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A commentary for neuropsychologists on CDC's guideline on the diagnosis and management of mild traumatic brain injury among children

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Abstract

Objective: In 2018, the Centers for Disease Control Prevention (CDC) published an evidence-based guideline on the diagnosis and management of mild traumatic brain injury (mTBI) among children. This commentary summarizes the key recommendations in the CDC Pediatric mTBI Guideline most relevant for neuropsychologists and discusses research gaps and topics that should receive attention in future iterations of the Guideline.

Method: We described the methods used to develop the Guideline, which included a comprehensive Systematic Review. We also distilled and presented key practice strategies reflected in Guideline.

Results: To optimize care of pediatric patients with mTBI, neuropsychologists should: use validated, age-appropriate symptom scales, assess evidence-based risk factors for prolonged recovery, provide patients with instructions on return to activity customized to their symptoms, and counsel patients to return gradually to nonsports activities after a short period of rest. Future iterations of the Guideline should encompass a review and guidance on care of patients with

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psychiatric and psychological difficulties, as well as the potential use of imaging to assess patients with persistent symptoms. Expanded research on mTBI among girls, children age 8 and under, and effective treatments for pediatric mTBI will be beneficial to inform care practices.

Conclusions: Recommendations in the CDC Pediatric mTBI Guideline highlight multiple opportunities for neuropsychologists to take action to improve the care of young patients with mTBI and to advance research in the field. Multiple resources and tools are available to support implementation of these recommendations into clinical practice.

Keywords

Brain; injury; concussion; TBI; guideline

Background

The Centers for Disease Control and Prevention (CDC) estimates that more than 800,000 children age 17 and under receive care for traumatic brain injury (TBI) in U.S. emergency departments each year (Peterson, Xu, Daugherty, & Breiding, 2019). Approximately 75% of TBIs that occur each year in the U.S. are classified as mild traumatic brain injuries (mTBI) (National Center for Injury Prevention and Control, 2003). Caused by an impact to the head or body that results in translational, rotational, or angular acceleration and deceleration forces to the brain, an mTBI is believed to be associated with neuronal dysfunction involving a cascade of ionic, metabolic, and physiologic events (Giza & Hovda, 2014; Graham, Rivara, Ford, & Spicer, 2014; McAllister, Sparling, Flashman, & Saykin, 2001; Meaney & Smith, 2011). This cascade, as well as microscopic axonal dysfunction, may lead to acute clinical signs and symptoms (Giza & Hovda, 2014). Signs and symptoms of mTBI generally fall into four categories: somatic symptoms (e.g. headache, nausea), changes in behavior and emotional functioning (e.g. irritability, sadness), cognitive symptoms (e.g. complaints of difficulty concentrating or slowed reaction time, which may or may not be reflected by performance on standardized cognitive testing), and sleep problems (e.g. sleeping more than usual, trouble falling asleep) (Centers for Disease Control and Prevention, 2017). In most cases, the physiological changes and resulting signs and symptoms will resolve, and the majority of patients will have a good recovery over time (Babikian et al., 2011; Barlow et al., 2010; Davis, Anderson, et al., 2017; Yeates et al., 2009).

Expanding research and media reports, among other factors, have led to significant attention on mTBI—especially among children and athletes (Graham et al., 2014; Sarmiento, Donnell, & Hoffman, 2017). Coinciding with this, widespread usage of concussion education programs, implementation of concussion protocols by schools and sports programs, and the passage of laws regarding concussion in youth sports in all 50 states and the District of Columbia has occurred over the last decade (Harvey, 2013; Harvey, Koller, & Lowrey, 2015). Due to the large and growing body of information about mTBI, healthcare providers may struggle to distinguish between highly promoted versus truly evidence-based practices related to the care of young patients with mTBI. A quick Internet search on mTBI yields reports and links to hundreds of products and tools promoting the ability to improve mTBI diagnosis and care. Uncertainty among healthcare providers about clinical best

