

NORTHWESTERN UNIVERSITY

**Roll-over Characteristics of Human Walking
With Applications for Artificial Limbs**

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ABSTRACT

Roll-over Characteristics of Human Walking, With Applications for Artificial Limbs

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Walking is performed on a variety of terrain, from level to sloped, from sand to stone, from grass to ice; The able-bodied human adapts to these conditions and walks on. This dissertation examines some of the many conditions humans walk under. Unlike previous studies of walking conditions, this research focuses primarily on the roll-over characteristics of human walking. These characteristics are examined at three levels of complexity of the lower limb. The term *roll-over shape* is introduced to describe the effective rocker shapes created by the ankle-foot (AF), knee-ankle-foot (KAF), and hip-knee-ankle-foot (HKAF) systems.

The general theory underlying this work is that circular-like roll-over shape is fundamental to the walking process. A sub-theory examined is that roll-over shape is generally invariant to many conditions of able-bodied human walking on level surfaces. Specific hypotheses developed under the invariance sub-theory are that the able-bodied human adapts to maintain a similar roll-over shape over a range of walking speeds, over a range of shoes with different heel heights, and

under various loads. These hypotheses were supported through analysis of roll-over shape characteristics such as radius of curvature and fore-aft position.

Roll-over shapes were examined on ramped walking surfaces. Able-bodied knee-ankle-foot systems created roll-over shapes that change orientation with the inclination of the walking surface. This automatic adaptation helps the human to maintain an upright posture when walking on slopes.

The roll-over shape alignment hypothesis was supported by a double-blind experiment. This hypothesis states that a prosthetic foot is aligned by positioning and orienting its roll-over shape, as closely as possible, with an “ideal” roll-over shape, which is believed to be the invariant roll-over shape used by able-bodied walkers.

Roll-over shape concepts offer many possible solutions to clinical problems in prosthetics and orthotics. The invariant roll-over shape, which is maintained by adaptation, appears to provide a goal for design, alignment, and evaluation of lower limb prostheses, orthoses, surgeries, and therapies. Able-bodied adaptations to shoe heel height and ramp walking provide insight for the

development of prostheses and orthoses that can automatically adapt to these conditions and thereby improve the walking performance of their users.

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