Transcranial Photobiomodulation Promotes Neurological Resilience in Current Collegiate American Football Players Exposed to Repetitive Head Acceleration Events

Repetitive head acceleration events (RHAE) are common in contact sports and associated with neuroinflammation, axonal injury, and long-term neurological impairments, including increased risk for chronic traumatic encephalopathy. Current strategies for addressing RHAE focus on post-injury care rather than proactive neuroprotection, leaving athletes vulnerable to cumulative neurotrauma. Transcranial photobiomodulation (PBM) has shown promise in reducing neuroinflammation and promoting neuroprotection in traumatic brain injury; however, its potential to mitigate the structural brain changes associated with RHAE in actively competing athletes has not been investigated. The aim of this study was to investigate whether PBM mitigates RHAE-related neuroinflammatory and microstructural changes in collegiate American football players over a single National Collegiate Athletic Association Division I season. We hypothesized that restricted diffusion imaging (RDI) and quantitative anisotropy (QA), diffusion magnetic resonance imaging markers of neuroinflammation and axonal remodeling, respectively, would increase in the Sham PBM group due to RHAE exposure but remain stable in the Active PBM group, indicating neurological resilience. Twenty-six collegiate football players were randomly assigned to Active (n = 13) or Sham (n = 13) PBM groups. PBM (810 nm) was self-administered 3 days a week under supervision in the athletic training room with a transcranial plus intranasal device throughout the preseason practice period and regular season (16 weeks). Diffusion MRI data were collected pre- and postseason, and correlational tractography was used to assess the effects of PBM on longitudinal changes in RDI and QA. Moderation analyses examined time × group interactions, with post hoc analyses exploring within- and between-group differences in RDI and QA cross-sectionally and longitudinally. Correlational tractography revealed significant main effects and interactions of time and group, with widespread increases in RDI and QA observed in the Sham PBM group over the season, consistent with neuroinflammation and axonal remodeling. In contrast, the Active PBM group showed relative stability in RDI and QA over time, with significant reductions

observed in some areas. These findings suggest that PBM may mitigate ongoing neuroinflammation and facilitate the recovery processes. This study provides the first evidence suggesting that transcranial PBM reduces neuroinflammatory and axonal injury markers in American collegiate football players over a single season. PBM may serve as a noninvasive and accessible intervention for mitigating the cumulative neurological effects of RHAE exposure, offering a neuroprotective strategy for athletes participating in collision and contact sports. Future research should examine the long-term benefits of PBM across multiple seasons and its impact on functional outcomes to further establish the role of PBM in athlete brain health and wellness.

Keywords: connectometry; diffusion weighted imaging; neuroinflammation; photobiomodulation; repetitive head impacts; sport-related concussion.