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Title
Quantifying Performance of a Prosthetic Foot with Frontal Plane Adaptability Using Standardized Mechanical Tests

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Summary
A novel prosthetic foot with polycentric ankle has been developed to provided frontal plane adaptability. Here various performance metrics are quantified and compared to six comparison feet using standardized mechanical tests.

Introduction/ basics
Adaptability of the anatomical foot in the frontal plane occurs frequently during activities of daily living. Segal and Klute1 studied mediolateral foot placement in response to a perturbation in 10 persons with transtibial amputation and 12 without amputation, finding that balance was particularly challenged by medial disturbances to the prosthetic limb among persons with amputation [1]. For optimal performance, comfort, and safety, prosthetic foot designs need to mimic the resultant motions of anatomical feet to adapt to frontal plane perturbations. Current prosthetic feet are engineering and aligned to be optimal for level ground. A new prosthetic foot ankle system has been developed to provide frontal plane adaptability without sacrificing the sagittal plane performance expected of energy storage and return feet. The purpose here is to test the structural integrity and performance of this new prosthetic foot ankle.

Material method; implementation/ process
The Meta Arc and six comparison feet commercially available were mechanically tested for different performance metrics. Energy return of the keel and heel as well as the amount of inversion an eversion rotation were collected following the AOPA test guidelines. These tests were completed on the hydraulic tension -compression machine. Further, ISO 16955 was performed to quantify reaction forces during static and dynamic trials. One sample was completed on each of the performance tests. Performance tests were performed in random

order depending on availability of the test machines. Samples were coded with a unique sample descriptor. Test data and notes were recorded by the test technician.
Data was normalized by the recommended user weight rating of the feet samples.

Results

Energy return data shows that the performance for all non-hydraulic feet is comparable. Hydraulic feet showed lower energy return. The frontal plane rotation experiment shows that at very low force input, just 20% of the prescribed patient weight, the Meta Arc achieved almost 12 times the amount of inversion/eversion that most competitive feet achieved at 100% body weight. ISO 16955 data found similar performance of all feet on flat terrain and difference between the Meta Arc and all comparison feet on a 10 degree cross slope. On the 10 degrees static cross-slope condition, all feet had a negative lateral force and inversion/eversion moment except for the Meta Arc, which had positive values with early and late peaks associated with the accommodation of the ankle unit. Similar trends were found in the dynamic 10 degree cross slope test, but with a mid-stance peak occurring for the Meta Arc. No meaningful differences were found between test samples for the sagittal plane results of ISO 16955.

Discussion/ conclusion; conclusion for the practice

A stark difference was found for the Meta Arc foot compared to all competitors for the frontal plane rotation experiment. This resulted in differences in the forces that would be experienced by the user as shown in the ISO 16955 results. The literature shows that uneven terrain is the second most common surface where prosthesis users are falling despite their avoidance of this type of terrain. Therefore, prosthetic technology that can improve stability without sacrificing other performance characteristics associated with forward propulsion is greatly needed. The main limitation of the study is that two of the eight feet samples had different user weight ratings since these feet were from a convenient sample of feet that were not bought specifically for this study. While the authors normalized the data to account for this effect, is it possible differences could exist if the same weight rating were used for each foot. Also, it is unknown at this time whether the mechanical testing results will have a functional impact on prosthesis users. The Meta Arc foot with a polycentric ankle was found to have increased frontal plane adaptability while exhibiting similar sagittal plane kinetics compared to six other commercially available feet.

The differences found in the frontal plane kinetics may provide a significant improvement for lower extremity prosthesis users to help overcome some of their current challenges in mobility. Human subject testing is needed to verify these results.

References

1. Segal AD, Klute GK. J Biomech; 47:2911. 2014

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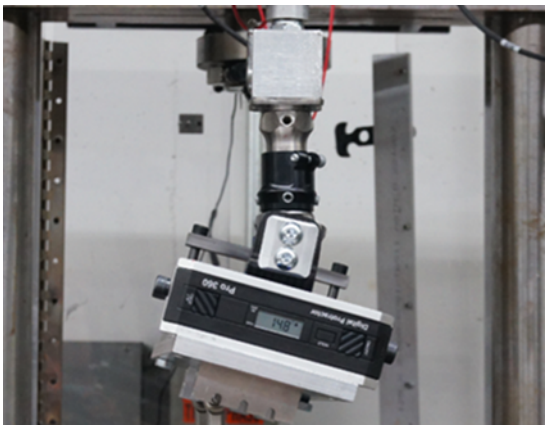

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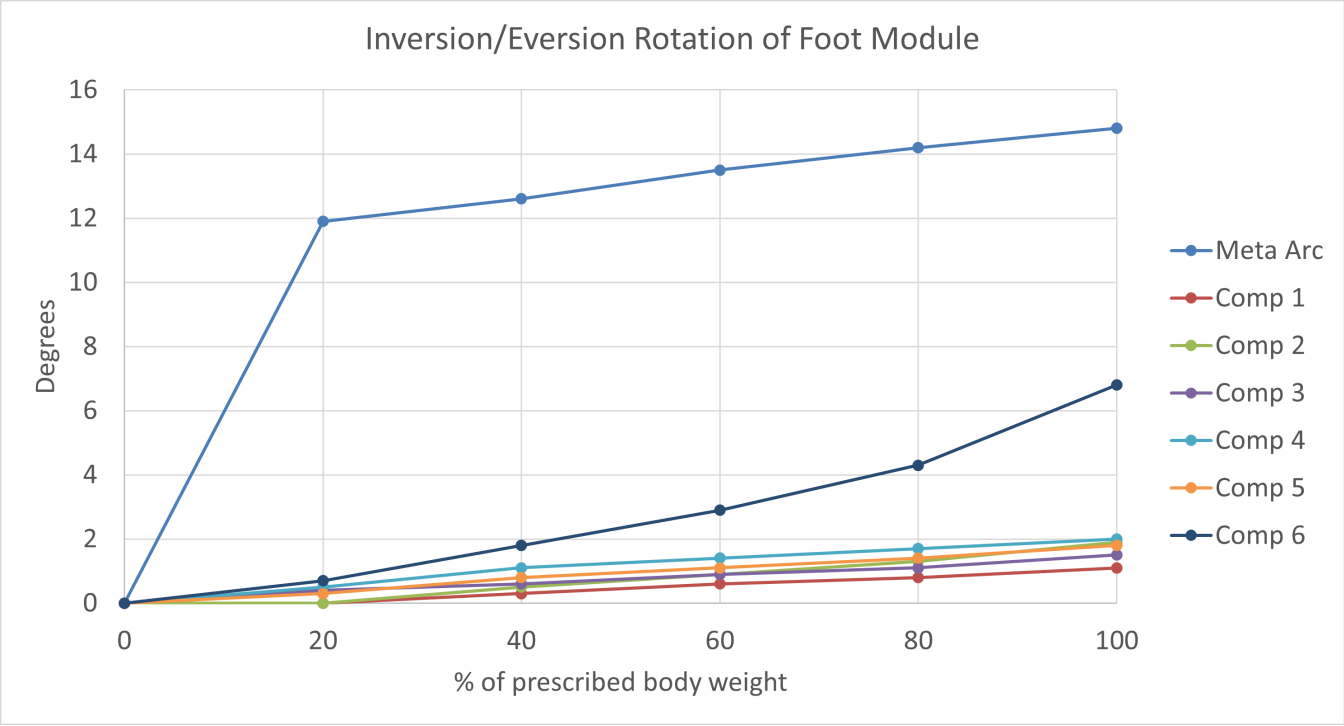

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