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Short communication

# Influence of visual inputs on quasi-static standing postural steadiness in individuals with spinal cord injury☆

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ABSTRACT

Postural steadiness while standing is impaired in individuals with spinal cord injury (SCI) and could be potentially associated with increased reliance on visual inputs. The purpose of this study was to compare individuals with SCI and able-bodied participants on their use of visual inputs to maintain standing postural steadiness. Another aim was to quantify the association between visual contribution to achieve postural steadiness and a clinical balance scale. Individuals with SCI ($n = 15$) and able-bodied controls ($n = 14$) performed quasi-static stance, with eyes open or closed, on force plates for two 45 s trials. Measurements of the centre of pressure (COP) included the mean value of the root mean square (RMS), mean COP velocity (MV) and COP sway area (SA). Individuals with SCI were also evaluated with the Mini-Balance Evaluation Systems Test (Mini BESTest), a clinical outcome measure of postural steadiness. Individuals with SCI were significantly less stable than able-bodied controls in both conditions. The Romberg ratios (eyes open/eyes closed) for COP MV and SA were significantly higher for individuals with SCI, indicating a higher contribution of visual inputs for postural steadiness in that population. Romberg ratios for RMS and SA were significantly associated with the Mini-BESTest. This study highlights the contribution of visual inputs in individuals with SCI when maintaining quasi-static standing posture.


## 1. Introduction

Maintaining a steady standing posture is challenging for many individuals with spinal cord injury (SCI) who have regained their ability to walk [1,2]. Frequent losses of balance in addition to the high incidence of falls (up to 75%) reported while standing [3,4] clearly illustrates this challenge. Therefore, a better understanding of how is regulated postural steadiness following SCI is needed.

Quasi-static postural steadiness, or the maintenance of quiet stance with no intended movement [5], depends on the integration of somatosensory, visual and vestibular inputs [6]. Given the somatosensory impairments following a SCI, the contribution of visual inputs during standing may be increased in that population compared with a healthy population. Individuals with cervical myelopathy have reduced standing postural steadiness when their eyes are closed compared to when their eyes are open, which has been explained by altered proprioception [7]. Similarly, individuals with SCI exceedingly rely on visual cues while walking being more prone to hit an obstacle when visual inputs are restricted compared to healthy controls [8]. Whether or not clinical measurements reflect the contribution of visual inputs on postural steadiness remains unknown for that population.

The purpose of this study was to compare quasi-static postural steadiness while standing with eyes open and closed between individuals with SCI and healthy controls. Moreover, for individuals with SCI, this study aimed to quantify the association between the contribution of visual inputs to achieve standing postural steadiness and a clinical balance scale.

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## 2. Methods

Fifteen individuals with an incomplete traumatic SCI (ASIA impairment scale = D) (age: 52.7 ± 17.0 years; height: 171.0 ± 0.07 cm; weight: 78.8 ± 16.1 kg; time since SCI: 305.2 ± 213.8 days) and 14 healthy controls (age: 40.2 ± 13.8 years; height: 174.0 ± 0.06 cm; weight: 79.9 ± 7.7 kg) walking independently with or without assistive devices participated in the study after giving written informed consent. Individuals with other associated neurological disorders or previous walking or balance difficulties were excluded from this study.

During a laboratory assessment, participants stood on two AMTI force plates (Advanced Mechanical Technology, Inc., Newton, MA), with their feet in a standardized position (heels separated by 10 cm; feet abducted 20°) and their arms alongside their trunk during two 45 s trials with their eyes open (EO) and closed (EC). Reaction forces were recorded at a sampling frequency of 1200 Hz. The resultant centre of pressure (COP) time series, computed from the tri-axial components of the combined reaction forces, was low-pass filtered (5 Hz) and down-sampled (600 Hz) before analysis.

The mean values of the root mean square distance (RMS; mm), the mean COP velocity (MV; mm/s), and the COP sway area (SA; $mm^2/s$) were chosen based on previous reports [9,10]. Romberg ratios (EO/EC performances) for all three COP measures were also computed to quantify the influence of visual inputs on postural steadiness. For individuals with SCI, standing balance was also assessed with the Mini-BESTest [11]. This 14-item clinical balance scale is a shortened version of the Balance Evaluation Systems test (BESTest) reflecting the unidimensional construct of "dynamic balance" [11,12].

Between-condition comparisons (EO vs. EC) were analysed with Wilcoxon signed-rank tests and between-group comparisons (SCI vs. controls) with Mann–Whitney tests. Spearman correlation coefficients quantified the association between the Romberg ratio and the Mini-BESTest for the SCI group. A statistical significance threshold was set at 0.05 for all tests. All data were analysed using SPSS.

