DEVELOPMENT AND PILOT TESTING OF A MANUAL WHEELCHAIR WITH INDEPENDENT POSITIONING OF THE PUSHRIMS AND DRIVE WHEELS

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Problem

- Upper limb pain and shoulder injuries are common in manual wheelchair users. [1-3]
- These injuries are linked to chronic overuse, inefficient propulsion biomechanics, and weight-bearing load during transfers. [4-6]
- A more forward position of the drive wheel axle (and pushrims) improves wheelchair propulsion biomechanics. [7]
- The horizontal adjustability of the axle position is inherently limited in standard wheelchairs; as the axle is moved forward the chair becomes more vulnerable to tipping backward.[8-9]
- The design of standard wheelchairs precludes investigation of anterior pushrim positions that compromise the stability of the chair.

Purpose

The purpose of this study was two-fold:

1. To develop a simple manual wheelchair prototype that allowed for independent positioning of the pushrims and drive wheels.
2. To test shoulder positions during the push phase of the propulsion cycle in three subjects using the new wheelchair prototype.

While not investigated in this study, the potential clinical benefit of this approach may be a reduction in shoulder pain resulting from manual wheelchair propulsion.

Methods and Results

a b

Figure 1. Prototype wheelchair with independently positioned pushrims in (a) posterior/standard and (b) anterior positioning.

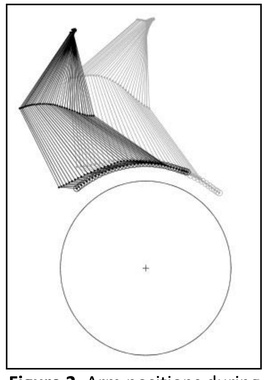


Figure 2. Arm positions during push phase, (black) anterior and (gray) posterior/standard pushrim positions.

Wheelchair Design

- The wheelchair prototype features pushrims and drive wheels that are connected by a chain. The pushrim position can be adjusted horizontally and/or vertically and can be positioned in front of the body's center of mass without compromising chair stability (Figure 1). Additionally, the pushrims can be quick-released for unobstructed lateral transfers.

Subjects

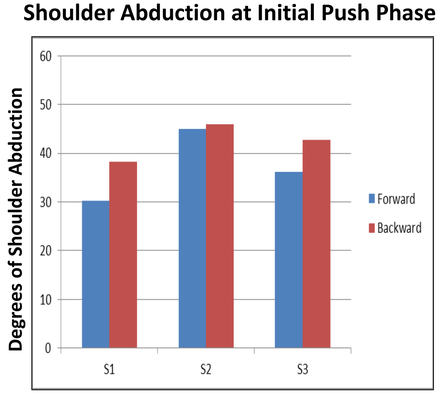
- Three male veteran subjects (S1, S2, and S3) with spinal cord injuries occurring at the levels of C7 and below were enrolled.

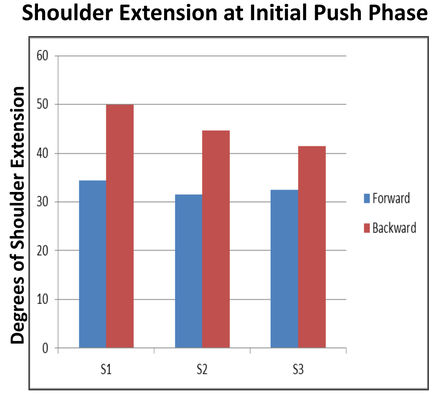
Procedures

- Two positions of the pushrims in the prototype wheelchair were tested, posterior (standard) and a position 18.5 cm anterior to the standard position.
- Two different horizontal positions of the pushrims were examined using an 8-camera motion capture system (Qualisys, Gothenburg, Sweden).

Results

- Shoulder extension and shoulder abduction were reduced during the push phase when the pushrims were positioned more anteriorly.





Discussion

The new wheelchair design has several advantages over standard manual wheelchair designs:

1. Less shoulder extension and abduction during the push phase can be achieved when the pushrims are positioned anteriorly.
2. Pushrims may be positioned in front of the user's center of gravity without sacrificing wheelchair stability.
3. Quick-release pushrims allow for unobstructed lateral transfers into and out of the chair.
4. Hand hygiene may be improved because the user's hands do not contact the wheels during propulsion.
5. Gearing may be incorporated into future versions of the wheelchair.

This research may help serve as a guide for future wheelchair design and for clinical optimization of shoulder biomechanics in manual wheelchair users.

References/Acknowledgments

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