SAGITTAL PLANE RESISTANCE TORQUE IN ANKLE BRACES

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KEYWORDS: ankle brace, angular torque, ankle joint

INTRODUCTION: Ligaments of the ankle joint complex are among the most frequently damaged structures during sports and physical activity (Eils et al., 2002). One common intervention used to prevent ankle ligament injury is the application of lace-up style ankle braces. These braces, usually made of non stretch nylon materials, increase the mechanical stability at the ankle joint by restricting the allowable range of motion thereby limiting strain on joint ligaments. Ankle braces are primarily designed to restrict motion in the frontal plane to limit ankle inversion and eversion without impeding the plantar-dorsi flexion (PF) motion (Eils et al., 2002). However, studies examining the effect of bracing on ankle motion during drop jumping have found a significant reduction in sagittal plane ankle motion while braced (DiStefano et al., 2008). Previous studies have examined isolated ankle range of motion restriction around the PF axis with different brace types (e.g. Eils et al 2002), but these studies were not able to distinguish the resistance torque due to the brace alone. The purpose of the present study was to measure the passive mechanical resistance torque around the ankle PF axis generated by a range of commercially available ankle braces while moving through the sagittal plane.

METHODS: Five widely used commercial ankle braces were examined (Table 1). All models were a lace-up design. One brace (ASO) was tested with and without removable plastic lateral supports (stays). A mechanical shank/ankle/foot was used to simulate passive motion around the PF axis. The shank was a sculpted wood blank and the foot was a 26 cm prosthetic foot. The shank and foot were connected by a mechanical ankle composed of a single revolute hinge simulating the PF axis. The PF axis was aligned to be perpendicular to the sagittal plane. The mechanical shank was rigidly attached to an isokinetic dynamometer (Humac Norm, Computer Sports Medicine, Inc., MA) with the PF axis of the ankle aligned with the axis of rotation of the dynamometer (Figure 1).

Table 1. Five brace designs tested. The ASO brace was also tested without plastic lateral supports.

Ankle Lok (Swede-O, North Branch, MN)
ASO (Medical Specialties, Inc., Charlotte, NC)
ASO without stays (Medical Specialties, Inc., Charlotte, NC)
Pro Lacer (Cramer Products, Inc.,Gardner KS)
AS1 (Cramer Products, Inc.,Gardner KS)
ATF (Mueller Sports Medicine, Inc., Prairie du Sac, WI)

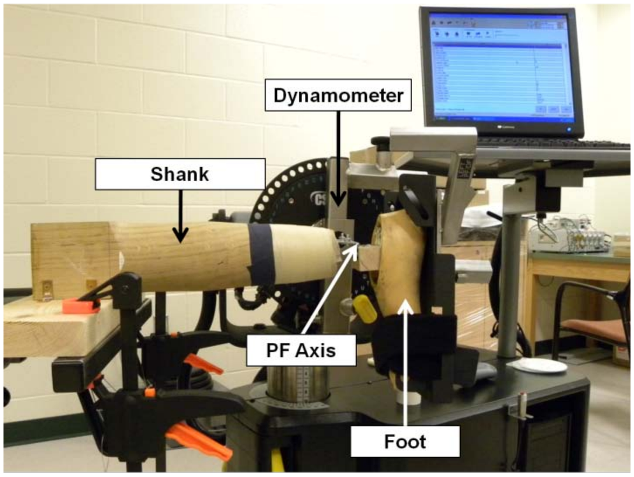

Figure 1. Mechanical shank/ankle/foot attached to dynamometer

Braces were applied to the mechanical shank/ankle/foot according to manufacturer's directions. Braces were tightened in a similar manner and initial tightness was controlled using a thin-film pressure transducer (FlexiForce, Tekscan, Inc, MA) placed under the laces in the proximal section of each brace. The dynamometer cycled each brace through a physiological range of motion (30° dorsiflexion to 60° plantar flexion) while simultaneously recording the resistive torque in the PF axis. All braces were cycled 10 times at a constant speed of 10°/s and torque vs PF angle profiles were obtained. A reference trial which no brace was attached to the shank/ankle/foot was obtained to account for residual torque from the experimental set-up and gravity effects. This residual torque was accounted for when calculating brace torques.

RESULTS: The torque produced by each brace differed over the entire range of motion with the greatest resistance torque produced during maximal plantar flexion (Figure 2). The ASO and AS1 ankle braces generated the largest torques (Figure 2). The neutral position (i.e. where no resistance torque was found) ranged between 12° dorsiflexion to 5° plantar flexion (Figure 2). The ASO brace tested with the plastic lateral supports removed showed a distinct decrease in PF resistance torque as well as an altered neutral position compared to the complete ASO with lateral support stays. Although all braces were measured at a velocity of 10°/s, different speed trials were performed (75°/s and 180°/s) with no difference in torque outputs and as such are not reported.

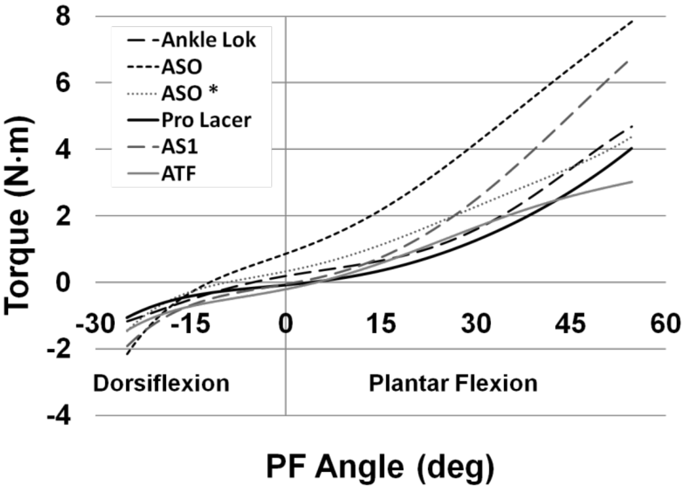

Figure 2. PF torque vs angle. (ASO* = without lateral supports)

DISCUSSION: The primary goal of this study was to determine the passive mechanical resistance torque in PF axis generated by 5 different commercially available ankle braces. The PF resistance torque was proportional to PF angle and there appeared to be differences between commercial brace designs. These observed differences in torque can be attributed to the material composition of each brace as well as subtle differences in lacing and support strap designs. The lateral plastic supports in the ASO brace markedly increased the passive PF resistance torque indicating a coupling between frontal and sagittal brace stiffness.

CONCLUSION: This study identified the passive mechanical resistance torque around the PF axis in a series of lace-up ankle braces generated during sagittal plane motion. Although ankle brace designs aim to limit the frontal plane of motion at the ankle, our results indicate that sagittal plane torque also occurs. This information will be useful when modeling ankle joint motion while wearing braces. In particular, when performing inverse dynamics analysis this type of information is needed to separate torques due to muscle and soft tissue action from those due to the passive mechanical properties of the brace alone.

REFERENCES:

DiStefano, L. J., et al. (2008) Lower extremity kinematics and ground reaction forces after prophylactic lace-up ankle bracing. *Journal of Athletic Training*, 43 (3), 234-231.

Eils, E., et al. (2002). Comprehensive testing of 10 different ankle braces, evaluation of passive and rapidly induced stability in subjects with chronic ankle instability. *Clinical Biomechanics*, 17, 526-535.

Acknowledgement

We would like thank the Natural Sciences and Engineering Research Council of Canada for funding provided to Mike Smith.