INTER-JOINT COORDINATION IN PATIENTS WITH CERVICAL SPONDYLOSIS DURING OBSTACLE-CROSSING

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INTRODUCTION

Cervical spondylosis (CS) is a frequent clinical problem characterized by symptoms and signs consistent with cervical spine and spinal cord structural abnormalities [1]. Previous studies have shown that the level of disc prolapse among CS patients in the surgical group mostly occurred around C5 and C6 [2]. Cervical spondylosis with myelopathy (CSM) can affect several motor and sensory pathways travelling along the cord [3]. Balance dysfunction due to CS or CSM can result in falls during walking and obstacle-crossing, leading to physical injuries. Obstacle-crossing during walking is essentially a multi-joint movement, requiring precise swing foot control and a high level of inter-joint coordination of the stance and swing limbs [4-5]. The stability of the coordination patterns, a fundamental feature of functional action, is also essential. Failure to meet these requirements will lead to falls. The purpose of this study was to compare patterns and variability of the inter-joint coordination between the CS group and healthy control group when crossing obstacles of different heights.

METHODS

Eleven patients with CS at the C4-C5 or C5-C6 level (age: 61.88±12.03 years, height: 160.05±7.42 cm, weight: 64.12±12.36 kg, leg length (LL): 80.81±5.23 cm) and 11 normal controls (age: 53.45±8.71 yrs, height: 158.38±5.85 cm, weight: 60.74±15.21 kg, leg length (LL): 78.83±2.11 cm) participated in the current study with written informed consent.

In a gait laboratory, each subject walked and crossed a height-adjustable obstacle at a self-selected speed across an 8-meter walkway. Forty-one infrared-retroreflective markers were used to track the motion of the body segments. Three-dimensional trajectories of the markers were measured using a 7-camera motion capture system (Vicon 512, Oxford Metrics Group, UK). Test conditions included obstacle-crossing of three different heights (10%, 20% and 30% LL). For each subject, a total of six successful trials, three for each limb leading, were obtained.

Joint angles and angular velocities were calculated and used to obtain the phase angles for each joint [4-5]. Continuous relative phase (CRP) between two adjacent joints was then calculated by subtracting the phase angle of the distal joint from that of the proximal. A parameter called deviation phase (DP) was calculated by averaging the standard deviations of the ensemble-averaged CRP curve points for the stance and swing phase for each obstacle height [4-5]. The group and height effects on all the calculated variables were tested using two-factor repeated measures ANOVA using SPSS (Version 17, Chicago, IL). A significance level of 0.05 was set for all statistical tests.

RESULTS AND DISCUSSION

In general, the CRP curves of the leading limb in the CS group were significantly different from those of the control group (Fig. 1) while no significant differences were found for the trailing limb. The CS group showed significantly smaller CRP values for the leading joints when the leading and trailing toes were above the obstacle, except for the hip-knee at trailing toe crossing (Fig. 1). These results suggest that the inter-joint coordination of the leading limb but not the trailing limb was altered with CS.

Significantly increased variability of the inter-joint coordination was observed in the leading limb of
the CS group, as indicated by the increased DP values, except for the knee-ankle (Fig. 2). As for the trailing limb, the variability of the inter-joint coordination was not significantly different between groups except also for the knee-ankle coordination. During trailing limb crossing, the CS group showed increased variability in the trailing swing knee-ankle coordination but decreased variability in the leading stance knee-ankle coordination. No significant height effects were found for all the variables.

![Figure 1](image1)

**Figure 1:** Ensemble-averaged CRP of hip-knee and knee-ankle of the leading limb for the CS (red) and control (green) groups when crossing obstacles of 20% LL. ‘*’ significant group difference (p<0.05)

The current results showed that during leading limb crossing, the stability of the control of this motor task in the CS group was compromised mainly owing to the altered patterns and increased variability of the hip-knee coordination in the leading limb. This may lead to increased variability of the end-point control, increasing the risk of tripping. During trailing limb crossing, the increased variability of the trailing swing knee-ankle appeared to be a major determinant of the stability of the task while the reduced variability of the leading stance knee-ankle may be a strategy to compensate for it. The observed changes of the patterns and increased variability in the inter-joint coordination in patients with CS may be a result of impaired sensory function and reduced muscle strength in the lower limbs which often occur in this patient group.

![Figure 2](image2)

**Figure 2:** Comparisons of the DP values for the leading limb between CS (red) and control (green) groups during stance and swing phases. An asterisk indicates significant group difference (p<0.05).

**CONCLUSION**

During obstacle-crossing, patients with CS showed different and less stable inter-joint coordination in both the leading limb and distal part of the trailing limb when compared to controls. This suggests that clinical rehabilitation programs should include strategies to restore not only the primary motion of individual joints but also the coordination of movements between joints.

**REFERENCES**