Kinematics of Lateral Transfers: A Pilot Study

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Background

For people with SCI, functional independence often depends on the ability to transfer. Acquiring the proper technique is paramount to shoulder joint integrity and personal independence. Current research on transfers has been limited to the upper extremity and proper technique is not clearly defined.

The purpose of this pilot study was to collect kinematic data on lateral transfers and identify different transfer strategies.

Methods

Subjects

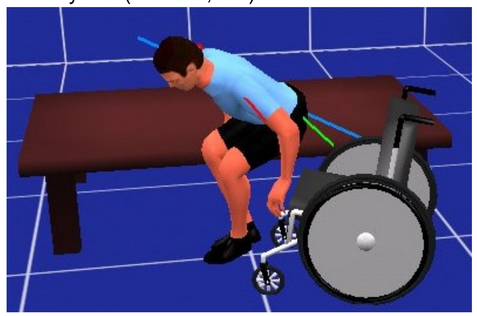
- Convenience sample of 14 male adults
- Able to transfer independently or with minimum assistance
- Thoracic injury
- No pressure sores or upper extremity orthopaedic conditions

Motion Capture Instrumentation

- Software by Motion Reality Inc. (Marietta, GA)
- 8 – 60Hz cameras
- 41 markers on the body and wheelchair

Protocol

- Subjects performed three (3) lateral transfers to their stronger side from wheelchair to 20" therapy mat and back.



Real-time animation during motion capture. Subject is at Mid-Transfer (defined by maximum buttocks height).

Analysis

The following kinematic variables were analyzed for each transfer:

- **Hand Spacing** - horizontal distance between left and right wrist during transfer
- **Maximum Trunk Flexion**
- **Maximum Trunk Rotation**
- **Total Transfer Path -** Total horizontal distance traveled by the buttocks from final lift-off to initial contact with the target surface
- **Wheelchair-Mat Angle** (Angle between wheelchair and mat during the transfer)

We applied a general linear model to predict these five kinematic variables based on the subject demographics and starting positions.

Results

There were no statistical differences between kinematic variables calculated from transfers to and from the wheelchair. Subjects started the final lift off of their transfers from different positions on the seat and pushed off of different parts of the wheelchair.

Subjects pushed off from the:

FRONT of Seat n=3: 2 pushed off seat rail, 1 off cushion

CENTER of Seat n=6: 4 pushed off seat rail, 1 off wheel, 1 off cushion

REAR of Seat n=5: 3 pushed off arm rest, 1 off back rest, 1 off seat rail

Table 1: Subject Demographics

Subject Information	Avg±Stdev (Range)
Injury Level	T3-T12 (1 polio)
Arm Length	29" ± 6" (21"-42")
BMI (self reported)	23 ± 3 (20-32)
Months post injury	144 ±160 (3-558)
Age (years)	32 ± 10 (18-50)

Table 2: Average kinematics

Kinematic Variable	Avg±Stdev
Hand Spacing	26" ± 3"
Max Trunk Flexion	54° ± 10°
Max Trunk Rotation	23° ± 7°
Total Transfer Path	31" ± 6"
Wheelchair-mat angle	23° ± 10°

Table 3: Linear models predict kinematics using subjects' demographics and strategies. ("+" = positive correlation, "-" = inverse correlation, "*" = correlation exists)

	Hand Spacing	Max Trunk Flexion	Max Trunk Rotation	Total transfer path	Wheelchair -mat angle
Level of Injury	+	–		–	–
Arm Length			+		
BMI	+		–	–	
Time Post Injury	+	–	–	–	–
Age	–		+		+
Distance From Back of chair		–		–	
hand position	*	*	*		*
R-squared (adj)	51%	78%	61%	65%	56%

Discussion

Persons with SCI use a variety of strategies to transfer between two surfaces. Although kinematics variables of transfers performed in two different directions do not show significant differences, this may suggest that the height of the initial and target surfaces do more to influence the transfer than the surfaces themselves. A linear model (Table 3) showed that there is generally less movement (i.e. trunk flexion, trunk rotation, and total transfer path) with time since injury. Future work needs to evaluate whether people learn to be more efficient with time or whether they are simply less mobile with time after injury. Additionally, the safety and stability of the transfers need to be considered along with the biomechanics.

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