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Developing an At-Home System for Evaluating Manual Wheelchair Propulsion and Directing Rehabilitative Training to Optimize Biomechanical Efficiency

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ABSTRACT

PROJECT TITLE: "Developing an At-Home System for Evaluating Manual Wheelchair Propulsion and Directing Rehabilitative Training to Optimize Biomechanical Efficiency"

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INTRODUCTION

Manual wheelchair use (MWU) is an important aspect of mobility for both children and adults with orthopedic disabilities affecting lower extremity function. This activity places high levels of stress on the musculoskeletal system in the upper extremity (UE), requiring substantial force production and endurance. Functional evaluation of MWU provides propulsion kinematics and can include marker-based motion analysis and novel biomechanical approaches [1] as well as interactive musculoskeletal modeling based on specific patient anthropometry. Clinical motion analysis systems can quantify UE motion in terms of angular kinematics, thus eliminating observer bias or subjectivity while increasing sensitivity in results. These systems are precise and reliable but require expensive equipment in a permanent laboratory setting and employ markers placed on the patient to detect motion. The authors have developed a low-cost, portable, markerless system based on Microsoft Kinect® depth sensors to track UE motion during functional activities [2]. The system is used in conjunction with a musculoskeletal model [3] modified for use with markerless motion capture. Recent work applies the system to calculate manual wheelchair propulsion kinematics. Future work will focus on directed training programs to optimize wheelchair propulsion efficiency and minimize risk of orthopedic injury to the UE.

SIGNIFICANCE

The markerless system has many advantages over traditional motion analysis, including significantly lower cost, higher portability, and markerless operation, while maintaining reasonable accuracy. Expanding kinematics-based evaluations beyond the clinically-based motion analysis lab and into the community and home environments will support convenience and increased evaluation frequency for improved monitoring and a reduction in the number of necessary clinical visits. With the proposed system, therapists will have expanded flexibility to develop rehabilitation programs tailored to individual patients, with periodic feedback of performance metrics based on UE kinematics.

FORWARD THINKING/INNOVATION

Technical development activities in the near future will refine the current kinematic evaluation platform and underlying subject-specific musculoskeletal models and create a new software protocol that supports real-time directed training of wheelchair propulsion activities. Two primary system components will be developed. First, real-time simplified kinematics will instantaneously score and display subject motion with visual feedback to promote a more ideal cyclic behavior. Second, detailed kinematics will be simultaneously recorded for post-processing, allowing in-depth analysis of patient-specific musculoskeletal data for improved propulsion kinematics and efficiency. There is a significant need for a system that provides high-quality therapy and progress reporting for manual wheelchair users at a low cost in the home or community environments.

STUDENT INVOLVEMENT

Jacob Rammer will lead technical development of the integrated manual wheelchair propulsion evaluation and directed training system and organize the design of research studies to test the system with manual wheelchair users. Support will continue from advisors Dr. Gerald Harris and Prof. Susan Riedel along with clinical collaborators.

REFERENCES

1) Schnorenberg, A. et al. (2014) Journal of Biomechanics, 47:269-276.
2) Rammer, J. et al. (2014) Proceedings of the 7th World Congress of Biomechanics, In Press.
3) Holzbaur, K., et al. (2005) Annals of Biomedical Engineering, 33(6):829-840.