GROUND REACTION FORCES RECORDED UNDERNEATH HANDS DURING SITTING PIVOT TRANSFERS IN INDIVIDUALS WITH SPINAL CORD INJURY

Dany Gagnon[1], Sylvie Nadeau[1], France Piotte[1], Luc Noreau[2] & Denis Gravel[1]

[1] Université de Montréal/Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain, Montreal, PQ, Canada, E-mail : dany.gagnon.2@umontreal.ca
[2] Université Laval/Centre interdisciplinaire de recherche en réadaptation et intégration social, Quebec City, PQ, Canada

INTRODUCTION

The performance of sitting pivot transfers (SPTs) ranks among the most strenuous wheelchair-related activities for the upper extremities (U/Es) among individuals with spinal cord injury (SCI) (Allison, 1997; Nyland *et al*, 2000; Gagnon, 2008). Given the paucity of biomechanical studies focusing on these functional activities, limited knowledge is available on SPT kinematics. Only Forslund *et al* (2006) have investigated vertical reaction forces (VRFs) under hands during SPTs among individuals with SCI. They documented substantial peak VRF approaching 50% of the body weight (BW) for men with SCI at one time under each hand during SPTs (Forslund *et al*, 2006). A tendency for the trailing U/E to be exposed to a greater mean VRF than the leading arm was also observed (Forslund *et al*, 2006). The horizontal reaction force (HRF) underneath hands has never been studied. The main objective of this study was to quantify the VRFs and HRFs exerted under hands when individuals with SCI perform SPTs from an initial seat to a target seat of same or high heights.

METHODS

Twelve males (age= 41.5 ± 8.4 years; mass = 81.8 ± 18.5 kg; height = 1.76 ± 0.09 m; time post-injury = 9.7 ± 11.1 years) with complete motor thoracic SCI (T4 to T11) participated in this study. Participants had the ability to independently transfer between seats of even or uneven heights and routinely used SPTs in daily life (number of SPTs performed daily= 20±7).

Participants performed SPTs from an initial force-sensing seat toward a height-adjustable target force-sensing seat, while the leading (right) and trailing (left) hands were each placed on distinct hand force-sensing surfaces attached to the side of the initial and target seats (Figure 1) (Gagnon *et al*, 2008). With both seats initially set at a height of 50 cm, three SPT trials were first recorded with the right and left U/Es always playing a leading and trailing role, respectively. After, only the target seat and leading hand surface heights were raised to 60 cm, and three additional SPTs were recorded

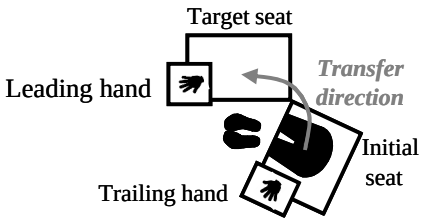

Figure 1: Top view of the experimental set-up used to assess sitting pivot transfers.

Each SPT trial was divided into pre-lift, lift and post-lift phases (Gagnon *et al*, 2008). The lift phase started when the VRF equalled zero at the initial seat and ended when the VRF reached its peak value (impact force) on the target seat for the SPTs. The start of the pre-lift and end of the post-lift phases coincided with the start of the acceleration and end of the deceleration phase of the head and trunk segments, respectively. Reaction forces were time-normalized to 100 data point per phase for a total of 300 data points for each trial, and then expressed as a percentage of body weight.

For each hand, outcome measures were the overall peak VRF and HRF values reached during SPTs as well as their mean values computed during the lift phase of the SPTs.

RESULTS

Peak VRFs were greater underneath the trailing hand compared to the leading one (p<0.02), and reached its highest value when transferring to the high target seat (p=0.003).

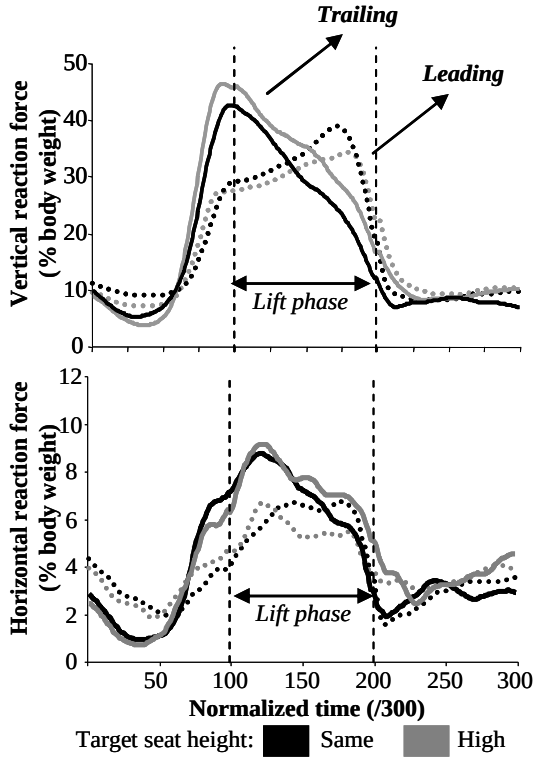

Figure 2: Overall mean vertical and horizontal reaction forces recorded under the leading (dotted lines) and trailing (solid lines) hands during transfers.

Similar mean VRFs were found between hands for each transfer studied (p>0.088). Unexpectedly, the mean VRF underneath the leading hand was greater when transferring to a target seat of same height compared than doing so to a high target seat (p=0.021), and vice-versa for the trailing hand (p=0.0001). Peak and mean HRFs were always higher underneath the trailing hand than the leading hand, independently of target seat height (p<0.001).

DISCUSSION

In conformity with the results previously reported by Forslund *et al* (2006), the peak VRFs were found to be higher underneath the trailing hand (same=45%; high=49%) than the leading hand (same=40%; high=36%) during SPTs. However, similar mean VRFs were found between the leading and trailing hands (same=32% versus 29%) when transferring between seats of same height which contradicts previous finding (Forslund et al, 2006).

The HRFs were quantified for the first time during SPTs. The peak (9-10%) and mean HRFs (5-8%) reached their highest values at the trailing U/E, and were not affected by target seat height. These HRFs may have their greatest effects at the shoulder joint where the rotator cuff muscles might be challenged.

The VRFs and HRFs found may exacerbate the development of secondary U/E impairments among this population. To reduce this risk, promoting the use of the strongest U/E, or of the pain-free one, as the trailing one during SPTs to a target seat of same or high height may be indicated in light of the current results. However, further research is required to assess relative muscular and mechanical demands during SPTs in individuals with SCI.

SUMMARY

This study assessed the VRF s and HRFs underneath hands during SPTs in individuals with spinal cord injury. The main results revealed that the peak VRF and HRF were always higher at the trailing hand when compared to the leading hand during SPTs, independent of the target seat height. Moreover, transferring to the high target seat shifted additional VRF at the trailing U/E accompanied by a decline of VRF at the leading U/E.

REFERENCES

Allison, G. (1997) Crit Rev Phys Rehab Med, 9:131-150.

Gagnon, D (2008) PhD Thesis, Faculty of Medicine, University of Montreal.

Gagnon D *et al.* (2008) J Biomech [In Press]

Nyland J *et al.* (2000) Spinal Cord, 38:649-657.

ACKNOWLEDGEMENTS

Project financed by the Quebec Rehabilitation Research Network (REPAR) and the Lindsay Rehabilitation Hospital Foundation. D.Gagnon & S.Nadeau are supported by the Fonds de la recherche en santé du Québec (FRSQ).