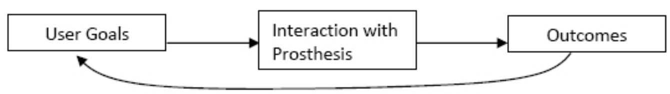
Priority Statement Title: Goal-directed design in rehabilitation device development and prescription
Priority Statement Code: LF2E
Domains: joint / limb & whole body / outcomes & function

Priority Statement

Background and Relevance

The International Classification of Functioning, Disability, and Health has provided a standardized concept of the quality of life of individuals and the impact of health conditions. In certain clinical domains, however, research has focused not on the individual but instead on a particular device or component. For example, users of lower-limb prostheses have a set of desired outcomes for function, participation, and activity. If the prosthesis can effectively facilitate the user's needs, then outcomes closely resemble goals and little feedback adjustment is necessary. If the prosthesis does not match the goals, outcomes may be substantially different, affecting quality of life.



Unfortunately, the scientific basis for prosthesis design and evaluation has been based primarily on empirical biomechanical analyses of amputee gait using descriptive kinesiological data.[1] However, because of the complex dynamic coupling within the musculoskeletal system, a muscle can accelerate joints it does not span and segments to which it does not attach because of its contribution to the ground reaction force and intersegmental joint forces.[2,3] As a result, inverse dynamics analyses cannot identify causal relationships between specific design characteristics and resulting gait mechanics. Furthermore, complex energetic exchanges between body segments, the component or device, and individual muscle groups cannot be measured experimentally and are often counterintuitive,[4,5,6] leading to little consensus in the literature regarding the energetic influence of elastic energy storage and return devices on amputee gait.[7] As such, conventional analyses are very limited in their ability to understand the movement-related goals of the individual and the biomechanical and neuromotor adaptation processes in gait, which is a prerequisite for designing effective prosthetic and orthotic devices. Consequently, the current understanding has prevented the emergence of an objective goal-driven basis for the design of more effective prosthetic and orthotic devices.

The primary opportunity associated with this priority is a more effective and efficient process by which medical devices such as prostheses and orthoses are designed. Currently, designs and fittings are based on excessive iteration and trial-and-error because designers do not have data related to the optimization criteria the end user seeks to maximize. Work in this priority area will likely require combined resources and expertise from areas including medical device design, clinical care and rehabilitation, musculoskeletal modeling and simulation, neuromotor optimization, activities of daily living, and outcome measures. Such multidisciplinary action represents both a barrier to the accomplishment of the priority and its potential for translational impact.

Objectives

1. Develop instruments to assess movement-related goals of individuals with limb loss and dysfunction, building on existing efforts in prosthetic outcome measures.
2. Use simulation-based biomechanical analyses for prosthetic and orthotic design.
3. "Close the loop" between researchers and designers/manufacturers to effect a fundamental change to goal-defined design.

Recommended Actions

1. For specific biomechanical impairments, such as lower limb loss, identify individuals' movement-related goals and participation outcomes in terms of the World Health Organization's ICF.
2. Develop musculoskeletal model-based computer simulations predictive of biomechanical function whose independent variables are the design characteristics of prosthetic and orthotic devices.

3. Promote the use of movement-related goals and biomechanical simulations into design, manufacture, prescription, and fitting of prosthetic and orthotic components.

1. Hafner et al., 2002a; 2. Zajac et al., 1989; 3. Zajac, 1993; 4. Neptune et al., 2001a; 5. Neptune et al., 2001b; 6. Neptune et al., 2000; 7. Hafner et al., 2002b