Final report summary

Improving jockey safety through the use of virtual reality and biomarkers of concussion

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Research

This study employed a prospective design to assess the temporal changes in:

1. Jockey performance based on cognitive tests pre- and post-concussion.
2. Jockey biomarkers pre- and post-concussion.
3. Workplace stress and inflammatory markers compared with cognitive performance (baseline-to-baseline comparisons).

Jockeys provided data on these measures at baseline (pre-concussion) and again at two days, seven days, 30 days and one year post-concussion. Additionally, the concussed jockey group was compared against a matched control group for both cognitive (n = 103) and biomarker data (n = 51). Baseline data was collected for two years from the whole cohort, and all concussion events across the three-year period were followed up.

The study also gathered data across the two baseline periods on measures of stress and each jockey’s history of concussion. In this arm of the study, blood samples, psychological data and cognitive data provided by jockeys (n = 40) across each of the two years were used to assess the temporal associations between workplace stress, inflammation, and cognitive performance.

The final study employed a cross-sectional design to assess whether a history of concussion or blood biomarkers of concussion were associated with performance on CONVIRT (n = 29) or were just traditional measures of cognitive performance.

Finally, whether a history of concussion was related to higher levels of circulating biomarkers of concussion, and whether that history of concussion impacted performance, was assessed based on cognitive measures.

Objectives

This research project was designed to serve five main purposes:

1. Use a longitudinal design to study the prospective effects of concussion upon several novel biomarkers of concussion, with the intention of identifying the most sensitive measure of concussion.
2. Assess whether the brain injury period, as noted from the blood biomarkers, continues beyond the time that concussion symptoms subside.
3. Use a prospective design to assess whether changes in workplace stress are related to increases in inflammatory markers and, further, whether these inflammatory markers are related to deficits in cognition.
4. Assess the viability of CONVIRT, a virtual-reality cognitive battery developed specifically for jockeys, for use in the horse racing industry.
5. Determine whether a history of concussion or elevated blood biomarkers are related to poorer performance on the CONVIRT battery or are just traditional measures of cognitive performance.

Background

Jockeys are exposed to serious health risks in their workplace and these risks are exacerbated by occupational stress. Rates of concussion among jockeys are very high. Injuries among licensed jockeys in the years 2002-2010 led to claims that cost $9 million per year, with the mean cost of a race day fall $33,756. If the fall involved a head injury, the mean cost was $127,127.

Our pilot research showed that when jockeys reported high stress in concert with signs of dysregulated stress physiology, their decision-making was substantially impacted. Such decrements likely increase the fall-risk in stressed jockeys.

This research aimed to determine whether a novel virtual-reality concussion tool, CONVIRT, which was built specifically to test jockey concussion, could provide evidence that better informs return-to-ride decisions. CONVIRT places the participant in a virtual horse race where they must respond to stimuli that assess visual processing speed, attention and decision-making by tracking eye speed and manual reaction times. Additionally, the viability of novel blood biomarkers of concussion, which may similarly inform prognosis and return-to-ride decisions, was studied. This is an important area of research, as there is mounting evidence that after a fall, the brain injury may persist long after concussion symptoms recede.

Finally, whether a history of concussion was related to higher levels of circulating biomarkers of concussion, and whether that history of concussion impacted performance, was assessed based on cognitive measures.
Results

Study 1: Biomarkers of concussion

• The biomarkers neurofilament light (NFL) and Glial fibrillary acidic protein (GFAP) appear to be good indicators of the timing of concussion injury resolution.

• Cognition (as measured by CogSport) and self-reported concussion symptoms generally return to pre-injury status within one month, but NFL levels may still be higher at one month and beyond, which suggests the injury has not resolved.

• Based on standard concussion management practices, there is a chance that some athletes are returning to play before their brain injury has resolved.

Study 2: Stress, inflammation and cognition

• When compared with mainstream occupations, jockeys are reporting high levels of workplace stress.

• High workplace stress is due to increasing demands and a burden of personal responsibility, and not low rewards.

• Jockeys with increased workplace stress have poorer attention.

• Jockeys with increased workplace stress have higher levels of the tumour necrotic factor alpha:interleukin 10 (TNFa:IL10) ratio, which suggests that increased workplace stress results in a primarily proinflammatory response.

• Jockeys with an increased TNFa:IL10 ratio perform more poorly on measures of attention.

Study 3: Concussion history, biomarkers of inflammation and CONVIRT cognitive test performance

• About 80% of the 45 jockeys reported a concussion event, with 53% of those jockeys reporting loss of consciousness.

• After statistically controlling for age and gender, jockeys with more concussions performed more poorly on the CONVIRT measure of saccadic reaction time and speed.

• After statistically controlling for age and gender, jockeys with higher levels of serum Tau proteins performed more poorly on CONVIRT measures of attention and decision-making. Tau proteins are proteins that stabilise microtubules and are abundant in the central nervous system. Diseases such as Alzheimer’s disease and Parkinson’s disease are associated with Tau proteins that have become defective and no longer stabilise microtubules properly.

Implications

The NFL and GFAP biomarkers appear sensitive indicators of concussion status and can help discern when an injury has fully resolved. The risk of serious and potentially chronic disease may be elevated for persons who sustain a concussion on top of a brain injury that has not fully resolved. Given the international spotlight on concussion management at present, a shift towards considering injury resolution may soon be used to assist with concussion management decisions. With further research, it is hypothesised that these tests may soon be validated to help identify and manage concussions.

The search for novel ways to better measure concussion recovery and inform prognosis is a big part of helping reduce workplace risk. To that end, the promising findings from the present study help bring the field one step closer to routinely using evidence-based biomarkers of concussion and behavioural measures of cognition (CONVIRT) to better inform decisions around best practice concussion management for jockeys.

Unlike other cognitive tests, the CONVIRT battery measures elements of the visual system that are compromised by concussion. By assessing attention, decision-making and visual processing speed using eye-tracking technology in a virtual horse race, the CONVIRT tool has clear advantages over traditional computer-based concussion tests, and may be used to assess whether jockeys are ‘fit to ride’. CONVIRT continues to provide evidence to improve industry acceptance and promote safer workplace practices.

References


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Research team

Dr Brad Wright, Dr Paul O’Halloran, Dr Matthew Hale, Professor Glynda Kinsella (all La Trobe University), Dr Stuart McDonald (Monash University), Professor Paul Maruff (Cogstate Pty Ltd), Associate Professor Ben Horan (Deakin University).

Dr Brad Wright
School of Psychology and Public Health
La Trobe University
Plenty Road
Bundoora VIC 3083
03 9479 2348
b.wright@latrobe.edu.au