

APPLICATION OF OPENSIM FOR VISUAL BIOFEEDBACK PROPULSION TRAINING IN PEDIATRIC MANUAL WHEELCHAIR USERS

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ABSTRACT

Manual wheelchair use by children with physical disabilities promotes substantial risk of orthopaedic injury to the upper extremities. Mechanical and metabolic efficiency depend on propulsion strategy and experience, affecting daily mobility. Efficiency and injury risk have been evaluated in adults, without consensus on a method to train and assess individual users. Pediatric manual wheelchair users (PMWU) have additional considerations, including effects of growth and development. There is a need to evaluate these effects and develop a methodology to determine optimal propulsion strategies and deliver improved efficacy and accessibility of manual wheelchair propulsion training. In this study, a visual biofeedback propulsion training system is applied based on markerless motion capture. The automated system is evaluated in an exploratory study of 5 PMWU and found to be effective in training four standardized patterns. Significant ($p<0.05$) differences were identified among the four patterns evaluated, with more complex patterns more difficult for training users. These results are a starting point to analyze injury risk and propulsion efficiency in daily mobility for PMWU. Further work is suggested to explore the differences in mechanical and metabolic efficiency among propulsion strategies.

Keywords: Pediatric Manual Wheelchair Propulsion, Motion Capture, Kinematics, Rehabilitation, Biofeedback

INTRODUCTION

Overuse injury is prevalent in adult wheelchair users, and research has shown that 61.5% of individuals report regular shoulder pain [1,2], compared to 2.5% of the general population [3]. Shoulder motion contributes the highest joint moment during manual wheelchair propulsion, resulting in common pathologies including supraspinatus tendinosis, bursitis, labral tears, degenerative arthrosis, edema, and ligament thickening [4,5]. Upper extremity propulsive patterns have been characterized to identify an optimal technique that reduces risk of injury. Four common patterns represent hand kinematics in the anterior-posterior and superior-inferior directions [6], including arcing (ARC), semicircular (SC), single-looping-over (SLOP), and double-looping-over (DLOP), shown later in Fig. 2. Differences in muscle demand and fatigue [7] and mechanical and metabolic efficiency have been identified among the patterns [8]. Information regarding shoulder mechanics associated with overuse-injury is not found in the literature. Prior work [9] introduced a motion capture system that produces spatiotemporal parameters, upper extremity kinematics, and muscle-tendon excursions. In this study, the system is extended to include visual biofeedback training to investigate differences among the four propulsion patterns. It is anticipated that this information could help identify propulsive mechanics associated with upper extremity overuse injury. In the future, this system could be extended to home and community outreach applications to evaluate upper extremity dynamics and provide training to pediatric manual wheelchair users (PMWU).