

# Wheelchair transfer kinematics assessment for paraplegic subjects

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## ABSTRACT

*Spinal Cord injury causes motor, sensitive and central neural system disorders. Wheelchair maximizes functional locomotion, reliance, independence and comfort to disabled subjects. The objective of this study was to assess the wheelchair transfer strategies of paraplegic subjects with high and low thoracic injury. Twelve thoracic spinal cord injured subjects participated in this study (T2 to T12) who had Neuromuscular Electrical Stimulation applied to the quadriceps muscles and peroneal nerve and were able to independently perform the transfers from a wheelchair to a table. Images of reflexive anatomic markers were captured by six infrared cameras and processed through software. Kinematics parameters of trunk and shoulders were assessed. The comparison of the variables was done using ANOVA. Transfer task was divided in three phases: pre-lift, lift and post-lift. Shoulder angular displacements showed statistical significance on injury level and transfer side ( $p=0.0470$ ;  $p=0.0134$ ). Biomechanical understanding and description of shoulder and trunk movement characteristics has shown differences on strategies for high and low thoracic spinal cord injured subjects.*

**Keywords:** Kinematics; Paraplegics.

## Introduction

Spinal Cord injury (SCI) is one of the most severe and impairing neurological syndrome that causes motor, sensitive and central neural system disorders in humans. The inclusion of SCI patients in our society requires the use of wheelchairs for activities of daily living (ADL) such as transfer to and from several places [1,2,3].

Ability to perform transfer depends on several factors such as age, time since injury, shoulder motion, strength, pain, arm length related to the trunk and spasticity. However, the individual with SCI is ready to perform the independents transfer when they acquire a good trunk balance and adequate push up. These patients perform from 14 to 18 transfers a day, due to the fact that these activities are essential for functional independence and quality of life. Patients with thoracic SCI need to use upper extremity limbs to perform ADL, locomotion and transfers. Due to this, pain and shoulder joint injuries occur in 30% to 50% paraplegic individuals. Decreasing of functional ability among body parts, causes fragility on the connection between upper extremities and trunk, overloading the glenohumeral joint as well as muscular unbalance and kinematics changes [4,5,6,7,8].

Thoracic SCI subjects need to adopt new postural patterns for their trunk stability and perform movements with corporal segments, which involve a combination of trunk and scapular girdle muscles. On high thoracic injury, some muscles of scapular girdle, for example latissimus dorsi and trapezius change their function to help with trunk stabilization [9,10].

The objective of this study was to assess the wheelchair transfer strategies of paraplegic subjects.

## Material and Methods

Twelve thoracic spinal cord injured subjects participated in this study (T2 to T12), they were involved Neuromuscular Electrical Stimulation in a rehabilitation program and were able to independently perform transfers from a wheelchair to a table with an area of one square meter by half meter high. Subjects were submitted to a postural and clinical assessment (ASIA). This study was conducted at the Laboratory Biomechanics and Rehabilitation at the University hospital. Ethical approval was obtained Informal Consent Forms were signed by the participants (table 1).

Table 1: Subjects characteristics

Subjects	Age	Year injury	Stature (m)	corporal mass (kg)	BMI (kg/m <sup>2</sup> )	Injury level	Asia	Transfer/day	Preferential side to transfer
1	23	6	1,73	78	26,06	T9	A	30	Left
2	61	15	1,75	74	24,16	T4	A	12	Left
3	34	3	1,58	64	25,64	T5	A	20	Right
4	24	3	1,65	56	20,57	T2	A	10 – 12	Right
5	25	7	1,85	82	23,96	T6	A	10	Right
6	27	9	1,92	82	22,24	T9	A	10	Left
7	35	21	1,75	96	31,35	T6	C	4	Left
8	37	4	1,70	68	23,53	T3	A	25-30	Left
9	29	10	1,73	75	25,06	T4	A	15	Left
10	33	2	1,66	63	22,86	T12	A	25-30	Right
11	21	2	1,87	85	24,31	T3	A	10 – 12	Right
12	42	11	1,81	80	24,42	T11	A	10	Left
<b>Mean</b>	<b>32,58</b>	<b>7,75</b>	<b>1,75</b>	<b>75,25</b>	<b>24,51</b>			<b>15,67</b>	
<b>SD</b>	<b>10,97</b>	<b>5,83</b>	<b>0,10</b>	<b>11,07</b>	<b>2,62</b>			<b>8,50</b>	

Researchers sorted out the lab with six infrared cameras, computer and table with 0,50m of height and one square meter area. Spherical reflexive markers (20 mm diameter) were fasted at anatomic landmarks: top of head, C7 spinous process, sternal, bilaterally on acromion, on lateral elbow epicondyle, processus styloideus radium and antero superior iliac spine. Another reflexive marker was placed beside the wheelchair, and the patients were instructed to place their wheelchairs beside the table, according to their preference. Both wheelchair foot supporters were removed as well as the arm supporter that is on the side of the table. So, the patients were instructed to leave their feet on the ground and their hands on their thighs. After an oral signal from the researcher, patients initiated transfer tasks according to their own transfer strategies and time. At the end of the task, the patients placed their hands on the thighs.

