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Additional Questions for the Record

The Honorable Lee Terry

1. **You mentioned that little research has been done on the frequency of concussions in athletes younger than high school. How would you propose a study collecting this information?**

   Partially in response to the finding that there are a lack of data on the occurrence of concussions in pre-high-school-age youth, the committee recommended that the Centers for Disease Control and Prevention, taking account of existing surveillance systems and relevant federal data collection efforts, establish and oversee a national surveillance system to accurately determine the incidence of sports-related concussions, including those in youth ages 5 to 21 (see recommendation 1, p. 286). The recommendation goes on to describe the types of data that should be collected as part of this surveillance system, but the committee did not comment specifically on *how* these data should be collected. The committee is not able to provide this type of guidance at this point because it has disbanded. In keeping with the committee's suggestion that existing surveillance systems and data collection efforts be taken into account, it may be worth hearing from individuals who have been involved with research on concussions in younger populations of youth about what has and has not been effective in terms of study design and data collection. Two such efforts that are briefly mentioned in the committee's report (see top of page 37) were a 2011-2012 Middle School RIO study that collected injury data from a national sample of middle school and Pop Warner football players (Middle School RIO™, 2013) and a 2-year USA Football study (2012 and 2013 seasons) of 10 youth football leagues in six states (USA Football, 2013). The data were collected by the Datalys Center for Sports Injury Research and Prevention (http://datalyscenter.org/). Additional studies may now be underway.

2. **The Committee on Sports Related Concussions in Youth recommends that NIH and DOD support research to establish metrics and markers of concussion diagnosis, prognosis, and recovery in youth. What are your ideal metrics and markers?**

   Given the absence of a diagnostic test or biomarker for concussion, diagnosis of concussion and monitoring of recovery is based largely on symptoms (physical, cognitive, emotional, sleep-related) reported by the individual. The diagnosis and management of concussion may be complicated if athletes misreport their symptoms. A further drawback to relying primarily on symptom reporting to identify concussion is that symptoms may not become apparent for hours or even days after injury. The use of multiple evaluation tools (e.g., combining symptom scales and checklists, balance testing, and neurocognitive testing) may increase the sensitivity and specificity of concussion identification, although at the time of the committee's report, evidence was insufficient to determine the best combination of measures. In addition, as is described in the report, studies of the effectiveness of neurocognitive tests to predict diagnosis and track recovery have had mixed results, and an individual's performance on these tests may be influenced by many factors. In response to these findings, the committee recommended that NIH and DOD support research to establish objective, sensitive, and specific metrics and markers of concussion diagnosis, prognosis, and recovery (see Recommendation 2, p. 287). The committee did not, and cannot at this time, suggest what these metrics and markers should be, but the report discusses advanced imaging techniques and serum biomarkers as tools that may be used in the future to aid in concussion diagnosis and management. Newer imaging techniques (e.g., magnetic resonance spectroscopy, positron emission tomography, functional magnetic resonance imaging, diffusion tensor imaging) had not yet been validated for clinical use at the time of the committee's report, although this is an ongoing area of study. Similarly, appropriately sensitive and specific serum biomarkers could be of great diagnostic and prognostic value in the future, but there was no evidence to support their use at the time of the committee's report. With respect to neurocognitive tests, the committee found that additional research is needed to provide more accurate and valid information about the relation of test scores to impairment following concussion.

3. **You stated that "[c]urrent testing standards and rating systems for protective equipment do not incorporate measures of rotational head acceleration or velocity and therefore do not comprehensively evaluate a particular device's ability to mitigate concussion risk."**

   a. **Does this imply that current helmet testing standards should not be relied upon in evaluating equipment choice?**

      At the time of the committee's report, helmet testing standards did not incorporate a measure of rotational acceleration, nor did they include a protocol to probe the ability of a helmet to mitigate rotational forces that have been shown to cause concussions. Due to the decoupling of linear and

rotational acceleration under certain impact conditions that occur in sports, a reduction in linear acceleration alone does not necessarily translate into a reduced concussion risk. The committee therefore found that current testing standards do not comprehensively evaluate a particular device's ability to mitigate concussion risk. Current testing standards do evaluate a helmet's ability to mitigate skull fracture and other serious head injuries and thus may be used in choosing a helmet.

b. Is there an effective test for rotational head acceleration?

As is noted in the committee's report (p. 250), NOCSAE has research underway to develop a test protocol incorporating both linear and rotational loading modes. Following the release of the committee's report, NOCSAE issued a proposed helmet testing standard that has a new testing method and a threshold of rotational acceleration below which all helmets must perform. The proposed standard will be open for comment until June 2015. At that time, if there are no revisions, NOCSAE's board is expected to vote to finalize the standard and require implementation by manufacturers by June 2016 (http://nocsae.org/wp-content/uploads/2011/10/NOCSAE-June-Board-Meeting-release-FINAL-6-20-14.pdf). Because the committee is now disbanded, it cannot comment on the appropriateness of NOCSAE's proposed testing method or the threshold of rotational acceleration that will be used.

The Virginia Tech STAR evaluation system for helmets has been expanded to include hockey helmets. In this expansion, measures of rotational acceleration have been incorporated into the injury risk assessment. The researchers who developed the STAR evaluation system may be able to provide additional information on the testing methods and criteria.

c. What improvements would you recommend in order to improve the adequacy of the current testing standards and rating systems?

As described in the committee's report (p. 250), advances in helmet testing standards that incorporate new methods and new injury criteria that evaluate protection in both linear and rotational loading modes are needed. Injury criteria for concussion may vary by age and other factors, and injury criteria for youth remain elusive. As the report points out, we need to know what levels of linear and rotational acceleration helmets need to be below in order to minimize the risk of concussion in youth.