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Commentary

The Neurophysiological Response Following Sub-Concussive Soccer Heading

Alan J Pearce, PhD

Swinburne University of Technology, Australia
The University of Melbourne, Australia

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Concussion is the most common type of traumatic brain injury (Shaw, 2002). Research into concussion has significantly increased in the past decade reflecting the growing recognition of repeated head-injuries in sport. Whilst the focus of the research has centred on those who have been concussed, there is also increasing awareness regarding the effects of sub-concussion. Defined as events that occur when there is an apparent brain insult with insufficient force to produce clinical symptoms that are characteristic of concussion (Gysland et al., 2012), sub-clinical acute effects of sub-concussion are relatively unknown. At present it has been suggested that exposure to repetitive, sub-concussive events may result in persistent cognitive or motor impairments, and behavioral changes (McKee et al., 2014) associated to long-term neurophysiological changes due to cumulative effects (Pearce et al., 2014). Moreover, there have been suggestions of the possibility that high numbers of repetitive sub-concussions, more than concussions, contributes to increased risk of neurodegenerative diseases including Alzheimer's or chronic traumatic encephalopathy (McKee et al., 2014; Smith et al., 2013).

Given longitudinal studies appear to point towards increased risk of neurodegeneration with repeated sub-concussions, it is therefore important that we learn about the acute mechanisms responding to sub-concussion(s). However, quantifying the effects of sub-concussion is difficult, given that studies 'in-the-field' require obvious signs and symptoms from an individual for them to qualify inclusion in studies investigating response and recovery time post concussion. Interestingly previous studies measuring the effects of sub-concussion have shown ambiguous findings. For example Gysland et al. (2012) showed that repetitive sub-concussive head impacts over a season did not result in short-term cognitive or motor impairments in a group of collegiate American football players. Conversely, in Junior (high school) American football players Talavage et al. (2014) using computerised cognitive testing and imaging via functional magnetic resonance imaging, observed measurable neurocognitive and neurophysiological impairments respectively after a competitive season in a group of athletes who showed no clinical symptoms. However, in both these studies testing for sub-concussion was only completed after a season's worth of matches, rather than the acute effects of sub-concussion, from one to ten days post match, in players who have received moderate or high force head impacts, but do not show any overt signs or symptoms of concussion.

To address the issue of measuring the direct functional outcome effects of sub-concussion, Di Virgilio et al. (2016) utilize the technique of single-pulse transcranial magnetic stimulation (TMS). A well-established and non-invasive technique to measure motor threshold, corticospinal conduction time, motor cortex excitability and intracortical inhibition (Kobayashi and Pascual-Leone, 2003), TMS has been used previously to determine neurophysiological changes following acute concussion events (Pearce et al., 2015) as well as long-term chronic neurological impairments in contact sport athletes with a history of multiple concussions (Pearce et al., 2014; Major et al., 2015).

The study by Di Virgilio et al. (2016) presents important novel data demonstrating transient changes in neurophysiological function and cognitive performance following a single exposure repetitive sub-concussive head impacts via routine soccer heading. Their data demonstrates that, despite showing no clinical signs or symptoms of concussion, repetitive impacts to the head from routine soccer heading increased intracortical inhibition, as well as performance outcome declines in short- and long-term memory. This is the first time such changes have been reported.

These findings are insightful because a common misconception is that no sign or symptom of concussions means that the individual has had no residual effect of the impact to their brain. As suggested by McKee et al. (2014) the accumulation (over many years) of sub-concussions can be substantial, but until the publication of this paper, determination of the sub-clinical effects of sub-concussions, particularly in the acute phase subsequent to the event, had not yet been quantified. However it is important to be reminded that TMS does have limitations that need to be considered in light of the protocol and findings presented in this study. Firstly, as discussed by Kobayashi and Pascual-Leone (2003) changes shown by single pulse TMS are not disease or injury-specific,

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E-mail address: ajpearce@unimelb.edu.au.

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therefore results need to be interpreted in context of other relevant data. However, whilst errors were observed in cognitive tests post soccer heading along with increased intracortical inhibition, it is important to note that single pulse TMS provides a response reflective of the motor pathway, therefore cognitive changes post soccer heading should be interpreted with caution. Secondly, single pulse TMS does not discriminate along the corticospinal pathway, therefore further work is required using paired-pulse TMS where the evoked potential is reflective of stimulation paradigms affecting supraspinal neural circuitry. This will enhance the findings of increased intracortical inhibition findings presented in this study.

However, these limitations should not detract from the novel and innovative study presented by Di Virgilio et al. (2016). Indeed the evidence from this study demonstrates that repeat sub-concussive head impacts affect the brain physiologically. These findings not only translate to clinical practice, where physicians and physical therapists should be aware of the underlying consequences of sub-concussions, but to also the wider community where sports coaches and physical education teachers who may prescribe practice activities of multiple soccer headers to their players, should be educated on the implications of such practices on their players brain health.

Disclosure

I have funding grants from the Australian Football League, and Smart Head Play charity, and have worked previously as scientific concussion consultant for Samsung.

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