Postural Adjustment of Spinal Cord Injured Subjects with Knee-Ankle-Foot Orthosis

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INTRODUCTION

Posture describes body position in space, and the proper control keeps the center of pressure (COP) within the base of support. Most studies investigated the posture control in normal subjects [1]. There is lack of studies concerning the postural control in spinal cord injured subjects (SCI) who may loose balance without support [2]. The purpose of this study was to compare the postural sway, joint angles and postural muscle activities in complete and nearly complete SCI who had to wear knee-ankle-foot orthosis (KAFO) during stance with and without support.

METHODS

The inclusive criteria of this study were SCI who had to wear the KAFO for standing, and would loose balance less than 5 seconds without support. Seven complete and nearly complete mid-low thoracic cord (T6-T12) injured SCI with mean age of 38.6 years old participated in this study. The duration of injury was 94.4 ± 79.2 months. Participants performed standing with each leg on separate force plate (AMTI, USA) for 5 seconds while holding the bars, then released holding until lost balance. Surface electrodes recorded the electromyographic activities (EMG) of trunk muscles and triceps. The joint angles were recorded by 3-D Motion Analysis System (Vicon 250, Oxford, UK). The Wilcoxon signed ranks test was performed to compare the differences in subjects with and without holding. $p < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

All the subjects lost the balance within 3 seconds after releasing the hands from the bars. As shown in Table 1, the sway path and sway area are significantly increased in subjects without holding ($p<0.05$). Compared with holding, the hip angle is less hyperextended at the time starting to loose balance, but the pelvis remains to be posterior tilt. The ankle angle between the neutral line and the line from ankle to greater trochanter is reduced at the time starting to loose balance, although it is not statistically significant (Table 1). During standing with holding, the EMG activities of right and left triceps recruit 4.8 ± 1.8%, and 5.1 ± 1.3% of maximal voluntary contractions (Figure 1). The EMG of abdominal and T12 paraspinal muscles seem to recruit more during standing with and without holding. However, the voluntary contractions of abdominal and T12 paraspinal muscles are low, so that the supporting effect of those muscles would be small.

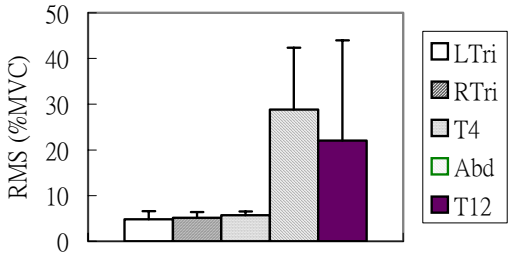

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Figure 1. The root mean square (RMS, % maximal voluntary contraction) of triceps and trunk muscle electromyographic activities.

CONCLUSIONS

The postural control in complete SCI depends not only the mechanical alignment of pelvis and other joints, but also on the postural muscle activities [3]. The training of proper alignment of joints and the strength of residual muscles would be important for fall prevention. The anticipatory effect of muscle recruitment needs further study.

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Table 1: The COP sway and joint angle during stance.

	With Holding	Without Holding
Sway path x-axis (mm)	0.8 ± 0.2	2.6 ± 0.7*
Sway path y-axis (mm)	0.8 ± 0.1	2.5 ± 0.5*
Sway area (mm^2)	49.3 ± 6.8	112.0 ± 18.7*
Pelvis angle (-: posterior tilt)	-9.9 ± 4.9	-9.7 ± 5.2
Hip angle (-: extension)	-12.8 ± 5.6	-8.1 ± 4.7*
Ankle to GT (-: extension)	6.7 ± 1.8	4.7 ± 0.9

Data were Mean ± Standard Error. * $p < 0.05$ if compared with and without holding.