Traumatic brain injury (TBI) is a public health concern, and there are multiple myths, debates, and unresolved questions about concussion and potential lingering symptoms or long-term effects. Mild TBI (mTBI), or concussion, occurs as a result of many causes, and most cases recover within days to weeks and are not typically associated with long-term effects.1 The article by Ntikas et al is timely and addresses an important topic, because a subgroup of those who experience mTBI continue to report lingering symptoms beyond the typical recovery window, yet this subgroup and their symptoms remain poorly understood. In their study, Ntikas and colleagues took a novel approach by using an international sample to examine clinical outcomes in individuals presenting to emergency departments in various countries following a sport-related TBI (SR-TBI) and compared them at 3- and 6-month follow-up with a group of adults with TBI who sustained their injury due to other causes.

Along with analyzing the entire sample, the authors focused on subgroups most relevant to sport—that is, mTBI with and without intracranial findings on imaging. Clinical outcomes included ratings of functional ability, quality of life, posttraumatic stress, depression, anxiety, and postconcussion symptoms, with outcomes dichotomized to reflect impairment or no impairment. Using functional ratings from the Glasgow Outcome Scale-Extended3 (GOSE) at 3-month follow-up, more than one-half of the SR-TBI group reported incomplete functional recovery (42% for those with mTBI overall, and 33% for mTBI and negative imaging findings), with elevated rates of postconcussion symptoms and impaired health-related quality of life. At 6-month follow-up, despite improvement in psychological indices, nearly one-half of individuals with SR-TBI reported incomplete functional recovery based on GOSE ratings, with subgroups of mTBI reporting negligible changes from the initial 3-month follow-up. Interestingly, there were no significant differences in functional status ratings between groups with and without SR-TBI, although the SR-TBI group did show lower anxiety, depression and other symptom scores compared with the nonsports sample. Related research in adolescents comparing sport-related concussion (SRC) vs concussion due to motor vehicle accidents found that those in the latter group reported higher symptom burden and longer recovery times than those with SRC.4

The present study builds upon the research literature in 2 substantive ways. First, by leveraging samples from 18 countries, Ntikas et al were able to compare gross recovery outcomes between individuals with sport-related and non–sport-related brain injuries. Few studies have compared directly sport-related and non–sport-related TBI, and such a large and internationally diverse sample theoretically should enhance power to detect meaningful differences and generalize to broader populations. In addition, the authors tracked recovery outcomes over a longer interval than some similar investigations, which is important because recovery trajectories are not uniformly linear and may vary depending on a host of factors, including severity, cause, preexisting conditions, and timing of injury. That said, the finding of such high rates of incomplete recovery ratings among their SR-TBI cases was somewhat surprising, given that most studies of SRC tend to show better outcomes and less frequent lingering symptoms.1

In reviewing these findings, it is important to keep in mind that TBIs are not created equal, and even within the mild classification, there is heterogeneity. The mild spectrum has been described as concussion, or uncomplicated mTBI, and complicated mTBI, with the latter being associated with evidence of structural intracranial abnormality on neuroimaging. First, it is critical to note that the majority of individuals who sustain mTBI do not show abnormalities on conventional neuroimaging, and imaging is usually not considered to be indicated in most cases of concussion. This is an

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important distinction because individuals with complicated mTBI usually have greater impairments in the acute period⁵ and/or take longer to recover, with some being on par with more serious injuries.⁶ To this end, the most recent diagnostic criteria for mTBI suggest adding a qualifier to indicate the presence of intracranial injury as another factor to be considered in the assessment of severity.⁷ Consequently, it is challenging to make broad inferences to all mTBI (sport-related or non-sport-related) cases from studies using mTBI samples which include hospitalization and neuroimaging as inclusion criteria. In this study,⁵ in addition to the fact that all subjects underwent hospitalization for their injury, 52% of the SR-TBI group had abnormal computed tomography findings, suggesting that their sample had a more serious injury than what is seen in typical SRC cases. The authors were able to leverage their large sample to examine and compare recovery based on functional ability ratings in a subgroup of mTBI with negative computed tomography findings and found a similar result of no differences in rates of functional impairment between the groups, but these patients, too, presumably were thought to have injuries serious enough to warrant hospitalization. Another limitation is the age of the SR-TBI group, which had a mean of almost 40 years. Such factors may make this overall sample nonrepresentative of most SRC or head injury in sport cases. Nevertheless, the findings are important to consider for similar adult cases of mTBI which are hospitalized and undergo neuroimaging as part of the diagnostic workup, as symptoms and rates of reported functional limitations may be higher in this subgroup, which merits further investigation.

Another limiting factor in generalizing results of the current study to SRC more broadly is the use of the GOSE as the primary outcome measure. The original iteration of the instrument was developed to assess disability in severe TBI but was later expanded to include functional categories dichotomized into upper and lower ranges. Although it remains popular in some clinical and research (particularly rehabilitation) settings, it has been used less often in SRC, where recovery for the majority of patients tends to occur rather completely within a few days to weeks and persistent disability is relatively rare.¹ The GOSE is a rather crude categorical rating scale (ie, ranging from dead to upper good recovery) and is not designed to assess lingering mTBI symptoms or associated problems; thus, it lacks sensitivity in the milder ranges of disability. The authors acknowledge the importance of characterizing what abilities are affected and the extent to which they are limited, but such information is beyond the scope of the GOSE.

Over the last 2 decades, concussion has received considerable attention regarding both acute and potential long-term consequences. Although most patients show good recovery after mTBI, a minority report lingering symptoms. Just as research supports early exercise as helpful in mTBI recovery and too much rest may be associated with protracted recovery, investigations are under way to identify objective biomarkers that may contribute to our understanding of the mechanisms, diagnosis, and prognosis of mTBI. Additionally, by applying sophisticated statistical models to big data in this area, researchers can begin to disentangle the complex relationships among prognostic factors to improve precision in risk assessment and recovery prediction. These emerging technologies and statistical methods have the potential to advance the field and lead to development of novel measures that inform concussion management protocols and promote optimal recovery from mTBI, while also beginning to help identify individuals who may be at a greater risk for negative outcomes.
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