# Effects of Subconcussive Head Trauma on the Resting State Default Mode Network

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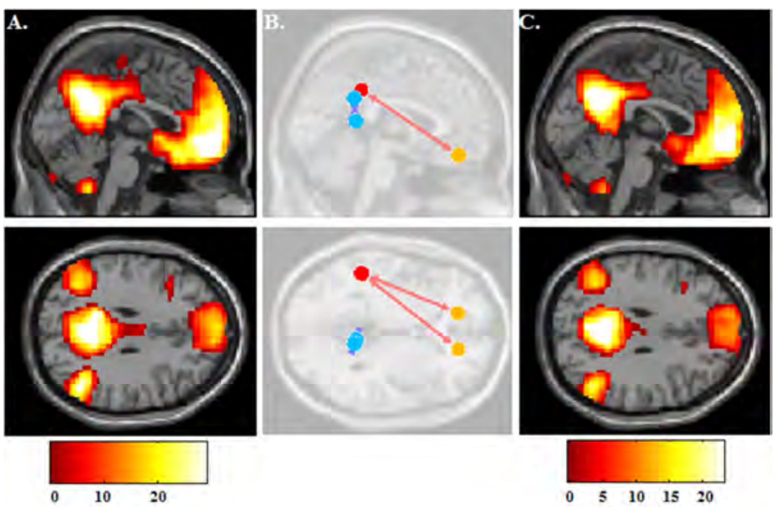
**Target audience:** Advanced Neuroimaging: Traumatic Brain Injury & Other Clinical Applications

**Purpose**: There is growing concern in the community regarding the immediate and long-lasting effects from sports-related traumatic brain injury, especially what effects these may have on the risks for developing neurodegenerative diseases.[1] Much of the research focused on sports-related traumatic brain injuries has been centered on concussions, while little attention has been placed on subconcussive impacts. However, subconcussive blows, which are below the threshold to cause or elicit any signs of a concussion, should not be overlooked as insignificant. Both animal and human research have shown that subconcussive blows can cause damage to the central nervous system and can cause pathophysiological changes in the brain despite not evoking any apparent acute behavioral changes.[2] The effects of subconcussive head trauma in terms of neurocognitive, behavioral, and underlying neural substrates have not been sufficiently studied and are not currently well understood. Studies using advanced neuroimaging on subconcussive head trauma are scarce and none to date have specifically investigated their acute effects. In this study we used resting state functional magnetic resonance imaging (rs-fMRI) to investigate the acute effects that subconcussive head trauma may have on the default mode network (DMN) of the brain.

**Methods:** 12 collegiate rugby players (mean age 19.8 +/-2.2) with no previous history of concussion (**No Hx mTBI**) and 12 collegiate rugby players (mean age 20.5 +/-1.5) with prior history of concussion were recruited for this study (**Hx mTBI**). All subjects under study underwent scanning 24 hours prior to a scheduled full contact game and within 24 hours following the end of that game. All images were acquired on a 3.0 Tesla Siemens Trio scanner using a 12-channel head coil. While in the scanner subjects were asked to lay quietly with their eyes open and not fall asleep. 2D BOLD echo planar fMRI sequence were acquired in the axial plane parallel to the anterior and posterior commissure axis covering the entire brain (3.0x3.0x3.0mm resolution, TR=2490ms, TE=24ms, EPI factor=74, Echo spacing=0.48ms, NSA=1, acquisition time=5:04). SPM 8 was used for data processing in conjunction with CONN toolbox and included preprocessing. After pre-processing, images were then band-pass filtered to 0.01Hz-0.09Hz and motion regressed to reduce the influence of noise. White matter, cerebrospinal fluid, and physiological noise source reduction were taken as confounds, following the implemented CompCor strategy [3]. Region of interest (ROI) analysis was performed by grouping voxels into ROIs based upon Brodmann areas (BA) and all BA were imported as possible connections for our selected seed ROIs. ROIs were selected based upon the commonly reported ROIs of the DMN and included: dorsal frontal cortex, anterior prefrontal cortex, orbitofrontal cortex, ventral posterior cingulated cortex, posterior cingulated cortex, angular gyrus, and supramarginal gyrus[4].




**Results:** Group analysis revealed alterations to the DMN seen from pregame to postgame in the form of both increased and decreased functional connectivity. Specifically, increased connectivity between left (p=0.005) and right (p= 0.003) orbitofrontal cortices and the left supramarginal gyrus. However decreased connectivity was also observed between the right retrosplenial cingulate cortex and the right dorsal posterior cingulate cortex (p= 0.009). To further understand these mixed results and to infer if history of previous concussion may influence changes in functional connectivity, analysis was performed on the **Hx mTBI** and **No Hx mTBI** subgroups. The **Hx mTBI** cohort demonstrated only reductions in functional connectivity following exposure to subconcussive head trauma. Decreased connectivity (p=0.005) from the left anterior prefrontal cortex and left right retrosplenial cingulate cortex, from the left inferior temporal gyrus to medial prefrontal cortex (p=0.006), and lastly between right ventral posterior cingulate cortex and left fusiform gyrus (p=0.007). Conversely the **No Hx mTBI** group exhibited only increased connectivity changes. Specifically, the left supramarginal gyrus increased functional connectivity to both the between left (p=0.003) and right (p= 0.003) orbitofrontal cortices. Additional increases were seen between left retrosplenial cingulate cortex and right fusiform gyrus (p=0.006), as well as from the left fusiform gyrus (p=0.006) to medial prefrontal cortex.

**Discussion:** There are several findings of interest from this study. First, history of previous full blown concussive episodes has the potential to infer long-term consequences as evident by significantly decreased functional connectivity within the DMN of the **Hx mTBI** group compared to the **No Hx mTBI** group assessed in the pregame evaluation. Second, short-term exposure to subconcussive head trauma has the ability to alter functional connectivity patterns. And lastly, there is evidence to suggest that there is a differential response in the concussed and non-concussed brain to subconcussive head trauma. Functional connectivity analysis of the DMN in full blown cuncussive episodes has revealed both hyper and hypoconnectivity. There is limited research on the effects of subconcussive head trauma as assessed by fMRI or other advanced imaging techniques. Although using a task based approach Talavage et al. reported significant alterations in fMRI activation in a study of 11 high school football players attributed to subconcussive impacts sustained over the course of a single season despite any clinically observable impairment. Specifically, there was decreased activation in the DLPFC, middle and superior frontal gyri, and cerebellum that correlated to the number of subconcussive impacts.

**Conclusion:** Impacts to the head in contact sports are unavoidable, and as serious as concussions are, subconcussive impacts happen much more often and are now being implicated as a source for the deterioration of cerebral structures and function later in life. It is important that clinicians take subconcussive head trauma seriously, as well as for more research to focus on the varying degrees of head trauma.

**References:**
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