**Proceedings of the Canadian Society for Mechanical Engineering International Congress 2021**
**CSME Congress 2021**
**June 27-30, 2021, Charlottetown, PE, Canada**

# Manual Wheelchair Stroke Time Estimation Using Hand-Mounted Sensor

Ramin Fathian[1], Alireza Noamani[1], Chester Ho[2], Hossein Rouhani[1*]
[1]Department of Mechanical Engineering, University of Alberta, Edmonton, Canada
[2]Department of Medicine, University of Alberta, Edmonton, Canada
* hrouhani@ualberta.ca

## ABSTRACT

Individuals living with spinal cord injury who use manual wheelchairs are dependent on their upper limb for mobility. The propulsion of a manual wheelchair is physically demanding for upper limb muscles. Repetitive loads applied to the shoulder expose manual wheelchair users to shoulder injury and pain. In fact, 30% to 70% of manual wheelchair users experience shoulder pain and injury as a results of repetitive shoulder strain injury. Considering the dependence of wheelchair users' lives on their upper limb for daily routine and mobility, shoulder injury is a considerable burden and directly affects their quality of life and independence. Previous studies identified the association between shoulder injury and manual wheelchair stroke-related kinematic and kinetic parameters, with stroke time, velocity, average peak resultant force applied to pushrim, and the stroke length being the most clinically relevant parameters. These parameters are considered as reference criteria and are mostly measured by SmartWheel and motion-capture systems. However, they are limited to lab environment and are time and labour-intensive. Therefore, there is a need to develop a different method to assessthe risk of repetitive shoulder strain injury to mitigate these issues. The purpose of this study was to propose a method based on an inertial measurement unit (IMU) mounted on hand to estimate stroke time. IMU is capable of measuring three dimensional acceleration and can be used in field and remote areas. For this purpose, five volunteers were recruited to perform five rounds of wheelchair propelling. In each round, participants performed ten strokes while the SmartWheel analyzed the push on the handrim and IMU measured the hand acceleration. Then the measured magnitude of the resultant jerk vector was used to detect the hand contact and hand release, and calculate stroke time. The stroke time obtained from the IMU method was validated against the one from SmartWheel. The mean error (standard deviation) and relative mean error (mean error divided to the stroke time duration) of stroke time estimated using IMU compared to ones obtained by SmartWheel were 67 (23) millisecond and 0.8% (0.4%). This study revealed that hand-mounted IMU was able to estimate the stroke time with high accuracy.