

Human Ankle Function and Performance in Sprinting

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Abstract

During sprinting, the ankle absorbs energy while flexing and performs work while extending, with the total mechanical work done by the ankle joint surpassing that of the knee and hip joint combined.¹ Ankle joint moment and angle have been observed as a closely coupled system, and therefore validates modelling the joint as a torsion spring.² Therefore, the ankle exhibits characteristics with potential for mechanical enhancement to athletic performance. Thus, the purpose of this project was to begin a research initiative to improve ankle function through angular spring behaviour optimization. Previous studies have reported ankle joint stiffness characteristics, but the literature is somewhat limited. This study began with biomechanics analysis performed on kinematic and kinetic normative data collected from the initial phases of maximal effort sprint starts. Joint moments were calculated through inverse dynamics and joint stiffness was determined during the loading and unloading phases from linear fits to the ankle angle moment relationship. Results showed that loading stiffness was always larger than unloading stiffness, with loading stiffness decreasing and unloading stiffness increasing with the number of steps from sprint start. The second part of this study initiated development of ankle apparel that modifies joint stiffness. The ankle joint can be enhanced in its spring-like behaviour through the addition of external springs, acting as supplemental elements in parallel with the joint musculature. The success of lower leg amputee leaf-spring prosthetics, which completely replace the ankle joint, further support the use of external springs. A working prototype was developed, implementing a brace design independent of the shoe and incorporating adjustable stiffness and resting length spring elements. Design characteristics such as weight, comfort, and ease of use were also accounted for. Future studies involving the ankle brace will determine what functions and levels of stiffness have beneficial impacts on performance.

References

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