

A Novel Method for Measuring AFO Stiffness Using Motion Capture

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While it is important to know the stiffness of ankle foot orthoses (AFOs) since this impacts their efficacy during gait, stiffness testing generally requires custom built testing equipment. Using motion capture along with a portable force sensor, we measured the stiffness of an adjustable AFO. Our results indicate that our testing method was fast and relatively reliable.

References

- [1] Waterval, et al. <https://doi.org/10.1186/s12984-019-0600-2>
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- [4] Iansak & Morris, M. E. (2013). *Rehabilitation in Movement Disorders*. Cambridge University Press.
- [5] Kobayashi, et al. <https://doi.org/10.3109/03093646.2010.495370>

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Introduction/Background

AFOs are used for the treatment of various foot deformities¹⁻³ as well as recovery from interventions at the foot or ankle⁴. While AFOs are prescribed individually, stiffness effects on gait are likely to be generalizable between patients. A clearer understanding of these effects may help clinicians better prescribe AFOs and improve patient outcomes. As tuneable AFOs become more available, rapid assessment of stiffness becomes more important in prescription and tracking of patient progress.

Insertable dorsiflexion assist hinges (first three pairs on the left), and neutral hinges at far right.



In a matter of minutes, the hinges in the AFO shown at right can be replaced to modify the device's stiffness, and to change its behavior from neutral to dorsiflexion assist.

Custom AFO built and donated by LaWalls Prosthetics with interchangeable hinge at ankle joint.

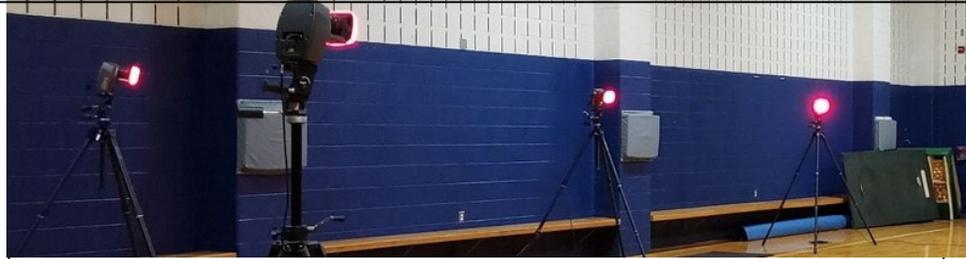
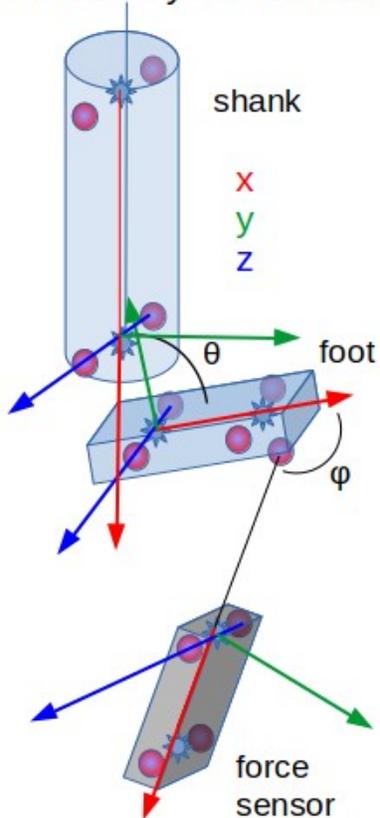
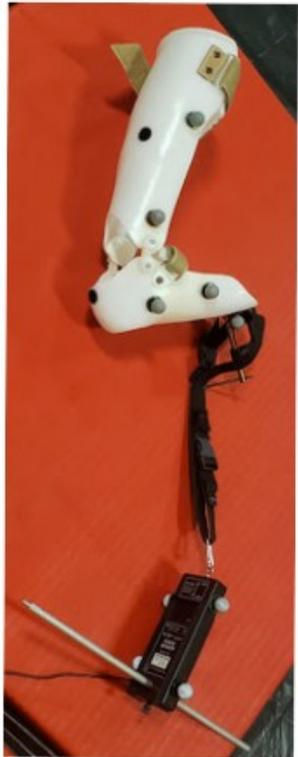


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Methods

Stiffness of an adjustable AFO was tested using three interchangeable dorsiflexion assist hinges and one neutral hinge using a combination of motion capture and force sensor data for each of the four hinge conditions. The force sensor was secured via a crossbar held between the tester's feet, and the AFO was then pulled vertically up away from the force sensor 10 times in a row to simulate loading in plantarflexion.

Marker Set and Coordinate Systems Utilized



Motion capture was done at 100 Hz using an 8 camera Motion Analysis Corporation Eagle system. The angle between the shank and foot θ , and the angle between the foot and direction of force ϕ were calculated in R using fixed-axis rotations based on coordinate systems defined by the markers.

