The Pediatric Athlete: Younger Athletes with Sport-Related Concussion

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KEYWORDS

• Concussion • Mild traumatic brain injury • Head injury
• Trauma • Injury • Sports

Most athletes involved in organized sports participation are pediatric athletes.[1] Approximately 25% of pediatric concussions presenting to emergency departments occur during athletic activity.[2] Fortunately, much of the published medical investigations were conducted in high-school and college athletes, therefore offering physicians some insight into the mechanisms, signs, symptoms, assessment, and management of a pediatric athlete who sustains a sport-related concussion (SRC).

Very little data regarding SRC, however, have been published in pre–high-school–aged athletes.[3] This situation is concerning because the human brain continues to develop into young adulthood. The effects of concussive brain injury on the developing brain are not well understood. There is both scientific and clinical evidence that traumatic brain injury (TBI) in children differs from that in adults. In addition, children and adults differ in the role played by sports participation in their lives, the amount of knowledge they are expected to acquire on a daily basis, and the frequency with which their cognitive function is assessed or tested.[4] Therefore, the recommendations

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for managing young athletes with concussion differ from those of adults. This article discusses the differences between pediatric and adult athletes who sustain SRCs.

EPIDEMIOLOGY

Concussion accounts for approximately 9% of all high-school athletic injuries.[5] The rates of SRCs are highest in contact and collision sports.[5–7] Most athletes engaged in such sports are younger than 19 years,[1] making concussion a major concern for clinicians caring for young athletes. Of all pediatric concussions presenting to the emergency departments, approximately 25% occur during sports.[2] Many athletes with SRCs do not present to an emergency department or seek medical attention.[7–9] Surveys of the general population suggest that a higher percentage of concussions are due to athletics, with some studies suggesting that more than 85% of concussions in 16- to 34-year-old people are related to sports.[10]

MECHANISM/BIOMECHANICS

The biomechanics of concussive injury differs between adult and pediatric patients. Factors including differences in relative size of the head compared with the rest of the body, brain water content, vasculature, degree of myelination, and shape of the skull account for the biomechanical differences.[3,4,11,12]

Concussion is caused primarily by a rotational acceleration of the brain.[13–15] Clinicians have hypothesized that increasing both the cervical muscle strength and tone at the time of impact can reduce the risk of concussion by increasing the effective mass of the head, which becomes more of a unit with the rest of the body as the neck muscles strengthen. This, in turn, reduces the resultant acceleration for a given force.[1,16] This difference in neck strength has biomechanical effects, shown both experimentally in animals and clinically in children.[17] Recent evidence supports this hypothesis.[18] Given the relatively weak cervical muscle strength compared with their older counterparts, younger athletes might be at increased risk for concussion when hit with the same magnitude of force. Of course, as other investigators have pointed out, this same decrease in muscle strength may result in less force delivered by the striking athlete at the time of injury, thereby decreasing the risk of injury.[5]

Countering this hypothesis, biomechanicians have demonstrated that greater force is required to cause similar concussive injury in smaller brains than in larger brains with greater mass.[11,17] Thus, it has been suggested that children symptomatic after a concussion have sustained greater force than an adult with similar postconcussive symptoms.[4] This would suggest that the weaker neck muscles and larger head may be a more important issue than the overall small size of the athlete because these weaker forces are disproportionately applied to the brain.

Clinically, the different effects of age on head injury have been investigated. An analysis by Berney and colleagues[19] revealed that children younger than 3 years sustained head injuries associated with lower energy mechanisms and more skull fractures, subdural hematomas, and early seizures than their older counterparts. They were also less likely to lose consciousness than older children. Those children aged 3 to 9 years sustained head injuries after higher energy mechanisms, were more likely to lose consciousness, were more often comatose, had less subdural hemorrhages, and had more significant cerebral edema. Injuries sustained by children older than 9 years were more like adult injuries with high energy mechanisms and more extradural hematomas. These age-dependent injury patterns warrant further investigation into the possible differences in concussive brain injury between patients of varying ages.