KINEMATIC INSIGHTS FROM A NOVEL GAZE AND MOVEMENT METRIC FOR UPPER LIMB FUNCTION: NORMATIVE AND PROSTHETIC COMPARISON

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ABSTRACT

The evaluation of advanced upper limb prosthetic devices is limited since current outcome metrics may not be sensitive enough to detect compensatory movements and control strategies. We developed two functional tasks for device and performance assessment that are amenable to motion and eye tracking that mimic activities of daily living. The tasks incorporate elements of lateral motion, crossing the body's midline, accuracy, and risk.

Kinematic data from twenty healthy participants and one prosthetic user with a myoelectric and body-powered prosthesis were analyzed. The following degrees of freedom were included in the analysis: trunk flexion-extension, abduction-adduction, and axial rotation; shoulder flexion-extension, adduction-abduction, and internal-external rotation; elbow flexion-extension and pronation-supination; and wrist flexion-extension and ulnar-radial deviation. The range of motion (ROM) was extracted from joint angle trajectories for each examined degree of freedom. End-effector metrics included time to task completion, maximum hand velocity, time and percent to peak velocity, and number of movement units.

Joint kinematics and end-effector metrics where substantially different between normative and prosthetic performance. In comparison to normative performance, the prosthetic user exhibited increased ROM in trunk flexion-extension and shoulder adduction-abduction for both prosthetic devices and tasks. This suggests a compensation for lack of elbow and wrist joint motion by relying more on trunk and shoulder motion to complete the tasks successfully. Despite longer movement times, when using his myoelectric prosthesis, the prosthetic user's ROM was closer to normative performance when compared to his body powered prosthesis. Velocity peaks occurred earlier during reach and grasp movements, indicating a prolonged deceleration phase or a change in movement strategy.

These preliminary results suggest that a range of quantitative information can be extracted from a kinematic analysis of upper body movements. Movement strategies that trend towards normative functional motion could have the potential to reduce the risks of overuse injuries in prosthetic users, given that repetitive movement outside of the normal ranges of function put individuals at greater risk (Kidd, McCoy, & Steenbergen, 2000). In fact, Jones & Davidson reported that 50% of individuals with upper limb amputations reported suffering from an overuse injury (Jones & Davidson, 1999). The proposed motion capture protocol allows us to assess differences between normative and prosthetic performance, but also between different prosthetic technologies. Like common gait assessment practices, the norms can be used as a benchmark for assessing upper limb impairments, advanced technologies, and performance improvements over time, which will be the focus of future work.