Biomechanical Impact of Neuromusculoskeletal Impairments on Wheelchair Propulsion in Daily Tasks

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Summary

Neuromusculoskeletal impairments (NMSI) affect wheeled mobility performance (WMP) in activities of daily living (ADL), where the trunk is crucial for propulsion, braking, and maneuvering. This study examines how NMSI influences wheelchair mobility by comparing two users: one with full trunk control (left transtibial amputation) and one without (SCI Th8-10). Using IMU-based motion analysis, participants performed four tasks: acceleration (START), stopping (STOP), turning (TURN), and pivoting (PIVOT). Preliminary results indicate that impaired trunk control leads to greater trunk displacement, increased movement variability, and challenges in regulating propulsion, braking, and directional changes. These findings highlight the role of trunk function in WMP and provide insights into movement patterns that could support future research on mobility strategies for individuals with NMSI.

Introduction

Neuromusculoskeletal impairments (NMSI) affect wheeled mobility performance (WMP) in activities of daily living (ADL), where independent wheelchair use is essential for daily function and social participation [1]. WMP depends on the wheelchair, the user-wheelchair interface, and the individual's physical abilities [3]. Among these, trunk control plays a major role in stability and force generation. However, limited research directly compares the biomechanical effects of trunk control impairment in key wheeling tasks. This study investigates how NMSI influences WMP by comparing two wheelchair users: one with full trunk control and one without trunk control.

Methods

Two male manual wheelchair users participated: one with full trunk control (age 33, left transtibial amputation, 5 years post-injury) and one without trunk control (age 45, SCI Th8-10, 32 years post-injury). Both were active wheelchair basketball players and daily wheelchair users. Participants performed four mobility tasks while wearing six IMUs placed on the wheels, chair, and trunk. Data on trunk angle, trunk angular velocity, chair angle, chair acceleration and chair angular velocity were analyzed.

Results and Discussion

Table 1 presents key biomechanical outcomes for each task. S1 exhibited controlled movements with stable trunk positioning, while S2 displayed increased trunk displacement, greater movement variability, and difficulty in regulating propulsion and stopping. In STOP, S2 had excessive forward trunk motion, indicating reduced braking control. In TURN and PIVOT, S2 showed higher lateral trunk movements and increased angular velocity, suggesting instability in directional changes.

Table 1: Key biomechanical outcomes for each task, where 1G equals 9.81 m/s².

TASK	Outcome measure	S1 (full trunk control)	S2 (no trunk control)
START	Max trunk flexion (°)	-69.1	-43
	Max trunk angular velocity (°/s)	193	205
STOP	Max trunk flexion (°)	21	35.8
	Chair inertia acc Z (G)	0.43	0.556
TURN	Max frontal trunk angle (°)	17.9	-22.9
	Max trunk angular velocity (°/s)	54.5	156
PIVOT	Max frontal trunk angle (°)	4.93	15.4
	Mean chair angular velocity (°/s)	-126.12	-171.72

Conclusions

This study highlights the significant role of trunk control in WMP. The participant without trunk control exhibited increased movement variability, greater trunk displacement, and instability across all tasks. These findings underscore the importance of trunk stability in daily wheelchair mobility and suggest that future research should explore compensatory strategies to improve mobility for individuals with NMSI.

References

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