Creighton University
School of Pharmacy and Health Professions
Department of Occupational Therapy

The Effect of Shoulder Position on Manual Wheelchair Propulsion Biomechanics: A Pilot Study

Amy Piekosz – Creighton University
Adam Graf, MS[1], Nancy Scullion, MPT[1], Karen Kruger, Ph. D.[1], Joseph Krzak, PT, Ph.D.[1]
[1]Shriners Hospitals for Children, Chicago, IL

INTRODUCTION

•The manual wheelchair (MWC) is the most utilized assistive mobility device used by individuals with spinal cord injury (SCI) to help maintain and improve functional independence in activities of daily living (ADL) and social participation[1-2].

•Improper wheelchair propulsion mechanics can lead to pain and injury to the upper extremity[3-5].

•A goal in the clinical management of manual wheelchair users is upper extremity preservation to promote health and function.

•The SmartWheel® is an instrument utilized by clinicians to measure different metrics that impact the integrity of the upper extremities (See Table 1).

Measure	Definition
Peak Force (N)	For each steady-state push (all pushes in the session except for the first three), the peak force is measured. This force is the total force applied.
Push Length (degree)	This is the average length of the subject's push, in degrees.
Push Mechanical Efficiency (%)	This indicates the approximate percentage of applied force which is directed such that the wheelchair accelerates. For example, if much of the applied force is down or outward, this value will be lower because pushing inward towards the hub or outward from the hub does not actually make the wheelchair accelerate.

Table 1. SmartWheel® Propulsive Biomechanics[6]

•Numerous studies have explored different strategies to preserve the upper extremity during propulsion, however, there is currently limited literature to describe the effect of shoulder position relative to the wheelchair axle on propulsive biomechanics.

•The **purpose** of this study is to describe and compare the effect of different shoulder positions (relative to the axle) on SmartWheel® propulsive biomechanics.

HYPOTHESIS

- We hypothesize that a shoulder positioned posterior to the axle will produce an increase in push length, a decrease in peak force, and an increase in push efficiency.

METHODS

- 9 healthy adults without neuromuscular/ musculoskeletal impairment (Table 2) participated in the current IRB-approved study.

Characteristic	Sample
Gender (# Male, # Female)	1,8
Age (Mean, SD)	36.4, 11.3
Weight lbs. (Mean, SD)	143.7, 20.7
Height inches (Mean, SD)	65.1, 3.6
Handedness (% Right)	88.9

Table 2. Participant Demographics

- A reflective marker was placed at the participant's dominant glenohumeral joint center.
- Participants were positioned in a single 16"x16" Ti LITE® ultra-lightweight manual wheelchair with a 24" SmartWheel® attached to the participant's dominant side.
- Participants were instructed to, "sit as far back in the seat as possible while sitting up tall".
- Static photos were taken in four views (See Figure 1).

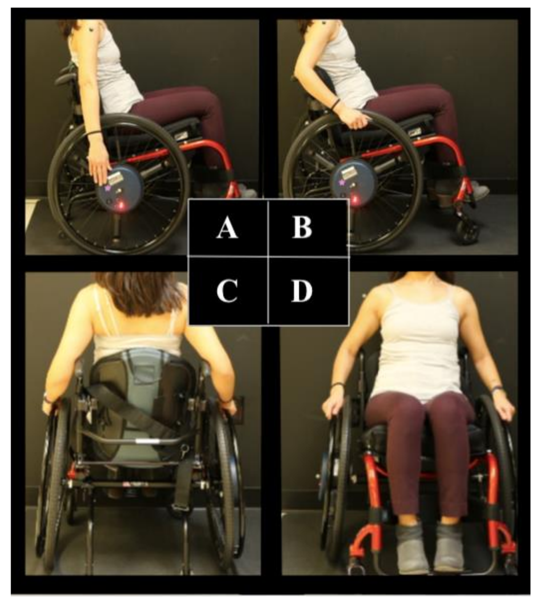

Figure 1. A) Fingertip to axle, B) Top dead center, C) Posterior view D) Anterior view

- Participants were instructed to propel across a tile-floor for approximately 20 meters at a self-selected speed.
- Four trials of each condition (axle position) were collected.
  - In-line with the shoulder
  - anterior to shoulder
  - posterior to shoulder

•Video footage from front, back, and side views was obtained during four trials.

