Stiffness properties of prosthetic feet under cross-slope conditions

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BACKGROUND AND PURPOSE: As an integral component after lower extremity amputation, prosthetic feet assist the body in forward progression, weight bearing stability and shock absorption. A key element of weight bearing stability is the foot's interaction with non-flat surfaces. Cross-slopes are encountered in daily activities from wheelchair ramps, to crossing uneven streets. Some prosthetic feet have been designed to accommodate such terrain. The objective of this study is to evaluate the stiffness of a representative sample of prosthetic feet when placed on a cross slope and use these results to discuss their potential as a classification tool.

METHODS: 15 prosthetic feet were acquired representing all available types of prosthetic feet. A servo-hydraulic testing machine was used for quasi-static loading of prosthetic feet under various conditions: Flat surface, medial slopes 7.5 deg, 15 deg., and lateral slopes 7.5 deg., 15 deg. Feet were cyclically loaded on two separate days to evaluate repeatability.

RESULTS: 400 N was selected as a reference point for today's discussion; it represents 50% of our hypothetical user's body weight and coincides with the force applied to the foot during quiet standing. A one way ANOVA test was used in addition to correlation data to assess variance across two separate test dates. A significant difference was not noted between trial days. It was observed that for nearly all feet, the lateral border experienced greater change in stiffness compared to the medial border when encountering a cross-slope. Feet showed a range of stiffness; at 400 N, the stiffness observed in the feet ranged from 54.6 N/mm to 236.2 N/mm. Feet also showed a significant range in the magnitude of change from stiffness on flat surfaces; the change in stiffness ranged from -158 N/mm, to 122 N/mm

DISCUSSION AND CONCLUSION: While prosthetic feet designed and marketed to accommodate uneven terrain tended to have a significant reduction in stiffness compared to other feet, this did not necessarily produce a less overall stiffness. High variation was seen between feet of the same family in their interaction with cross-slopes. Laboratory tests can be used to classify prosthetic feet and clarify differences between feet. These results have implications for prosthetic foot prescription, reimbursement, research and development, although should be interpreted alongside clinical research to fully understand their implications.

References from presentation on reverse: