IDENTIFICATION OF CONCUSSION INDUCED DUAL-TASK GAIT INSTABILITY IN ADOLESCENTS THROUGH ANALYSIS OF HEAD CENTER OF MASS MOTION

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INTRODUCTION

Return to play (RTP) criteria for concussed adolescent athletes vary considerably and are currently based on time, resolution of subjective symptoms, and normalization of simple balance tasks. Based on these metrics RTP usually occurs 1-2 weeks post injury. Recent investigations of concussion related gait imbalance employing a dual-task paradigm reveal an inability of concussed subjects to control their whole body center of mass (WB COM) as indicated by an excessive medial-lateral (M-L) displacement, faster peak M-L velocity, and slower peak anterior-posterior (A-P) velocity [1]. This impairment was shown to exist at a significant level as long as two months post injury and worsens when subjects RTP inside of two months, suggesting current RTP criteria may not be sensitive enough to capture lingering deficits in dynamic motor functions [2]. Simplification of dual-task gait instability assessment may allow for increased clinical utility and facilitate the application of emerging low cost inertial measurement unit technology. This study aims to determine if head COM kinematics are able to identifying dual-task gait imbalance previously identified by whole body COM kinematics.

METHODS

Twenty-two (4F) subjects suffering a concussion in athletics participation were tested within 72 hrs of injury. Concussed subjects were matched to healthy controls by sex, height, mass, age, and sport. Subjects walked at a self-selected pace along a straight walkway under two task conditions: walking only (single-task) and walking while answering questions (dual-task Q&A) consisting of spelling a five letter word backwards, or counting backwards by sixes or sevens.

29 retro-reflective markers were placed on bony landmarks [3] and tracked with a 10-camera motion analysis system, sampling at 60Hz. Marker data was low-pass filtered using a zero-lag, second-order Butterworth filter with a cutoff frequency of 8Hz. WB COM was calculated as the weighted sum of 13 body segments. Head COM was defined as the midpoint between the two ear markers. Total M-L COM displacement was defined as its excursion along the M-L axis during one gait cycle. Peak COM velocities along the M-L and A-P axes were also calculated. Two-way analyses of variance were performed on head COM data to determine effects of group (concussed and control) and condition (single-task and dual-task).

RESULTS AND DISCUSSION

Concussed subjects were tested at 2 ± 0.7, 8 ± 1.7, 17 ± 3.4, 31 ± 4.1, and 59 ± 3.4 days after injury. Previous analysis of WB COM [1] revealed significant group by task interactions for M-L displacement and peak A-P velocity and main effects of group and task for peak M-L velocity. Similar analyses were performed in this study for head COM that did not detect any significant interaction effects for any of the three outcome measures. Further analysis of head peak A-P velocity revealed a significant main effect of group (p = .017), however, in repeat analysis with average gait velocity as a covariate, the main effect was reduced to a non-significant level.

Figure 1: Total M-L displacement (mean ± SE) of head and WB COM for concussed subjects during single-task and dual-tasks.

Examination of head and WB COM displacements along the M-L direction revealed similar trajectories through the gait cycle. Head displacement magnitudes were about twice those of the WB, and head trajectory deviations occurred on average 7% sooner than WB deviations (Fig. 2), suggesting the deviation of the head contributes to WB COM M-L displacement rather than being used as a strategy for WB COM stabilization.

Figure 2: Representative plot of head and WB COM trajectories along the M-L axis.

CONCLUSIONS

The establishment of head COM kinematics as a sensitive measure of dual-task gait imbalance would facilitate laboratory and clinical study of this impairment. However, results from this study failed to establish its validity. While the profiles of the head COM data for each of the three outcome measures (Fig. 1) were similar to those of the WB COM, substantial variability in head COM measures likely contributed to the lack of significant effects. The inability to reliably control head orientation without significantly affecting natural movement patterns appears to eliminate the utility of head COM measures in detection of dual-task gait imbalance in concussed adolescent athletes.

REFERENCES