practices has also been reported (Arbogast et al., 2017; Sarmiento, Donnell, Hoffman, & Tennant, 2018). A CDC study that assessed healthcare providers' attitudes and behaviors related to pediatric mTBI found that less than half of the participants (44.4%) felt "very prepared" to make decisions about mTBI management, such as when a pediatric patient can safely return to activities (e.g. school and sports) (Sarmiento et al., 2018). When healthcare providers in the study were asked how often they use screening or assessment tools to help evaluate pediatric patients with mTBI, more than half reported that they "seldom" or "never" use those resources (24.6% and 22.0%, respectively) (Sarmiento et al., 2018). These findings suggest that many providers may feel ill-equipped to assess and manage mTBI and uncertain about what tools are available for tracking recovery (Sarmiento et al., 2018).

Thus, to provide a consistent and comprehensive picture of the diagnosis and management of pediatric mTBI based on the current state of the science, CDC embarked on a large-scale effort to summarize the existing research and create an evidencebased guideline to optimize the care of young patients with this injury. CDC published the Pediatric mTBI Guideline and Systematic Review in September 2018 (Lumba-Brown et al., 2018). This commentary describes the conduct of the Systematic Review and development of the resultant guideline. In addition, we distilled the key implications for clinical neuropsychologists related to the diagnosis, prognosis, and management and treatment of mTBI and highlighted topics that should receive attention in future iterations of the guideline.

Methods

To develop this commentary we first considered the systematic review and resultant CDC Pediatric mTBI Guideline. Topics covered in this commentary were identified in light of those documents, and also based on identified information gaps in the literature, common topics covered in guidelines and protocols for neuropsychologists, and the authors' expert insights into the critical issues facing neuropsychologists.

The CDC Pediatric mTBI Guideline is based on a comprehensive review and analysis of the scientific literature, public comment, peer-review, and feedback from medical societies and experts in the field. Despite being a common neurological disorder, no single definition for mTBI is universally accepted. Adding to the complexity, the terms concussion and mTBI are often used interchangeably throughout the scientific literature. Presently, no consensus exists on the definition for concussion or mTBI or whether these terms describe the same or different conditions. The American Congress of Rehabilitation Medicine (American Congress of Rehabilitation Medicine, 1993), American Academy of Neurology (American Academy of Neurology, 1997), American Academy of Pediatrics (American Academy of Pediatrics, 1999), World Health Organization (Carroll, Cassidy, Holmquist, Krause, & Coronado, 2004), CDC (National Center for Injury Prevention and Control, 2003), and the Concussion in Sport Group (McCrory et al., 2017) have all issued definitions for concussion and mTBI. Primarily these definitions are based on research on adults with mTBI (Kirkwood et al., 2008). Initially, definitions of mTBI focused on loss of consciousness, confusion, amnesia, and vomiting as sentinel indicators of mTBI. However, as research evolved, later definitions of mTBI encompassed a broader range of clinical symptoms or neurological impairment. Recognizing the heterogeneity of presentations and outcomes of children with

mTBI, the Guideline authors used a broad definition. As such, the CDC Pediatric mTBI Guideline defines mTBI to be inclusive of patients with, “Glasgow Coma Scale (GCS) scores of 13 to 15 with or without the complication of intracranial injury (ICI) on neuroimaging, and regardless of potentially requiring a hospital admission and/or neurosurgical intervention” (Lumba-Brown et al., 2018). The inclusion of patients who required hospital admission or neurosurgical intervention prevented the exclusion of children representing the more severe end of the mTBI spectrum. This is an expansion from other mTBI definitions in the published literature.

The literature search strategy was based on six clinical questions (Table 1). These questions spanned issues related to diagnosis and risk factors for ICI to factors that increase the risk for long-term sequelae and effective treatment strategies. The literature search focused exclusively on the pediatric population, defined as children birth to age 18 years, and included peer-reviewed studies published between 1990 and 2015.

