Experimental Validity of Wheelchair Propulsion in Pediatric Manual Wheelchair Users

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Abstract

Biomechanical assessment of steady-state manual wheelchair propulsion is often difficult to conduct overground in laboratory conditions due to space constraints. Wheelchair roller systems, an analog to treadmills for running, resolve this issue but introduce questions of validity. The purpose of this study is to assess differences in upper extremity kinematics between roller and overground conditions in a population of pediatric manual wheelchair users. These aims will be completed by analyzing an existing data set of twelve pediatric manual wheelchair users, each tested in overground and roller conditions, to obtain upper extremity triaxial joint kinematics and comparing the two conditions and assessing the validity of the roller platform. The study validates necessary equipment to conduct laboratory research involving manual wheelchair users, thus continuing the current line of research enabling future work to be done with the system.

Background

Pediatric manual wheelchair users (MWU) can include children with cerebral palsy and other orthopedic disorders. Therapists train with MWU with propulsion technology such as ergometers to reduce risk of biomechanical injury and increase efficiency in mobility. Ergometers provide a platform which simulates the resistance of normal mobility while the wheelchair propels in a static position. Major benefits of these ergometers include compatibility with motion analysis cameras, lateral stability, and configurability based on user anthropometry and wheelchair specifications [1]. This technology coincides with developments in markerless motion analysis utilizing Mircrosoft® Kinect® sensors and OpenSim musculoskeletal modeling which is more cost-effective and applicable in clinical settings than current systems on the market. Combination of these two technologies can aid in important novel research with the significant deficit in current literature on manual wheelchair propulsion biomechanics and physiotherapeutic treatment for pediatric MWU [2].

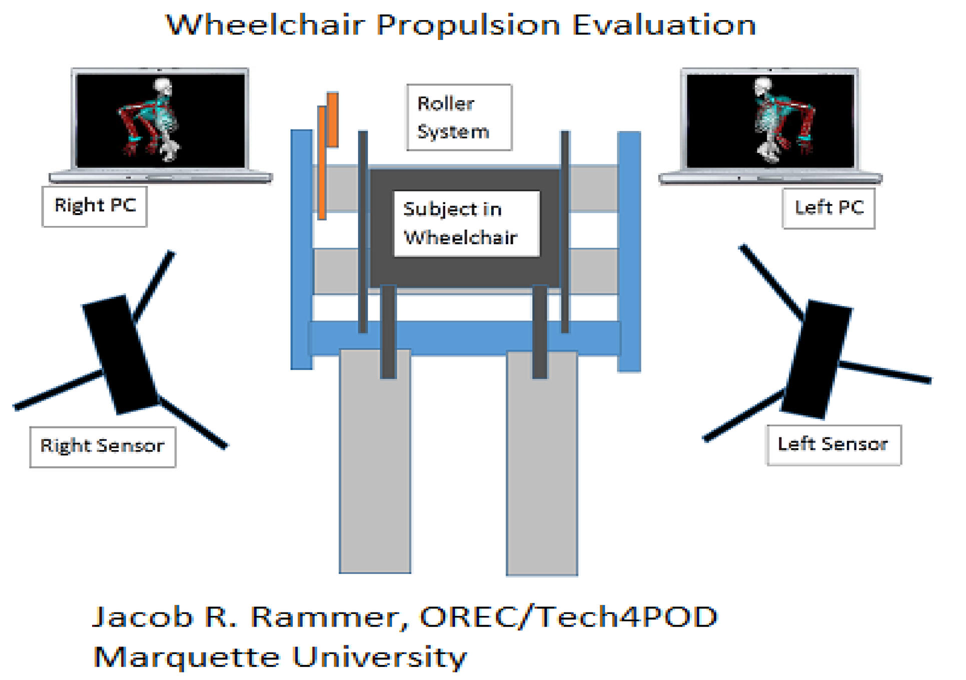

Fig 1. Markerless Wheelchair Analysis System with ergometer roller system used in experiment

Methodology

Twelve subjects who were MWU with various orthopedic disorders had their motion during normal wheelchair-use analyzed with the markerless motion system described previously.

Data has already been collected and graphed in various forms including MATLAB files. Data was extracted and then further analyzed using IBM SPSS Statistics software. Tests include independent sample t-tests to compare variances in parameters between wheelchair motion on the floor and the roller platform. Temporal spatial parameters include cadence and cycle time and kinematic parameters include shoulder flexion range of motion and shoulder abduction range of motion.