## 3. Results

All data confirmed reduced postural steadiness in individuals with SCI compared to controls in both EO and EC conditions. All COP measures, excluding the RMS and SA among controls (RMS:

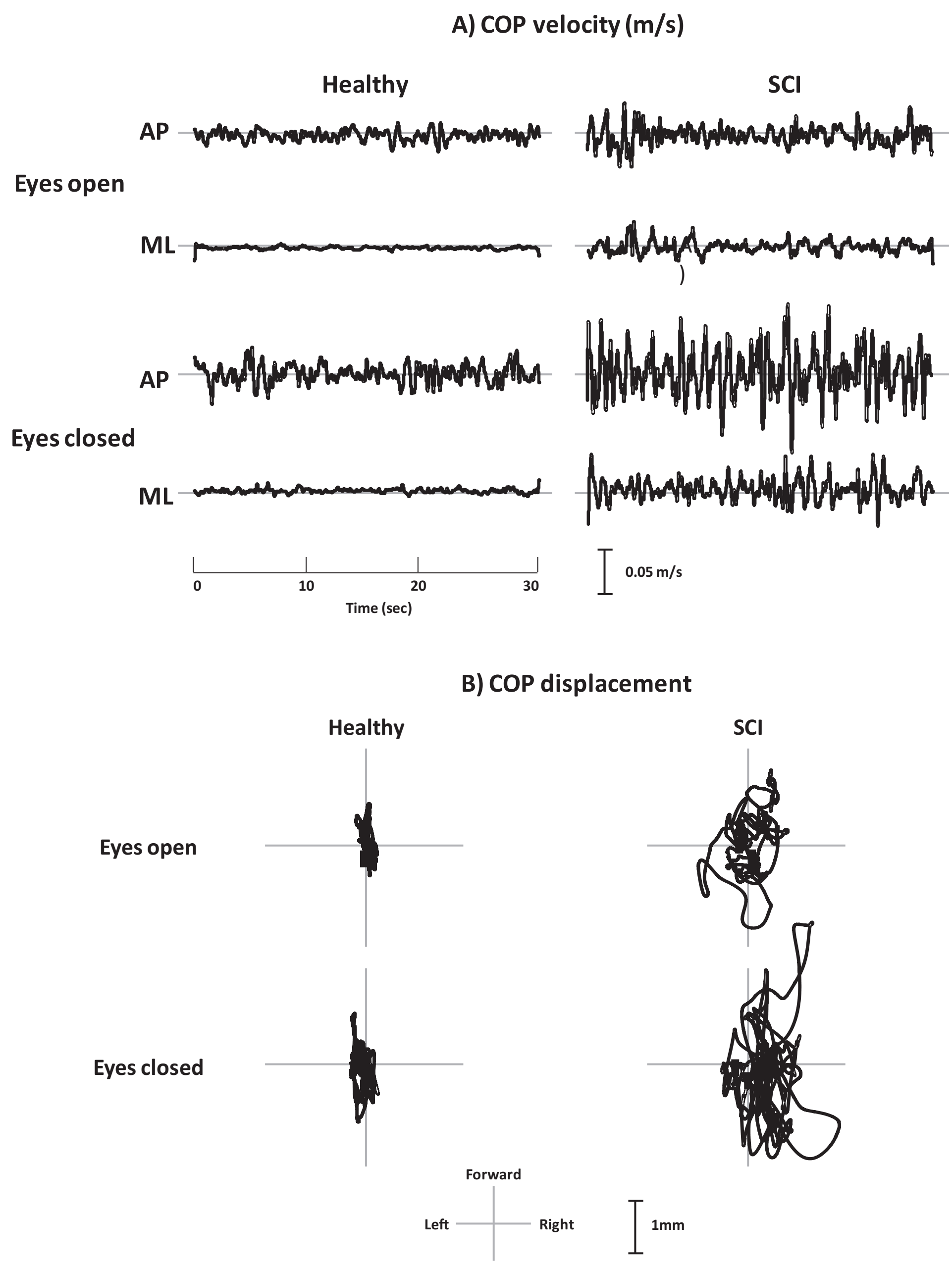


**Fig. 1.** Typical profile for COP displacements and velocity in the anteroposterior and mediolateral direction during quasi-static standing with the eyes open and closed from representative able-bodied and SCI participants. The mean velocity represents the instantaneous velocity of the COP taken at each time interval and is therefore different from the median value reported in Table 1, which represents the distance travelled by the COP during the 45 s of data collection.