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Value of Advanced MR Imaging Techniques in Mild Traumatic Brain Injury

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This commentary addresses the article, “Prevalence and Incidence of Microhemorrhages in Adolescent Football Players.”¹ The authors performed SWI in 78 adolescent football players before and after the season. The number of examined football players was fairly large. They found a prevalence of microhemorrhages of 15.38% in the group, with an incidence of 2.56% per season. Concussion was evaluated by the Sports Concussion Assessment Tool (SCAT5; <https://bjsm.bmj.com/content/bjsports/early/2017/04/26/bjsports-2017-097506SCAT5.full.pdf>) or by self-reporting history before the study. No statistically significant relationship was found between concussion and the presence of microhemorrhages.

The article by Shah et al¹ is in line with several recent works dealing with MR imaging in mild traumatic brain injury (mTBI; concussion). Providing noninvasive biomarkers in mTBI has implications for any kind of contact sport such as boxing and soccer and perhaps for any situation in which the human brain is accelerated or decelerated such as in traffic collisions, starting and landing fighter jets or rockets by pilots or astronauts, or any kind of minor head trauma (concussion). The results are in good accordance with other studies on SWI in mTBI.^{2,3} In brain trauma, shearing forces lead to microhemorrhages, especially at the gray-white matter boundary. However, brain damage may also occur without the consequence of microbleeding if axonal stretching occurs without vessel injury. Besides SWI, other advanced techniques are currently being used as an MR imaging biomarker in mTBI, such as DTI and Tract-Based Spatial Statistics (TBSS; <http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/TBSS>),⁴ measurements of cerebral perfusion and metabolism,⁵ and MR volumetry.^{6,7}

Champagne et al⁵ found reductions in metabolic demand despite no significant changes in resting oxygen extraction. Accordingly, hypoperfusion after sports-related mTBI might reflect compromised brain metabolism after injury.⁵ In a meta-analysis of 224 references to the terms “white matter,” “mTBI or concussion,” and “TBSS,” Hellewell et al⁴ extracted 8 relevant articles on acute ($n=2$), chronic ($n=4$), and subconcussive⁸ ($n=2$) injuries. Their most important finding was a dominant, bilateral, increased fractional anisotropy (FA) in the superior longitudinal fasciculus, internal capsule, and arcuate fasciculus. In

subconcussion, defined as “cranial impact that does not result in known or diagnosed concussion on clinical grounds,”⁸ the changes in FA were found to be bidirectional. Hellewell et al emphasized the possible future role of DTI in the detection of mTBI.

In our recent study on amateur boxers,⁶ we found statistically significant lower volumes in several cerebral substructures compared with nonboxing individuals, such as the nucleus accumbens (14%), caudate nucleus (11%), globus pallidus (9%), and cerebral white matter (9%), respectively, but there was a correlation of neither total brain volume nor any volume of cerebral substructures with intelligence quotient or years of boxing. Our results are in good agreement with the study of Cohen et al,⁷ who found brain atrophy in patients with mTBI along with a reduction of whole-brain *N*-acetylaspartate in MR spectroscopy. In a study by Lui et al,⁹ classification algorithms using a variety of MR imaging features, such as conventional brain imaging, magnetic field correlation, and multifeature analysis, have been used to define patients with mTBI.

Noninvasive acquisition of biomarkers in mTBI using MR imaging is of growing interest due to the popularity of contact sports such as football, as mentioned in the article by Shah et al,¹ and possibly also for advisory opinions regarding the medical and legal consequences of traffic collisions and interpersonal violence. Advanced MR imaging techniques such as SWI, DTI, MR spectroscopy, perfusion imaging, and MR volumetry in correlation to neuropsychological findings might answer a variety of questions in this field.

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