ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

DUAL-TASK EFFECT ON GAIT BALANCE CONROL IN CONCUSSED ADOLESCENTS

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INTRODUCTION

Much of the current research available on adolescent concussion has focused on neuropsychological function [1], reported to be the cornerstone of the concussion assessment [2]. However, previous investigations indicate concussion is a multi-dimensional injury which affects not only neuropsychological function, but also body movement control and that these two functions are related [3]. Although previous disruptions of gait balance control lasting up to 28 days following injury in young adults have been reported [4], the effects of concussion on gait control in the adolescent population are yet to be investigated. Therefore, the purpose of the study was to prospectively and longitudinally examine gait balance control during single and dual-task walking in concussed adolescents within a 72 hour acute post-injury interval and over the subsequent two-months following injury.

METHODS

Twenty high school students participating in sports were identified as suffering a concussion by a specialized health professional (certified athletic trainer/physician). Each subject reported to the lab for testing within 72 hours of injury, and returned one week, two weeks, one month, and two months post-injury. Each concussed subject was then matched with a healthy control subject (n = 20) by sex, height, mass, age, and sport. Control subjects were tested in a similar timeline.

Subjects walked barefoot at a self-selected speed along a 10m walkway under two conditions: walking with undivided attention (single-task) and walking while completing a continuous auditory Stroop task (dual-task). The secondary Stroop task consisted of the subject listening to the word "high" or "low" played in a high or low pitch four times in random order during each walking trial. The subject attempted to identify the pitch of the word, regardless of whether the pitch was congruent with the meaning of the word.

A total of 29 retro-reflective markers were placed on bony landmarks and whole body movement was recorded using a ten camera motion analysis system (Motion Analysis Corp., Santa Rosa, CA) at a sampling rate of 60 Hz. The whole body COM position was then calculated with a 13-link model [5]. Gait temporal-distance variables were average walking speed: the mean forward velocity during the gait cycle, step length, and step width: the distance between right and left heel markers in the anterior/posterior and medial/lateral directions, respectively. Peak linear COM anterior (Av) and medial/lateral (MLv) velocities were identified during the gait cycle as well as total COM frontal plane excursion (MLdisp). These variables have previously been reported to provide sensitive detection of gait imbalance [5]. In order to account for individual differences in attentional loading and walking speed, the change between single and dual-task conditions was calculated and reported as the *dual-task cost*. Accuracy on each Stroop response was calculated as the total correct responses divided by the total trials completed.

Three-way mixed effects ANOVAs were used to analyze each walking variable to determine the effect of group, time, and task. Two-way mixed effect ANOVAs were used to determine the effect of group and time for *dual-task cost* and Stroop accuracy rates. For all omnibus tests, significance was set at $p < .05$. Follow up pairwise comparisons were then examined using the Bonferroni procedure to control Family Wise Type I Error.

RESULTS AND DISCUSSION

For average walking speed, all subjects walked slower in the single-task condition compared with the dual-task (group x task interaction, p = .024; time x task interaction, p = .019). Concussed subjects walked with a significantly shorter step length at the 72 hour and 1 week testing times compared with the 2 week, 1 month, and 2 month follow ups, while control subjects did not significantly change their step length throughout the two months of testing (group x time interaction, p = .012). No significant interactions or effects were found for step width.

The results demonstrated that concussed subjects walked with a significantly greater Av dual-task cost compared to control subjects (main effect of group, p = .017). Figure 1C displays that concussed subjects walked with a significantly greater MLdisp in the dual-task condition compared with the single-task and compared with the dual-task of the control group (group x task interaction, p= .006). The MLdisp dual-task cost was also significantly greater throughout the two month testing period (main effect of group, p = .013). Concussed subjects demonstrated significantly higher COM MLv than control subjects (main effect of group, p = .027; Figure 1B). Both groups walked

with a significantly higher MLv during dual-task walking compared with single-task walking (main effect of task, p = .010; Figure 1B).

Stroop task accuracy for control subjects was significantly greater than concussed subjects throughout the two month testing period (main effect of group, p = .004).

