Physiologic Ankle-Foot Roll-over Shapes: Implications for Design and Evaluation of Prosthetic Feet

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Abstract: A method for measurement of the effective rocker (cam) shapes of able-bodied lower limb systems during walking has been developed. We call these rockers roll-over shapes because they occur during the phase of walking in which persons are rolling forward and before they make use of stored energy in late stance. Our investigations of roll-over shape were initially intended to answer questions surrounding the design of an inexpensive biomimetic foot: “How should the prosthetic foot’s roll-over shape change (1) at different walking speeds, (2) when carrying different amounts of weight, (3) when wearing shoes of different heel heights, and (4) when walking on ramped surfaces?” We found that roll-over shapes of the ankle-foot system (including the shoe) do not change appreciably when persons walk under various conditions of level ground walking. The shapes do change in meaningful ways when walking on ramped surfaces and appear to be flat during standing and swaying. We have been able to describe the findings of several previous studies using roll-over shape and have developed and tested a hypothesis surrounding alignment of trans-tibial prostheses that is based on the roll-over shape. Our findings also suggest that humans may control locomotion using effective surface maps (3D shapes) of ground-contact points in body-based coordinates. The maps may be fairly simple but appear to change shape based on the intended task, i.e. walking on level, standing, walking on inclines, initiation of gait, and termination of gait. We hope to use these ideas in the development of lower-limb prostheses that can automatically adapt for various tasks.

Dr. Hansen received a Bachelor’s degree in Biomedical Engineering with honors and highest distinction from the University of Iowa in 1995. During a summer in Iowa City, Dr. Hansen worked as a Prosthetics Technician under the direction of Mr. Donald Shurr at American Prosthetics Incorporated. During that time, Mr. Shurr introduced Dr. Hansen to Dr. Dudley Childress, a researcher in the field of prosthetics and orthotics. Dr. Hansen completed a Master’s degree in Biomedical Engineering in 1998 and a Ph.D. in Biomedical Engineering in 2002 both under the direction of Dr. Childress. Dr. Hansen is currently research faculty at the Northwestern University Prosthetics Research Laboratory and Rehabilitation Engineering Research Program in Chicago, Illinois.