The Three Dimensional Passive Support Characteristics of Ankle Braces

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ABSTRACT: The purpose of this study was to evaluate the effect of ankle braces on the three dimensional passive load-displacement properties of the ankle. Since the ankle possesses three rotational degrees of freedom (dorsiflexion/plantar flexion, inversion/eversion, internal/external rotation), the effect of the brace in each one of these directions must be examined. For this purpose, the Ankle Flexibility Tester (AFT), an instrumented six degrees of freedom linkage, was used. This unique device allowed direct assessment of the load-displacement properties of the ankle in all rotational directions. Specifically, it measured the passive three dimensional properties of each ankle brace system. Two types of braces, lace-up and stirrup, were studied. Lace-up braces included the Ascend and the Swede-O. Stirrup braces included the Aircast and the Active Ankle. All four braces were tested on a volunteer population of ten healthy adults ranging in age from 28 to 40 years. All subjects participated in a variety of athletic activities on a regular basis. None of the subjects had a history of severe ankle injury. The parameters used in the evaluation included segmental flexibility, range of motion (ROM) at a specified torque, and an index of performance in dorsiflexion and plantar flexion. In brief, data analysis required gathering data sets each consisting of load-displacement data from five loading/unloading cycles. The averages of these five cycles were calculated and used in the subsequent analysis. The intercycle variability was found to be negligible. In the dorsiflexion and plantar flexion directions, two parameters were used in analysis: (1) range of motion and, (2) performance index. The ratio between the ROM with each brace and the ROM without the brace was calculated and reported in percentages. The index of performance was defined as the ratio of ROM divided by the moment which was required to produce that range. Repeated measure analysis of variance followed by a student Neuman-Keuls test at $P>0.05$ was performed to identify significant differences among the braces as well as between the braced and the non-braced conditions.

RESULTS: On the basis of segmental flexibility in inversion, all four braces were found to provide significant stabilization to the ankle. However, the Active Ankle brace was found to provide significantly higher stabilization than the other three braces. The reason for this increased support was most likely due to the lateral rigidity of this brace as compared to the other braces (figure 1). On the basis of segmental flexibility in eversion, the findings were the same as for those of segmental flexibility in inversion. That is, similar to inversion, all braces were found to significantly reduce lateral ROM with the Active Ankle brace providing significantly higher restriction than the other braces (figure 2).

