

Evaluation of Manual Wheelchair Propulsion for Disabilities: Pulling the Rims

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Introduction & Objective

- A manual wheelchair is a primary means of mobility for people with spinal cord injury (SCI)
- A manual wheelchair requires repetitive unidirectional movement, typically by pushing the rims forward
- Prolonged use of a manual wheelchair can lead to musculoskeletal problems in the upper body, such as shoulder imbalance and pain
- These problems can be alleviated through back muscle exercises, such as pulling the arms and shoulders backward
- Therefore, a new assistive device for a manual wheelchair was developed
- The device provides two propulsion methods—pushing and pulling—and is detachable
- Consequently, this study conducted a usability test to evaluate the device and to identify potential improvements for people with SCI



Figure 1. Prototype of the Assistive Device and a Manual Wheelchair Equipped with It

Methods

- The device was designed using a planetary gear train, enabling two propulsion methods
- By manipulating the lever on the device, users can switch between pushing pulling propulsion methods
- A usability test of the device was conducted involving people with SCI
- Participants propelled a manual wheelchair equipped with the device
- After completing the propelling tasks with the device, participants evaluated both the device and the pulling propulsion method using a questionnaire
- The questionnaire was developed for this study and consisted of 45 items
- Each items was measured with a 5-point Likert Scale

Table 1. Overview of the Seven Questionnaire Categories and the Number of Items

| Category | Number of items |
|--------------------|-----------------|
| Ease of learning | 6 items |
| Safety | 10 items |
| Functionality | 2 items |
| Efficiency | 9 items |
| Satisfaction | 14 items |
| Aesthetics | 3 items |
| Cost-effectiveness | 1 item |
| Total items | 45 items |



Figure 2. Usability Test Process: Wheelchair Propulsion Task and Device Evaluating

Results

- Scores for ease of learning, safety, functionality, and satisfaction were high (> 4.5)
- Participants noted that:
 - The device was intuitive and easy to use
 - The pulling propulsion method operated accurately with the device
 - No safety issues, such as pinching or falls, were reported during propulsion or use of the device
 - The pulling the rims backward through the device may help alleviate shoulder imbalance and pain, as the motion engages back muscles
- Scores for efficiency, aesthetics, and cost-effectiveness were slightly lower (< 4.5)
- Participants noted that:
 - The pulling propulsion method required some adjustment effort at first
 - The device was relatively heavy
 - The device may pose a financial burden

Table 2. Usability Test Results: Mean Scores and Standard Deviations (SD) by Category

| Category | Mean | SD |
|--------------------|------|------|
| Ease of learning | 4.82 | 0.47 |
| Safety | 4.83 | 0.43 |
| Functionality | 4.50 | 0.82 |
| Efficiency | 4.48 | 0.93 |
| Satisfaction | 4.74 | 0.57 |
| Aesthetics | 4.3 | 0.74 |
| Cost-effectiveness | 3.35 | 1.09 |

Conclusion

- The present study confirmed the usability of the device and identified areas for potential improvements through the usability test
- The device can serve as a means of both mobility and back muscle exercise, featuring the pulling propulsion method
- Based on the findings, future studies will focus on reducing the weight and improving the cost-effectiveness of the device

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