The challenge of matching across ages

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There are many diseases and treatments encountered by the pediatric neurosurgeon and other brain-based specialists that may affect patients differently depending on age. It is well accepted that radiation is more harmful in the youngest children, while recovery from focal deficits such as those to language networks is more difficult in the older child or adolescent than in preschool children. Whether children do “better” or “worse” or are more or less vulnerable to traumatic brain injury has been the subject of much discussion, and, as in most things, the answers remain contradictory, depending on the specific question being asked, the type of injury being studied, and the data being used to find an answer. This is the case as well for the currently intensely scrutinized topic of sports-related concussion (SRC) spectrum injuries.

Concussion provides a particular challenge for analysis because its definitions are not uniform, its diagnosis is not standardized, and its main method of determination in the context of sports is a self-report of subjective symptoms. Thus, any factors that might influence the degree or timing of symptom reporting may introduce differences in diagnosis and analysis of when the symptoms have resolved and, thus, whether one age is designated as “more vulnerable” than another to the effects of injury. Additionally, while the two age ranges compared reflect our educational system parameters (secondary vs postsecondary groups), there is no particular inherent neurobiological reason that these groupings are those most likely to have different effects from concussion-type injury. It is likely that a variety of host factors—genetic, developmental, and morphological—all may play a role.

By controlling for a number of potentially important variables in the present study, Lee et al. have improved significantly on much of the available literature on the question of age and concussion effects. They retrospectively compared data from a commonly used computer-based cognitive evaluation and symptom checklist completed by 92 athletes aged 13–16 years and 92 athletes aged 18–22 years who were matched for prior concussions, sex, and other premorbid factors in order to assess whether there was a difference in the number and degree of postconcussion symptoms and time to resolution. The study is also unique and important in that 56.5% of the patients in each group were female athletes, often a factor not considered in this field. Contrary to a commonly quoted idea that “younger athletes are more vulnerable to concussion,” Lee et al. found no differences between age groups. This study improves on several others published because of the complete data sets, careful inclusion and exclusion criteria, and matched cohorts.

Nonetheless, demonstrating how difficult it is to match on every potentially confounding variable, the authors also matched individuals for mean number of days from injury to the first postinjury ImPACT test, but the second ImPACT test was administered, on average, more than 1 day later in the younger group compared to the older group (9.93 days vs 8.63 days [see Table 6]). Thus, because days until return to baseline symptoms—the main outcome measure—were determined by these results, it is not altogether surprising that the younger group would register a longer duration to symptom resolution, although this was not statistically significant (6.92 days vs 5.66 days [Table 6]). In practice, these differences in timing of postinjury testing likely reflect the fact that many secondary schools (especially pre–high school) have very low numbers of trainers compared to college and likely have much smaller athletics budgets and personnel; thus, younger athletes may not have as much regular access or motivation to take serial ImPACT tests within the more condensed time frame offered in many college athletics programs. These are the kinds of methodological difficulties researchers face when comparing age groups in research of this type, and the authors are to be congratulated for surmounting many of them in their study.

Other challenges researchers face in group comparisons of this type include the fact that the college athletes may comprise a more select group—a “shifted bell curve” compared with younger athletes—with respect to athletic ability, IQ, academic achievement, or other parameters that might affect neurocognitive reserve or selection for resistance to effects of injury. Additionally, while the two age ranges compared reflect our educational system parameters (secondary vs postsecondary groups), there is no particular inherent neurobiological reason that these groupings are those most likely to have different effects from concussion-type injury. It is likely that a variety of host factors—genetic, developmental, and morphological—all may play a role.

Finally, it is worth noting that there is some reason to suspect that diagnosed “concussion” per se may not be the only, or most important, “currency” of all parameters of brain injury in the sports context, including acute, subacute, and chronic effects. Rather, it may be that total number and magnitudes of impacts, perhaps superimposed on specific host vulnerabilities that are yet to be...
fully elucidated, are the most important determinant of what happens to contact athletes and will ultimately inform how we should best protect their brains.2
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Disclosure

The author reports no conflict of interest.

References


Response

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We are grateful for the thoughtful editorial by Dr. Duhaime. Her expertise in pediatric traumatic brain injury (TBI) and mild TBI adds invaluable perspective to our original research.

Predicting outcomes after severe TBI, a disease process with incontrovertible imaging requirements, is difficult and variable. Delving into the world of SRC, an injury devoid of strict imaging criteria, in which diagnosis is driven by signs and symptoms, enters an area rife with controversy. Neurocognitive testing and RCI methodology are some of the strongest weapons we have in our arsenal to bring standardization and reproducibility to an already gray area.

As Dr. Duhaime points out, one of the strengths of our study is the rigorous matching criteria. Athletes were matched based on age, sex, number of prior concussions, and days to first postconcussion ImPACT test—all factors with potential to modify outcomes. However, as mentioned by Dr. Duhaime, the second postconcussion test date was administered 1.3 days later for the younger group, which brings to light a limitation of the real-world, clinical nature of our study. Our project was not a prospective analysis in which patients returned to clinic on predetermined dates, as done in other studies.2 Rather, patients were seen based on the athlete’s and physician’s schedule availability. Moreover, in our particular case, the Vanderbilt Sports Concussion Center evaluates athletes from nearly 25 high schools, some up to 40 miles from campus. Distance, especially in athletes too young or without the means to drive, can be a significant barrier to care. As Dr. Duhaime further discusses, differences between collegiate and high school staff size, availability of athletic trainers, and budgets pose methodological challenges when comparing disparate age groups. Ideally, one of our main outcome measures—the number of days until symptoms resolved to baseline status—would have been perfectly matched in terms of the time to second test administration. However, despite our best efforts, we were unable to obtain precision. Nevertheless, there was no statistically significant difference between the age groups and number of days to return to symptom baseline. In the time since our article was submitted, the new Concussion In Sport group guidelines have been published.2 Several recommendations regarding younger athletes were made, one of the most important being the impact of concussive injury on school performance. The post-SRC evaluation in young athletes requires input from patient, parent, teacher, and other school personnel.2 School attendance and extracurricular activities are often modified to avoid symptom exacerbation.2 Our study did not include any school- or parent-related information. One potential area of future investigation is to correlate an athlete’s school and neurocognitive performance after SRC. How are an athlete’s grades affected after an SRC? Does her attention capacity decrease? Does his school behavior change? The interrelationships of these (and other) variables are fruitful areas for further research.

Lastly, the most recent Concussion In Sport statement closes the age section by concluding, “Because of the different physiological response and longer recovery after concussion...a more conservative return to play approach is recommended...Concussion modifiers apply even more to this population than adults and may mandate more cautious [return to play] advice.” We hope that our study can add a small piece to the broader evaluation and treatment of youth athletes after SRC. It appears that symptoms may not be as prominent a driver when assessing differences in SRC outcomes based on age. Some of our prior work indicated that neurocognitive differences may be the more sensitive predictor of age disparities following SRC.3

We thank Dr. Duhaime for taking the time to broaden the discussion of our article. Her comments have added important context and useful directions for future research.

Disclosure

Dr. Solomon reports being a consultant for ImPACT.

References


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