Kinematics parameters of trunk and shoulders were assessed. The comparison of the variables used ANOVA for repetitive measures with segmented factors. The significance level adopted for statistical tests was 5%. This research compared injury level (higher/lower) and preference and non-preference sides of transfer for sternal maximum speed and curve index. Besides it was also compared the leading and contralateral shoulders for angular displacement (AD).

### Results

Transfer tasks were divided in three phases at Pre-lift, Lift and Post-lift. Pre-Lift Phase: The time that the researcher gave a vocal order to start, the subject's leading shoulder was positioned on the table and the contralateral shoulder was placed on the wheelchair arm. So both superior limbs performed a shoulder abduction, flexion and

external rotation with an elbow semi flexion and wrist in extension. The trunk performed an anterior flexion with a lateral lean to the side of the leading arm. Lift Phase: during the lift phase, after the limbs had been held on both table and wheelchair, trunk lift movement occurred. In order for this movement to happen the head and the trunk performed an anterior flexion, the elbows extended and buttocks went out of wheelchair were suspended, was performed a pivot approaching the leading arm. Post lift phase: the buttocks held on the table. Sternal curve index and maximum speed means and standard deviations (SDs) did not show statistical significance. However, the shoulder angular displacements showed statistical significance on injury level effect and transfer sides ( $p=0.0470$ ;  $p=0.0134$ ) (Figure 1).

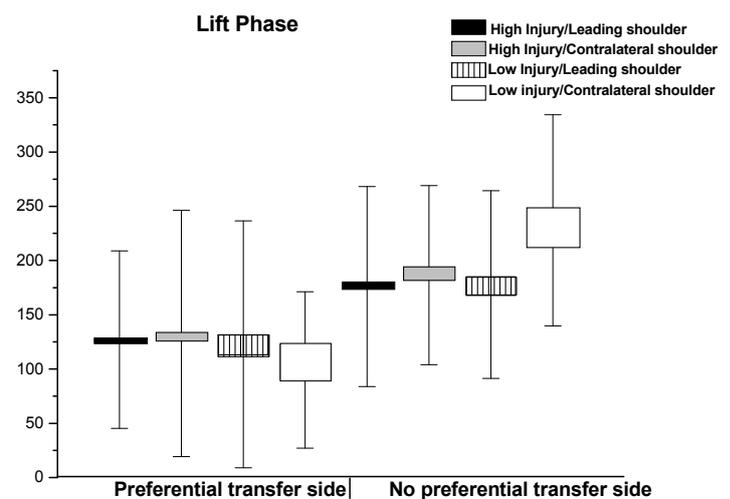


Fig 1: Shoulder angular displacement mean values (Lift Phase)

## Discussion

This study assessed the independent transfer strategies used by paraplegic subjects, which confirmed kinematics being a sophisticated resource, showing corporal segment movements and their interactions with proposed tasks. Volunteers were divided according to injury level and preferential and no preferential sides were compared. Forslund et al [11] showed that the subjects who have muscular unbalance, pain or lesion in one of the arms, should choose the weaker arm to play the role of the leading one, so the contralateral arm, suffers a greater overload than the leading one.

However, this yields to the muscle unbalance and lesions glenoumeral joint. On this study, it was observed similar corporal biomechanical characteristics of paraplegics with the same injury level in comparison to preferential and no preferential transfer sides. Therefore, these subjects must be guided and trained to perform bilateral transfers towards avoiding one preferential side. This study showed statistical significant differences between leading and contralateral arm during lift phase. The contralateral shoulder showed greater angular displacement mean values in comparison to leading arm. Limb behaviors were similar to Gagnon et al [3], which observed AD leading = 23° and AD contralateral = 35°.

## Conclusion

Trunk and shoulders of thoracic SCI volunteers during transfer tasks were characteristics and showed different strategies among participants with high and low paraplegia.

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