Effect of Selected Ankle Supports on Resistance to Inversion Force and Range of Motion

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Introduction

Ankle injuries account for 15-60% of all volleyball injuries (Briner *et al.*, 1999) and 85% of all ankle injuries (Garrick, 1977). The majority of injuries are sprains caused by excessive inversion which stretch and tear the lateral ligaments of the ankle. As the most common acute injury in volleyball, sprains are caused by landing improperly, either on the floor or another player's foot or by repetitive jumping (Bahr *et al.*, 1994). The incidence of reoccurrence of ankle injuries is very high. Chronic pain or instability occurs in 20-50% of all people who have suffered ankle sprains (Robbins *et al.*, 1998).

Ankle braces have been designed to protect ankles from injuries by limiting active and passive inversion range of motion and supporting weakened ligaments. High-top volleyball shoes were also created to provide additional support to the ankle and to prevent ankle sprains. Ankle instability occurs during loading and unloading of the foot, so the shoe should reduce impact, alter the pressure distribution and provide stability during the push-off phase of gait (Barnes *et al.*, 1994). The mechanism by which these supports prevent injury had not been quantitatively measured. The purpose of this study was to determine if the ankle braces and volleyball shoes chosen were able to provide increased resistance as measured by the inversion and eversion moments of force without influencing ankle plantar flexion or dorsiflexion ranges of motion.

Methods

Thirty subjects (14 male and 16 female; mean age 21.8 ± 3.8 years, mean height 172.37 ± 5.76 cm, mean weight 68.28 ±13.75 kg) volunteered for the study. The shoes chosen were the ASICS Gel volleyball shoe in the low-top and midcut models. The midcut shoe has additional ankle support because the shoe laces to the level of the malleoli. This was the highest shoe available and was considered a high-top shoe for the purpose of the study. The two braces used were the Active Ankle T1 Trainer (AA) and the Ankle Support Orthosis (ASO). The AA is a rigid hinged orthosis and the ASO is a more flexible lace-up brace with additional neoprene straps in a figure-eight pattern.

The subjects were tested for the increase of resistance to inversion and eversion force on the KinCom isokinetic dynamometer with a modified ankle inversion attachment. The modified attachment allowed the subjects to be weight-bearing during testing. The KinCom operated in the passive mode for the moment of force measurements at a slow acceleration and a velocity of 30°/s. The limits for the range of motion were set while the subject was wearing the low-top shoe (control condition). The subjects moved from maximal eversion to maximum inversion and back again. Five trials were completed for each of the six support conditions. A support condition consisted of the low-top shoe or midcut shoe, one of the two braces or no brace. Plantar flexion and dorsiflexion ranges of motion were measured in the six support conditions using a handheld goniometer and the subject free of the KinCom.

A repeated-measures ANOVA was done on the difference in force production during inversion, eversion and on active range of motion for plantar flexion and dorsiflexion. The force value for each trial was taken when the angle was between zero and the maximum for inversion or eversion. The maximum value during this period was used in the analysis.

Results and Discussion

There were no significant differences between the support combinations for resistance to eversion force production but there were significant differences in terms of resistance to inversion moment of force ($F(5,145) = 2.95$, $P < 0.05$). Tukey *post hoc* tests revealed that the differences were between the low-top shoe with AA and the high-top shoe without a brace. The high-top shoe and brace combinations provided less resistance to inversion (Figure 1). The construction of the midcut shoe may have interfered with the brace inhibiting its performance. It was difficult to fully tighten the AA in the high-top shoe and the shoe was not as tightly laced with either of the braces as compared to without a brace. The braced conditions provided a increased moments of force as compared to the unbraced condition. These differences were not always statistically significant but apparent trends show an increase in moment of force for each of the shoe heights with the addition of either one of the braces.

Plantar flexion ($P<0.0005$) and dorsiflexion ($P<0.0005$) ranges of motion were decreased in most of the support conditions (Figure 2). These reductions are within the normal parameters needed for walking as determined by Nordin and Frankel (1989). It was assumed that they would not negatively affect athletic performance once the athlete became accustomed to the brace.

The conclusion is that the best ankle support tested was the low-top shoe and Active Ankle brace combination. This combination produced the greatest resistance to inversion force and only slightly decreased plantar flexion or dorsiflexion. The hinged ankle orthosis moved freely in the sagittal plane while providing greater force to limit inversion and eversion. It was also easy to apply and comfortable to wear in the low-top shoe. In the midcut shoe the brace was awkward to apply and difficult to fully tighten. This might explain why this combination did not provide the greatest resistance to inversion force as had been expected.

The forces produced by the testing procedure did not compare to the forces required to cause injury. This was a result of the need to keep the subjects safe from harm. Testing on cadaveric ankles in which injury causing forces could be applied to the ankle in different support conditions to provide a clearer picture of the support condition that provides the most moment of force to resist inversion.

