INTRODUCTION

Spinal cord injury adversely impacts sensory and motor pathways. Depending on the location and severity of injury there is a disruption of efferent and afferent signals below the level of injury. Seated postural control is an essential motor task for individuals with spinal cord injury (SCI) (Gagnon et al., 2005). Although individuals with SCI maintain a seated posture for an extend time during daily physical activities, they have decreased seated postural control compared to healthy counterparts (Seelen et al., 1997).

The majority of research examining seated postural control in SCI has examined traditional parameters of center of pressure motion (e.g. sway path length, area, etc). However, this traditional approach provides minimal information about the stability of seated posture. There are numerous methods to examine postural stability. One method to determine postural stability is by calculating the virtual time to contact (VTC) to the stability boundary (Slobounov et al., 1997). The virtual time provides an estimate of the time required for the center of pressure (COP) to reach the functional stability boundary (see methods). It is calculated at every point in time series of the center of pressure.

Importantly, this method does not measure the relative position of the COP to stability boundary but estimates the time need to reach to the boundary (Slobounov et al., 2006). As such it does not require losses of stability making it ideal for clinical populations.

In the current investigation, we examine VTC in SCI in order to better understand seated postural control of SCI individuals. We expected SCI individuals to have smaller VTC compared to NSCI individuals. Additionally we predict individuals with higher injury level (i.e. lower function) would have smaller VTC compared to those with lower injury levels.

METHODS

16 subjects (mean age 24.6yrs, height 1.71cm, weight 68.2kg, 3 high spinal cord injured (HI), 5 low spinal cord injured (LI) and 8 non-spinal cord injured individuals (NSCI)) participated in this study. Injured level of HI was T10 and above and LI was from T11 to L4. To quantify seated postural control, participants sat on a wooden box placed on force platform (AMTI, Inc.) with their and arms by their side. The platform records three force and three moment components: Fx, Fy, Fz, Mx, My, and Mz. The signals were amplified using a six-channel AMTI-Model SGA6-4 amplifier. A maximum gain of 4000 was used and filtered with 4th order low pass Butterworth filter of 10Hz. The data were collected with a sampling frequency of 100 Hz.

In order to calculate virtual time to contact, functional stability boundary was determined by the procedures of Slobounov et al (1997). The “functional stability boundary” of each subject was determined by having them lean forward, backward, laterally and diagonally pivoting at the hip joint, in the circular direction leaning as far as possible without losing balance for one minute (Slobounov et al., 1997). Also, the center of pressure – a reflection of the neuromuscular response to the imbalances of the body's center of gravity was calculated (Winter, 1990).

To examine the effects of the supported and vision on functional boundary and VTC to the stability boundary, subjects did two static postural tasks: sitting still with eyes open (EO) and eyes closed (EC).

RESULTS AND DISCUSSIONS

It is clear in Figure 2, that the HI group has smaller
functional boundary than the NSCI group at both EO and EC (EO: 208.8 vs. 99.4; EC: 195.7 vs. 86.1 cm², <.05).

Figure 1. Representative trials of the COP for the boundary trials and EO sitting trials from a subject of each group

Analysis of VTC revealed that HI group had shorter mean VTC than NSCI with EO and HI had shorter VTC to the stability boundary than both other groups with EC (EO: 0.29 vs. 0.23; EC: 0.33 vs. 0.31 vs. 0.25, <.05).

Discussion

A novel observation of the current investigation was that only the HI SCI had a smaller stability boundary than the healthy control group. Individuals with spinal cord injury T10 and above lack control of some trunk musculature. The lack of control of the trunk musculature minimizes the amount of sway that they can experience without risking stability. However, individuals with a SCI that does not affect trunk musculature do not demonstrate a limitation in functional stability boundary.

However, the lack of differences in functional stability boundary between the healthy control group and low injury SCI group should not be interpreted as evidence that they do not lack stability in seated postural control. In fact, the examination of virtual time to contact revealed that both the low injury and high injury group had smaller virtual time to contact than the healthy control groups. This was paramount when visual information was not available. This observation implies that individuals with SCI are closer to losing seated postural stability especially when vision is not present.

CONCLUSIONS

The effect of vision on VTC in the HI group implies that when vision is available they can compensate for their lack of proprioceptive input and demonstrate normal seated postural stability. However, when visual feedback is removed they become increasingly less stable. More work is necessary to examine whether these stability differences in SCI can be influenced by training or specific rehabilitation regimes.

REFERENCES