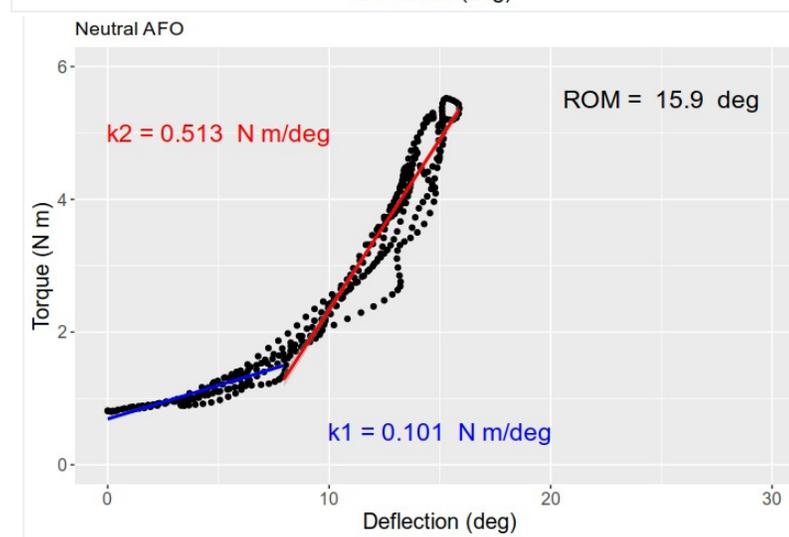
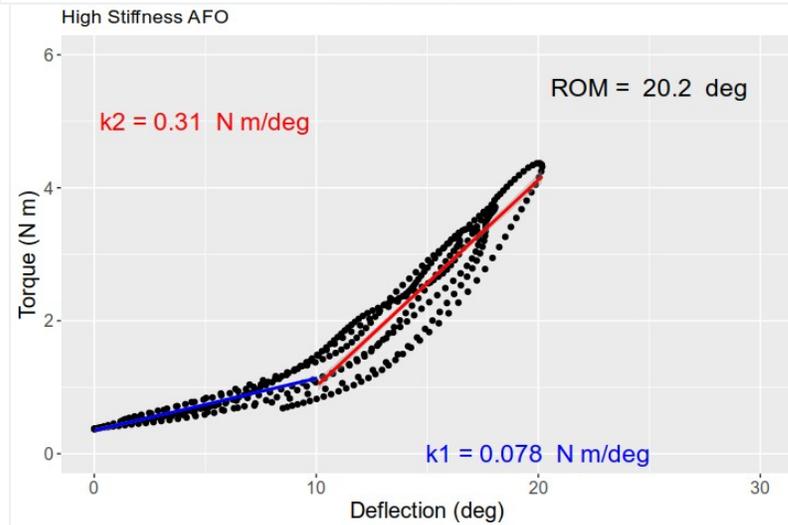
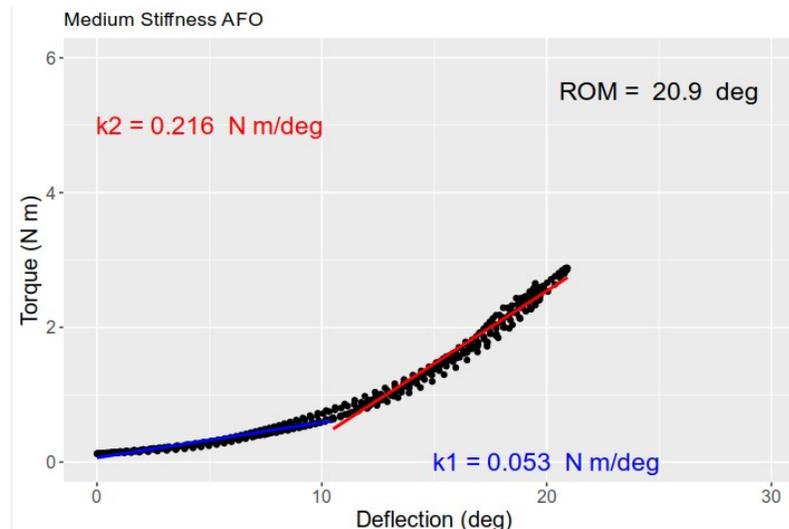
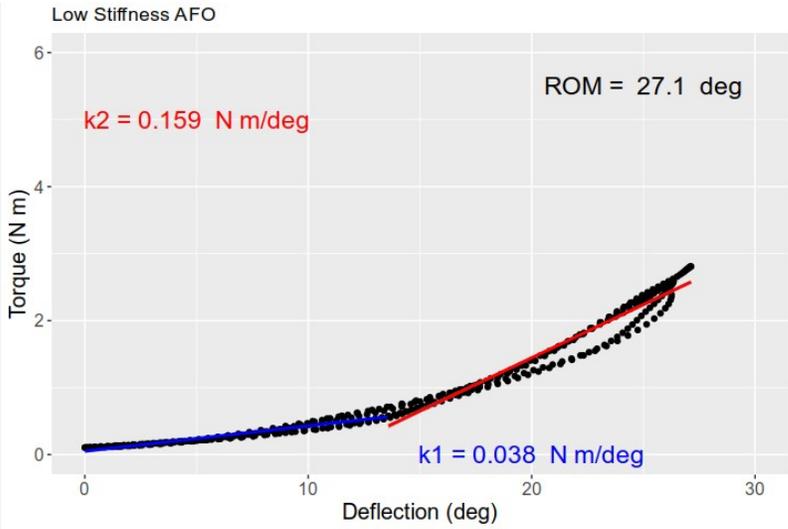
The portable PASCO force sensor with ± 50 N range set to collect at 100 Hz.



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Results and Conclusions

Torque vs Deflection plots had relatively small scatter indicating relatively good reliability. These plots indicate increasing stiffness with greater range of motion.



- * The method is slightly more consistent at lower stiffnesses.
- * Trials could be collected within a minute's time
- * Stiffness values for the leg of the curve (red), are consistent with prior results for articulated AFOs⁵.

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