A. PROJECT SUMMARY

This proposal seeks to develop a computational framework that will facilitate identification of effective personalized rehabilitation strategies for individuals with gait pathologies. The four main objectives are to: 1) Demonstrate that whole-body momentum variations for normal and pathological gait cluster differently from one another and that these clusters can be viewed as "momentum signatures" for different gait patterns; 2) Develop an optimization methodology to predict different subject-specific gait patterns using a subject-specific computational model that matches a specified momentum signature; 3) Predict what normal gait should look like for individuals with a gait pathology by applying a normal gait momentum signature to a computational model of the patient; and 4) Predict where to focus rehabilitation efforts for specific patients by imposing patient-specific limitations (e.g., on coordination, strength, power, or joint ranges of motion) on the patient's computational model and evaluating how different limitations affect the patient's ability to approach a normal gait momentum signature.

Computational models are valuable for developing and testing hypotheses that otherwise would be impossible to explore experimentally. They can also provide a theoretical framework to explain experimental observations. In the case of pathological gait, despite many studies reporting that the central nervous system (CNS) regulates angular momentum during walking, no simple control law currently exists to explain how the CNS makes walking efficient or even possible. Fewer studies have looked at how linear momentum is conserved during human locomotion, although recent findings indicate conservation occurs for various locomotion tasks. A computational model that uses basic momentum considerations to predict achievable, improved gait patterns for individuals with pathological gait could be a valuable tool to aid clinicians in making objective, highly effective treatment decisions.

(1) Intellectual Merit of the Proposed Activity
The intellectual merit of the proposed research will be the **development of a simple method for generating different gait patterns on a patient-specific basis**. Recent results indicate that locomotion tasks exhibit clusters of momentum variations. This finding suggest that that an optimization approach that targets these variations may be able to predict which rehabilitation strategies would be most effective for a specific patient. **This *novel* approach will be valuable for people with disabilities** resulting from either neurological disorders (i.e., cerebral palsy, stroke) or mobility impairments (i.e., dependence on a cane or crutches) **by helping them achieve more normal gait patterns**. The **transformative nature of this proposed research is the paradigm shift away from making treatment decisions based on subjective experience and instead basing them on objective predictions** made by patient-specific computational models that obey the laws of physics and account for patient-specific limitations.

(2) Broader Impact Resulting from the Proposed Activity
If successful, the proposed computational methodology may provide an objective means for identifying where to focus rehabilitation efforts that are likely to produce the largest functional improvement for a particular patient. Not only will it be beneficial for people with pathological gait, but the proposed research can also be applied to other areas, including deep space health (i.e., by helping astronauts achieve adequate loading in a weightless environment to reduce bone and muscle loss) and general mobility (i.e., by helping patients improve their mobility for non-locomotion tasks).

In addition, this research will include an underrepresented graduate student who will be mentored through the completion of this project. The research results will be evaluated by comparing the optimization predictions with experimental measurements for normal and emulated pathological gait patterns. The results will be disseminated through publications and conference presentations.