References

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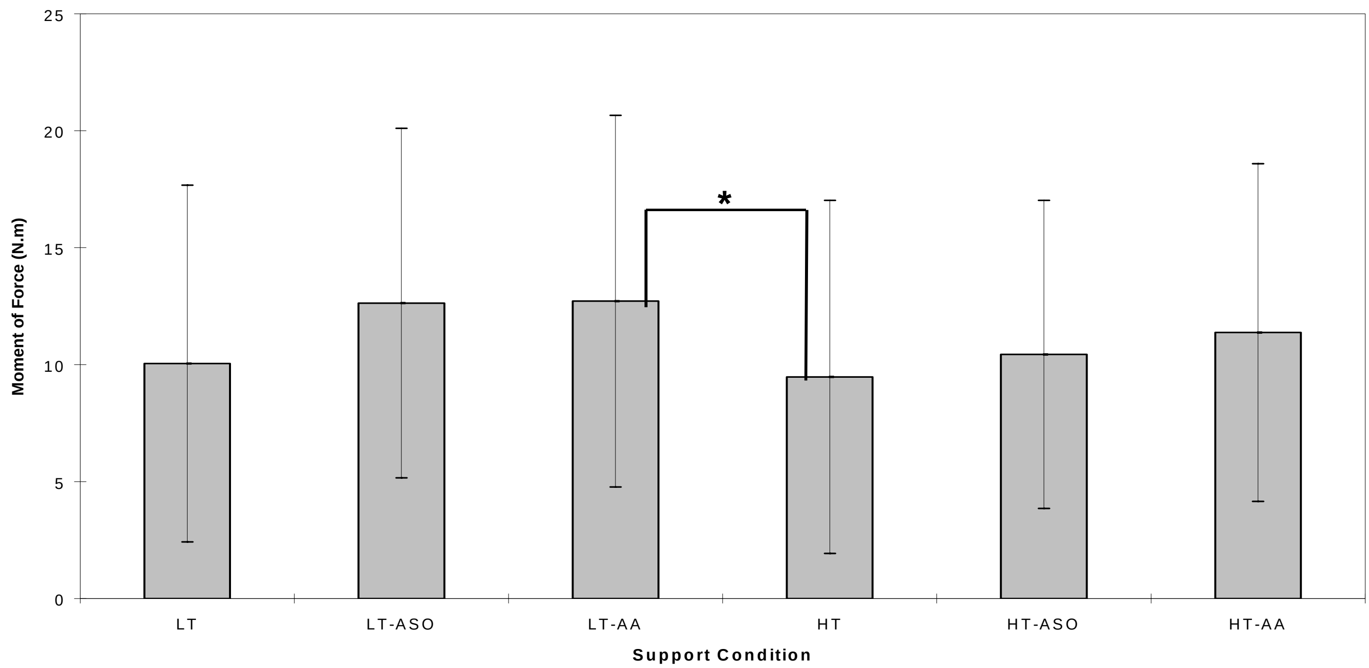

Figure 1. Resistance to inversion moment of force for the support conditions.
* Mean values are significantly different at the 0.05 level.

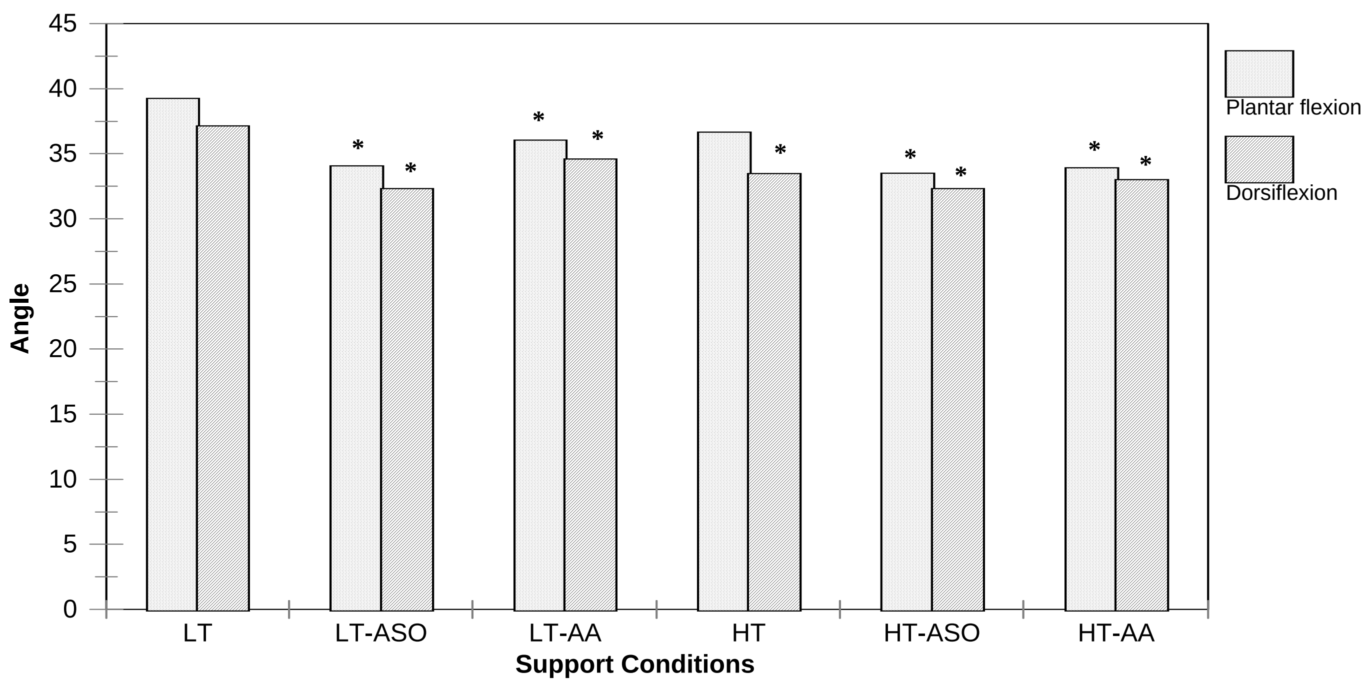

Figure 2. Reduction in range of motion for the support conditions.
*Mean values are significantly different from the control (LT) condition.