

B. PROJECT SUMMARY

Stroke is the leading cause of serious long term disability in adults worldwide. Over 795,000 strokes occur in the United States each year. Walking dysfunction is one of the greatest stroke-related physical limitations. While approximately two-thirds of persons who suffer a stroke regain ambulatory function, their gait is slow, asymmetrical, and metabolically inefficient. Despite recognition of the problem, there is limited evidence that rehabilitation produces meaningful changes in walking function. These findings underscore a significant knowledge gap regarding the capacity for locomotor recovery and represent an urgent unmet need obstructing development of interventions to promote recovery and restoration of locomotor function in persons post-stroke.

Our long term goal is to improve walking function in persons post-stroke. The objective of this proposal is to develop computational simulation technology that can predict best achievable gait patterns by individuals who have had a stroke. The technology will account for both subject-specific neural control limitations caused by the stroke and remaining neural control capabilities, as well as subject-specific musculoskeletal anatomy. The simulations will target two key aspects of normal walking function – speed and bilateral symmetry – when seeking to predict the gait patterns that a hemiparetic individual is theoretically capable of achieving. Differences between current and predicted muscle excitation patterns, joint kinematics, and joint kinetics will be used in a future project as the basis for selecting, on an individual subject basis, the neurorehabilitation treatment protocol most likely to restore normal gait speed and symmetry.

Intellectual Merit: The intellectual merit of the proposed project is development of novel neuromechanical modeling methods that will permit the prediction of best achievable gait patterns by individuals who have had a stroke. The novel technical aspects are three-fold. First, a new technique called “statistical moment estimation” will be developed that allows the transformation of measured muscle electromyographic (EMG) signals directly into joint moments. The method uses a statistical over-determined system of equations rather than a geometric under-determined system of equations to calibrate the necessary model parameter values. Second, existing muscle synergy analysis techniques will be extended to quantify subject-specific neural control limitations and constrain gait motion predictions. Third, statistical moment estimation and muscle synergy analysis will be incorporated into an existing computational framework for predictive gait optimization. Whereas existing neuromechanical modeling methods are only descriptive of situations for which experimental data exist, our enhanced computational framework will be predictive of situations for which no experimental data yet exist.

Broader Impact: The broader impact of the proposed project is the development of computational simulation technology that can add objectivity to the design and selection of neurorehabilitation treatments for stroke. Current treatment design paradigms are highly subjective, being based primarily on clinician experience. Thus, there is often no clear rationale for selecting one treatment approach over another or for selecting the specific quantities to target within a selected treatment approach. Objective prediction of the gait patterns that a patient is theoretically capable of achieving could provide clinicians with valuable new information to improve the efficacy of the treatment design process.

Transformative Nature: The proposed research is transformative in two ways. First, it would be the first computational simulation technology capable of predicting gait patterns that an individual is theoretically capable of achieving, given the neural control limitations imposed on the individual by stroke. Second, it could be a paradigm shift in neurorehabilitation treatment design, since it would transform a subjective, qualitative process into an objective, quantitative one.

BME Theme: Neural Engineering.