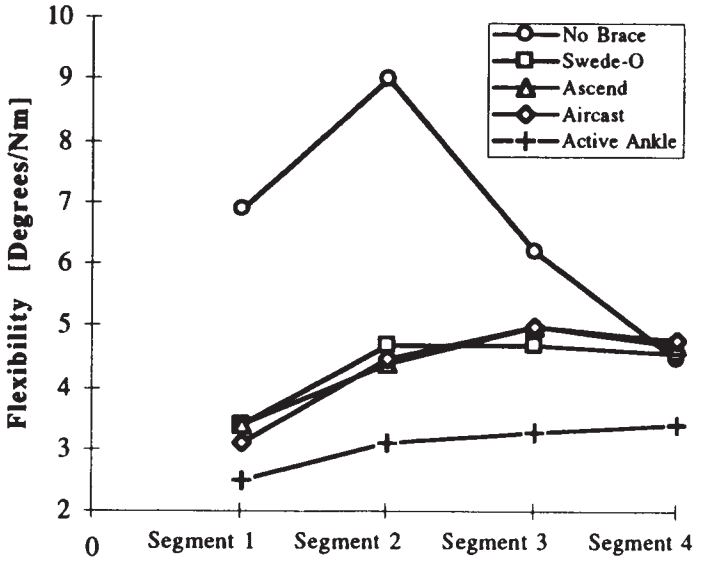

Figure 1. Inversion

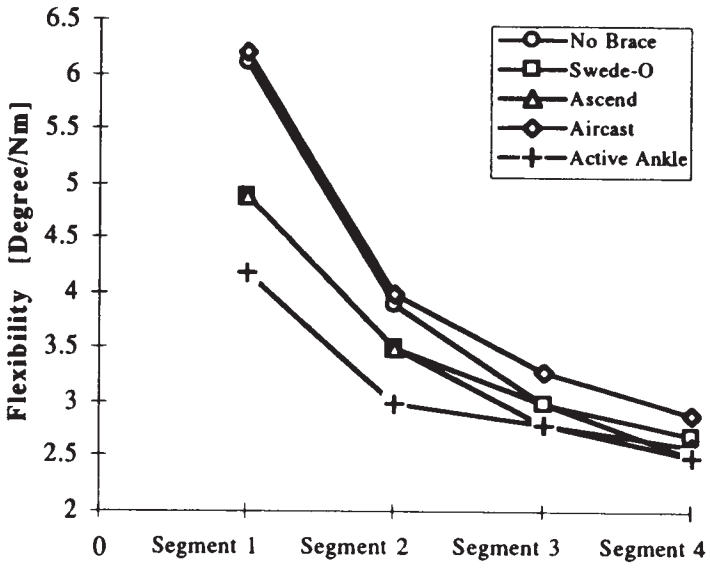

Figure 2. Eversion

On the basis of segmental flexibility and ROM, all braces were found to provide significant support to the ankle in internal rotation in segment 1 (figure 3). The support provided by the stirrup braces in this direction was found to be higher than that of lace-up braces. In external rotation only the stirrup braces provided significantly increased support in segments 1 and 2 (figure 4). These results are also most likely explained by the rigidity provided by the stirrup braces.