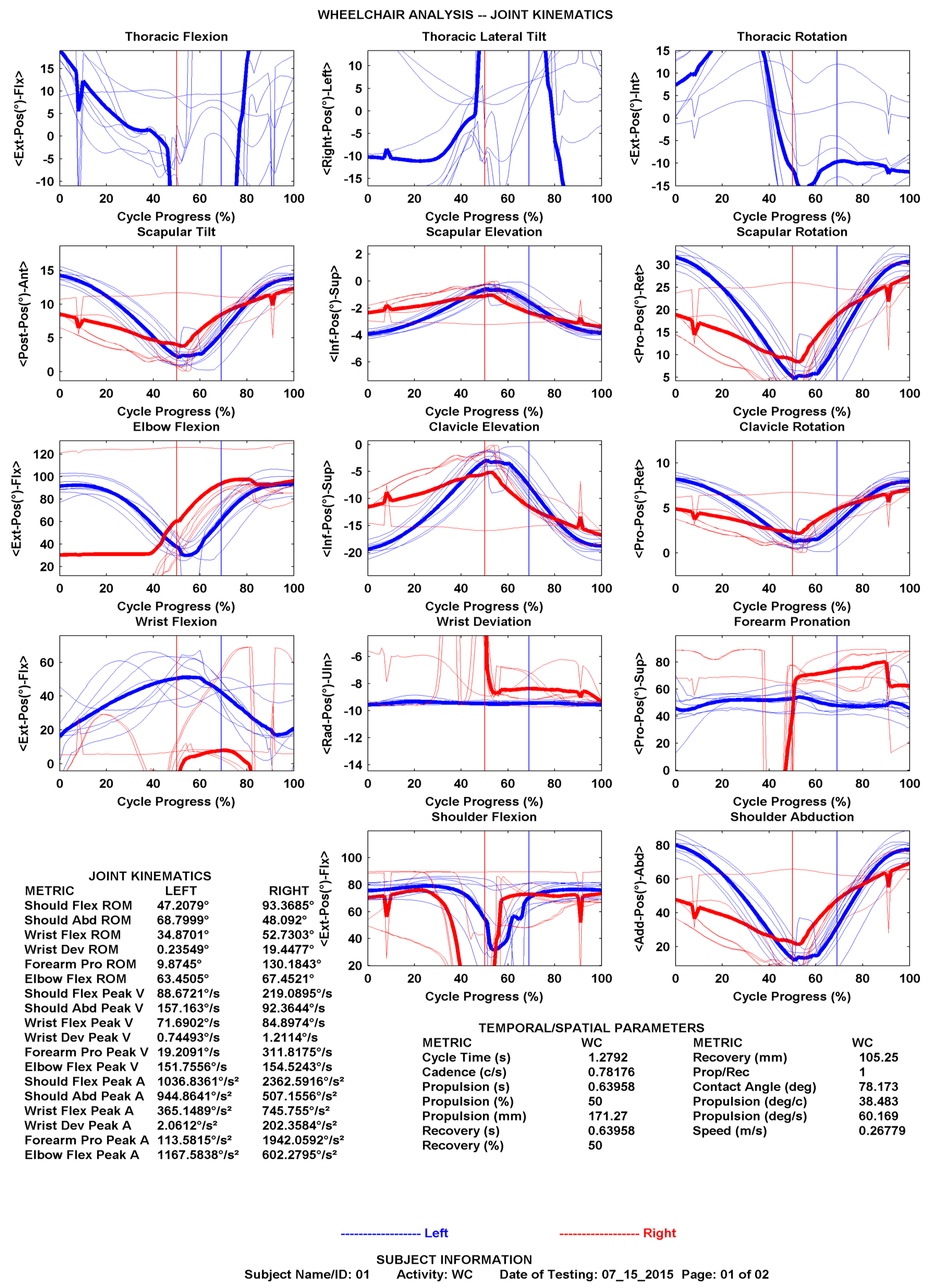

Fig 2. Joint Kinematic Sample Data

Results

The data for each parameter was collected and entered into SPSS. A nominal numerical variable called "PlatformType" was created with a value of either 0 or 1 to designate data collected from a patient on a roller and on the floor respectively. Variable types for cadence, cycle time, shoulder flexion, and shoulder abduction ROM was created and analyzed using the independent samples t-test. The results are shown for each type of parameter in Table 1 and Table 2.

	Platform Type	N	Mean	Std. Deviation	Std. Error Mean	Sig.
Cadence (c/s)	Roller	12	.6998408	.05494738	.01586194	.359
	Floor	12	.6656250	.06762735	.01952234	

	Platform Type	N	Mean	Std. Deviation	Std. Error Mean	Sig.
Cycle Time (s)	Roller	12	1.436800	.1102087	.0318145	.185
	Floor	12	1.517000	.1584487	.0457402	

Table 1. Temporal Spatial Parameters Results (SPSS)

	Platform Type	N	Mean	Std. Deviation	Std. Error Mean	Sig.
Shoulder Flex L (degrees)	Roller	12	52.6480	46.99923	13.56751	.930
	Floor	12	53.5432	48.38352	13.96712	

	Platform Type	N	Mean	Std. Deviation	Std. Error Mean	Sig.
Shoulder Abd ROM (degrees)	Roller	12	41.2610	19.24800	5.55642	.960
	Floor	12	41.0140	19.00191	5.48538	

Table 2. Joint Kinematic Parameter Results (SPSS)

Means and standard deviations were found for each parameter between the roller and floor types. The sig (p-value) associated with parameter allows us to determine if there is a significant difference between the data of the two surfaces. If a standard alpha level of 0.05 is used, all p-values were greater than this value meaning we can accept the null hypothesis that there is no significant difference between the roller and floor for all data parameters (0.359, 0.185, 0.930, 0.960 for cadence, cycle time, shoulder flexion ROM, and shoulder abduction ROM respectively).

Conclusion

The results of the SPSS test showed there is no significant difference between data collected from MWU on the roller platform and the floor. This was shown for the temporal spatial parameters of cadence, cycle time, shoulder flexion ROM, and shoulder abduction ROM.

The development of a roller platform that can accurately simulate wheelchair use on the floor would be ideal for immediate implementation in research due to its size, weight, and cost that are significantly less than currently available products and alternate motion analysis set-ups that require the wheelchair to be moved over larger distances on the floor. This device will allow further research to be carried out for wheelchair propulsion biomechanics and physiotherapeutic treatment of pediatric MWU which is significantly lacking in current literature. Future work to further confirm that accuracy of the roller platform could include comparing other temporal spatial parameters such as propulsion length and recovery. Other joint kinematic data could be compared for ranges of motion of the wrists, forearm, and elbow which are utilized in wheelchair gait. Finally, joint kinetic data could be explored with the aid of MATLAB and OpenSim programs.

References

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