ASSESSMENT OF OCULOMOTOR CONTROL AND BALANCE POST CONCUSSION

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INTRODUCTION
Concussion is a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces [1]. It is estimated that over 300,000 concussion related sports injuries occur in the US, as sport involvement increases, there is an increased need for research to reduce prevalence and expedite recovery of concussion injuries [2,4]. Damage sustained from a concussion can result in lingering balance disturbances and vertigo [3]. Rehabilitation focused on the vestibular system has shown to improve balance performance post-concussion [5]. However, the role of the vestibular system in oculomotor control for stabilization and tracking post-concussion has been limited. The purpose of this research was to measure oculomotor behavior and the observed differences in post-concussed and non-concussed athletes via gaze control during active balance assessment. The goal was to provide evidence for the use of gaze control in conjunction with balance assessment post-concussion.

METHODS
Nine post-concussion (PC) and nine non-concussed (NC) athletes performed 3 balance assessment trials while wearing a head mounted eye tracking system (Applied Science Laboratories, MA, USA). Balance performance was measured via Nintendo WiiFit® soccer heading game. This game is a comprehensive balance activity as it involves directing center of pressure in response to visual stimuli. Gaze stabilization was measured as the percent of time fixed on the center of the game screen. Gaze deviations from center of the screen were also recorded. Between subjects ANOVA were performed for gaze time on center, soccer game score, and gaze deviations from center. Additionally, Pearson Product correlations between gaze time on center and soccer game score were performed. Lastly, learning effects on the Wii soccer heading game over a three-week period (NC) and two-week period (PC) were investigated. Repeated measures ANOVA assessed differences in scores over the weeks in each group. For all statistics an alpha level of 0.05 was set a priori.

RESULTS
A significant correlation between gaze time on center and WiiFit soccer score was found. Non-concussed individuals had a positive correlation ($r = 0.792, p = 0.011$) while post-concussed individuals had a negative correlation ($r = -0.846, p = 0.004$). No significant difference in Wii soccer score or time on center was found between PC and NC. However, deviations from gaze were significantly different PC (46.5±13.58) and NC (24.1±8.82, $p < 0.001$). Repeated measures for the learning effect of the Wii were significantly different from week 1, week 2, and week 3 ($p < 0.001$), yet, non-significant between week 1 and week 2 for PC individuals ($p = 0.061$).

DISCUSSION & CONCLUSIONS
Results indicate differences in oculomotor behavior during a comprehensive balance activity in concussed athletes. Concussed athletes directed gaze to the center of the screen, however scores were low, indicating less effective body responses to visual stimuli. Greater gaze deviations in concussed athletes from the center of the screen suggest a deficit in visual tracking or stabilization. In addition, NC participants demonstrated a significant learning effect during weekly play. In contrast, PC individuals did not significantly improve score over a two-week recovery period. The effect or strength of the learning component is still unknown; however, this effect points to an interesting area for further investigation. Overall, visually driven balance responses and assessing gaze may provide greater insight into dysfunction of the vestibular system in PC individuals.

REFERENCES

Table 1: Post-Concussion (PC) and Non-Concussed (NC)

<table>
<thead>
<tr>
<th></th>
<th>Correlation</th>
<th>Wii Soccer Score</th>
<th>Time on Center</th>
<th>Gaze Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>-0.846</td>
<td>94.90 (21.80)</td>
<td>64.20%</td>
<td>46.5 (13.58)</td>
</tr>
<tr>
<td>NC</td>
<td>0.792</td>
<td>132.2 (25.57)</td>
<td>63.20%</td>
<td>24.1 (8.82)</td>
</tr>
</tbody>
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