•Temporo-spatial and force data was obtained from the SmartWheel®.

METHODS (CONT.)

- Upper/lower extremity joint angles and measurements were calculated from still photos using Kinovea software (See Figure 2).
- Descriptive statistics (means/standard deviations) were calculated for all dependent variables.
- To evaluate the effect of shoulder position on upper extremity propulsive biomechanics, three one-way ANOVAS were used to compare dependent variables across axle positions.

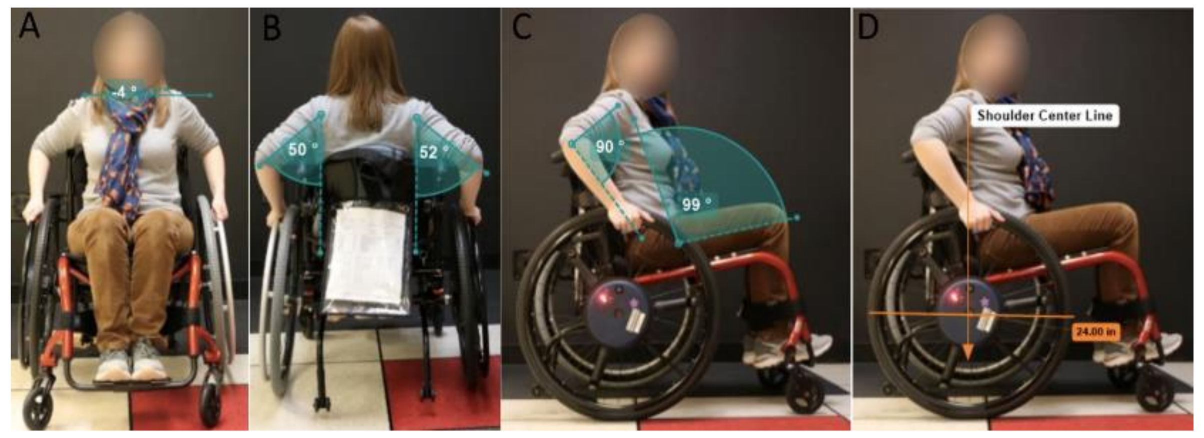

Figure 2. Kinovea measurements with hand at top dead center. A. Anterior view measuring shoulder obliquity from acromion processes. B. Posterior view measuring bilateral shoulder abduction. C. Sagittal view measuring elbow flexion & trunk to seat angle. D. Sagittal view demonstrating wheel diameter and horizontal position of shoulder joint center relative to axle (this example demonstrates in-line).

RESULTS

- Three one-way between subject ANOVAS were conducted to compare the effect of an anterior, in-line, and posterior shoulder position (relative to the axle) on push length, peak force, and push efficiency.
- There were no significant effects of an anterior, in-line, and posterior shoulder position (relative to the axle) on push length, peak force, and push efficiency at the $p < .05$ level (See Table 3).

Source of Variation on Push Length	df	F	P-value (significance)
Between Groups	2	.08	.922
Source of Variation on Peak Force	**df**	**F**	**P-value (significance)**
Between Groups	2	.16	.850
Source of Variation on Push Efficiency	**df**	**F**	**P-value (significance)**
Between Groups	2	1.54	.235

Table 3. One-Way ANOVA Results

Limitations

- This study is limited by a small sample size of participants.
- Since participants have no previous history of neuromuscular/ musculoskeletal impairment, these results do not reflect those individuals that are primarily manual wheelchair users.
- Participants were evaluated propelling forward on a tile floor and so this study does not account for different terrain, turning, and incline.

BOTTOM LINE FOR OT

- It is within our scope of practice as occupational therapy practitioners to promote the health and wellness of individuals at risk for developing an injury or impairment as explained within the Occupational Therapy Practice Framework (2014).
- Future research on the influence of the associations between SmartWheel propulsion biometrics and shoulder position is necessary to further promote best practices in the evaluation and intervention implementation of manual wheelchair users.

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