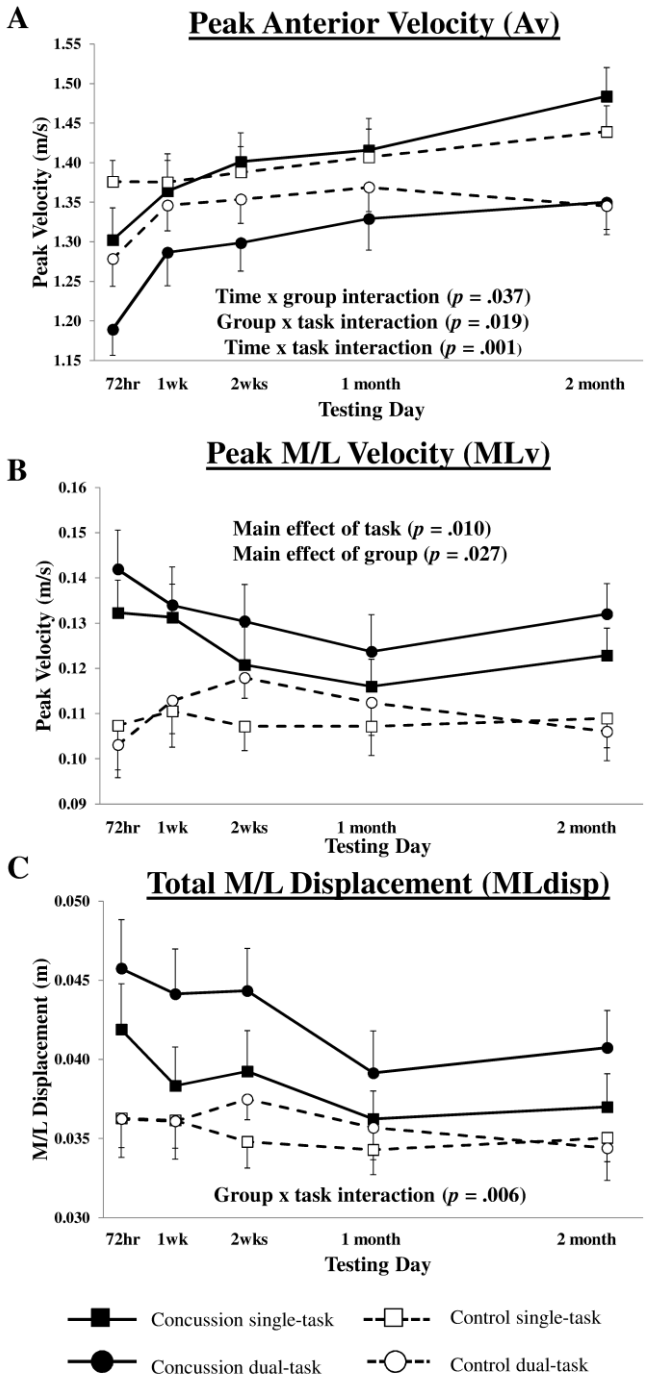

Figure 1: Results across the two month testing period for (A) sagittal plane COM velocity, (B) frontal plane COM velocity, and (C) frontal plane COM excursion.

The results of the study indicate adolescents with concussion are disrupted in their ability to control forward momentum and maintain gait balance control to a greater degree than control subjects while walking and performing a concurrent cognitive task. Concussed subjects demonstrated a greater dual-task cost on COM Av and MLdisp variables throughout the two month testing period compared with control subjects. Concussed subjects also displayed a higher MLv and MLdisp within the dual-task condition compared with control subjects across the two months of testing.

Previous work has demonstrated the utility of COM analysis in detecting disturbances in concussed adults [4], and suggests deficits may indicate a disrupted ability to maintain gait stability [6]. The current data on adolescents are in agreement with those findings: dual-task walking was significantly disrupted in concussed adolescents compared to controls for two months following injury.

The greater COM Av dual-task cost for concussed subjects may be an adaption previously reported to reflect a mobility impairment, and may be due in part to an effort to reduce COM forward momentum in order to accommodate to divided attention [6]. This may suggest a disruption in motor or cognitive function during walking, or a disruption of the integration between these two functions. This is consistent with other literature which suggests limited attentional resources in young adults suffering from concussion [7].

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The data suggest that in adolescents, concussion not only affects gait performance, but appears to affect response accuracy during walking. This result along with the COM Av dual-task cost increase indicates both cognitive and motor domains are affected for up to two months following concussion; a longer period of time than previously reported for adolescents [8].

CONCLUSIONS

Concussion reduces balance control ability during dual-task walking up to two months following injury in adolescents. The results of the study suggest examination of dynamic balance control during dual-task walking may provide additional useful information in the clinical assessment and recovery of concussion

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