a lace-up brace with one study[36] also reporting reduced peak angle with an Aircast-stirrup brace. Conversely, one study[37] found no change in DF angle with a lace-up brace, and two[36,38] found no change with rigid-stirrup braces.

Of the five studies investigating initial contact (IC) plantarflexion (PF) angle three[35,36,40] found reduced IC angle with lace-up braces and one[36] with an Aircast-stirrup brace. Conversely, two studies found no effect of lace-up[37] or rigid-stirrup[36] braces on IC angle and one study[38] found greater IC PF angle with a rigid-stirrup brace.