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SCIENTIFIC LETTERS

Concussion and vision screening

Concussion is a diffuse brain injury that can lead to a variety of symptoms such as headaches, impaired memory, lack of focus or concentration, and sensitivity to light and noise (e.g.),[5]. In fact, a common symptom for evaluating concussion is visual sensitivity (e.g., [6]. However, visual screening is not currently a recommended component of concussion assessment (e.g.),[4]. For example, the widely used SCAT5[2] includes "sensitivity to light" and "blurred vision" as items in the symptom checklist (c.f.),[6] but none of the components of the SCAT5 explore the extent to which vision is affected by a potential concussion.

Sensitivity to light may indicate difficulty regulating light. Blurred vision may indicate problems with focusing. Of course, blurred vision can lead to headaches, which is another common concussion symptom. Blurred vision also makes reading difficult leading to eye strain and reduced comprehension. While these are certainly important issues, concussed individuals may also experience difficulty with eye teaming, depth perception, eye tracking, and either overactive or underactive peripheral vision. Thus, the current level of vision assessment in concussion screening measures appears inadequate. In this exploratory study, we examined the impact of concussion on visual acuity and binocular vision using simple screening tools.

Participants were predominately college freshman and sophomores (n = 216). They completed the Acuity Screening Inventory (ASI; [1]) and Binocular Vision Dysfunction Questionnaire (BVDQ).[3] The ASI is a ten-item self-report measure using a five-point scale. It has high reliability (Cronbach's α = 0.94) and strong predictive validity. Similarly, the BVDQ is a 25-item self-report measure using a four-point scale. The BVDQ has strong reliability (Cronbach's α = 0.91) and good concurrent validity. For both measures, higher scores are associated with greater impairment. Participants also indicated if they were previously diagnosed with a concussion. Based on responses, participants were assigned into non-concussed (n = 155) or concussed (n = 61) groups.

Although there was no difference in visual acuity between the non-concussed and concussed groups, there was a significant difference in binocular visual dysfunction (Welch's $t(81.46) = 3.01$, $p = .003$; $d = 0.49$). The results show that participants who had previously received a concussion had greater binocular disfunction (M = 28.13, SD = 25.03) than those who had not (M = 17.70, SD = 16.54). Reliability of the BVDQ for this sample was excellent (Cronbach's α = 0.96).

A logistic regression analysis was conducted to predict concussion from the BVDQ. Sensitivity was poor (Sn = 0.10). However, specificity was superior (Sp = 0.99) suggesting that, using the SpPIn rule (i.e., a positive test on an assessment with high specificity rules in the condition), high BVDQ scores may be useful for diagnosing concussion. It is also important to note that the amount of time between this study and the diagnosed concussion was not constrained and varied across participants with most participants being concussed one to three years prior to the study. Therefore, the results from this study further suggest that binocular dysfunction may linger for a period of time after a concussion. Based on this finding, binocular dysfunction may also be useful for recovery prognosis. Furthermore, these results suggest that scores from a binocular vision screening may help inform a treatment plan. For instance, a certain score may indicate that a particular visual therapy is required.

The last two points concerning prognosis and treatment are important. It is reasonable to assume that a more comprehensive initial post-injury assessment will lead to individuals receiving care tailored to their specific needs faster thereby reducing the long-term impact of concussion-related deficits and minimizing the negative impact that concussion can have on school and work performance.

This study was conducted to draw attention to an understudied and underrepresented area of concussion care that could have important implications for diagnosis and treatment. Based on the results from this study, including vision-related self-report measures in post-injury concussion assessments may have several advantages. First, additional information will be obtained regarding a common symptom of concussion allowing for a more complete picture of impaired functionality and concussion severity. That additional information can be used to better estimate the recovery time and to help determine treatment options. Specifically, if screening measures are used in the evaluation process then it increases the likelihood that patients will be properly referred to optometrists when needed. Further research is required to determine the extent to which visual impairments contribute to recovery or RTP time. Also, this study only examined two aspects of vision, namely acuity and binocular dysfunction. Post trauma vision syndrome (PTVS) suggests that other forms of visual impairment can be found after head trauma. These impairments can be related to ocular

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motor dysfunction, convergence, egocentric localization, visual vestibular mismatch, and accommodation. Therefore, other aspects of visual processing (e.g., ocular motor dysfunction) may be associated with concussion severity and recovery time. How all these aspects of vision interact with each other after concussion warrants further investigation to improve assessment and treatment strategies.

Conflicts of interest

The authors have no conflicts of interest to declare.

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