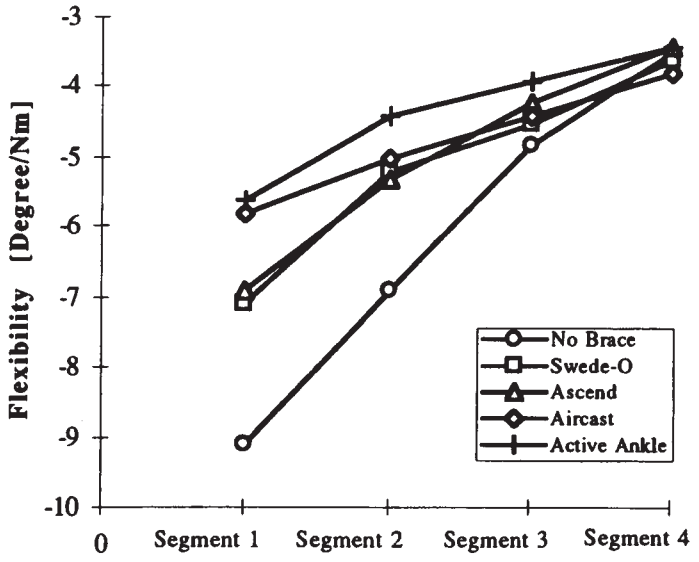

Figure 3. Internal Rotation

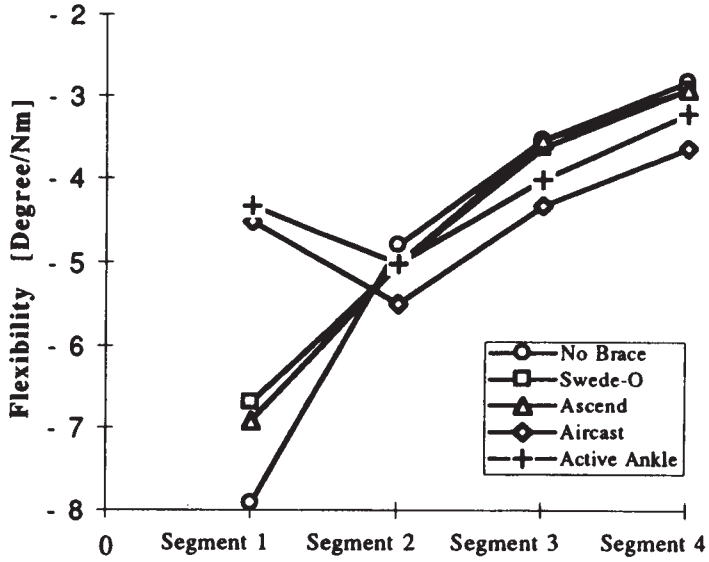

Figure 4. External Rotation

The Active Ankle brace did not significantly effect the range of motion of the ankle complex in dorsiflexion while the Swede-O, Ascend, and Aircast braces did significantly effect the dorsiflexion ranges. This is most likely explained by the bilateral hinge present in the Active Ankle. In plantarflexion, none of the braces caused a significant reduction in range of motion (figure 5). The index of performance in dorsiflexion for the Active Ankle brace was found to be significantly higher than that of the other three braces . In plantar flexion, the index of performance of the two lace-up braces and of the Active Ankle brace were significantly higher than that of the Aircast brace (figure 6).

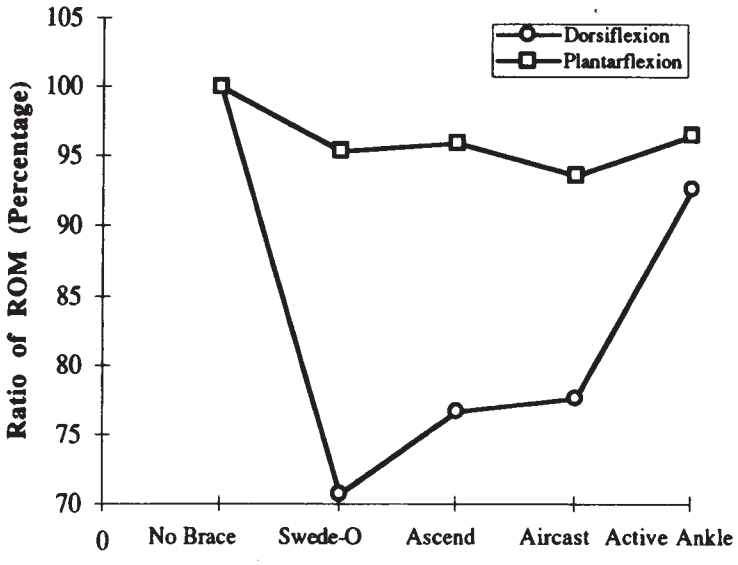

Figure 5. Ratio of ROM

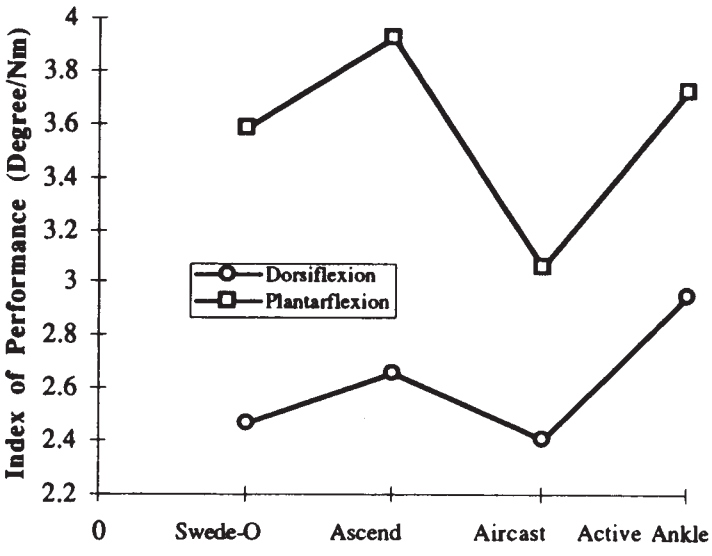

Figure 6. Index of performance

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Presented at the 1996 American College of Foot and Ankle Surgeons Meeting and Scientific Seminar
Under submission to the American Journal of Sports Medicine
Complete study available upon request