Of the more than 37,000 abstracts identified and reviewed through the literature search, approximately 2,900 articles met the inclusion criteria for full-text review described in Lumba-Brown et al. (2018). Following full-text review, 345 articles were selected and deemed sufficiently relevant for data extraction. The data from these articles were analyzed and compiled into evidence tables. To judge overall confidence in the evidence, the authors used a modified Grading of Recommendations, Assessment, Development and Evaluations (GRADE) methodology. This process explicitly considered the risk of bias in individual studies (Class of evidence), consistency between studies, precision, directness, and magnitude of effect relative to the risk of bias, presence of an expected dose-response relationship, and the direction of bias (Gronseth & Getchius, 2011). Ultimately, 66 studies met the rigorous inclusion criteria and were included in the text of the Systematic Review that formed the basis of the Guideline. Further details on the methodology used to developed the guideline can be found in Lumba-Brown et al (Lumba-Brown et al., 2018). The CDC Pediatric mTBI Guideline consists of 19 clinical recommendation sets that cover diagnosis, prognosis, and management and treatment. These recommendations are applicable to healthcare providers working in a variety of settings, including inpatient, emergency, primary, and outpatient care settings.

Results

Below is a discussion of actions outlined in the CDC Pediatric mTBI Guideline that neuropsychologists can take to optimize the care of their pediatric patients with mTBI (Table 2).

Diagnosis

Diagnosing an mTBI can be challenging, as “postconcussive” symptoms are nonspecific and can occur without any injury at all, as part of an individual’s typical experience (e.g. feeling fatigued, inattentive, forgetful) (Asken, Snyder, Smith, Zaremski, & Bauer, 2017; Iverson et al., 2015). In addition, some post-concussive symptoms are shared with other possible co-occurring conditions including post-traumatic stress, depression, dehydration, pain, and headache (Lagarde et al., 2014). Given neuropsychologists’ expertise in brain-behavior

relationships and training in the use of psychological, neurological, cognitive, and behavioral tools, they are well-positioned to assist with distinguishing between preexisting and post-concussion-related symptoms and ensuring an accurate diagnosis (Echemendia & Gioia, 2018; Kirkwood et al., 2008; Plourde, Brooks, Kirkwood, & Yeates, 2018). In the acute period, diagnostic evaluation of pediatric patients with suspected mTBI often encompasses assessment of the following factors: characteristics and circumstances of the injury; symptom type, severity, and timing; and risk factors for prolonged recovery, as discussed below (Bazarian et al., 2019). The CDC Pediatric mTBI Guideline recommends the use of age-appropriate, validated symptom rating scales (Lumba-Brown et al., 2018) and several symptom-based tools are available for use by neuropsychologists. Examples of validated symptom scales that assess symptom type and severity include, but are not limited to, the: Post-Concussion Symptom Inventory (embedded within Acute Concussion Evaluation) (Gioia, Collins, & Isquith, 2008; Schatz, Pardini, Lovell, Collins, & Podell, 2006), Health and Behavior Inventory (Gioia, Schneider, Vaughan, & Isquith, 2009) (HBI; embedded in the Child-Sport Concussion Assessment Tool, SCAT (Davis, Purcell, et al., 2017; Nelson, Loman, LaRoche, Furger, & McCrea, 2017), and Post-Concussion Symptom Scale (Gioia et al., 2009). Recommended usage by age group and timeframe following mTBI vary among these tools (Echemendia & Gioia, 2018). Echemendia and Gioia (2018) examined the strengths and weaknesses of neuropsychological assessments, including traditional paper-and-pencil testing and computer-administered tests (Echemendia & Gioia, 2018). Neuropsychologists should understand the limitations of all of these tools, as further validation for the purposes of diagnosing mTBI is needed. While these tools vary in their strengths and their results can be affected by a variety of factors, such as the testing venue (e.g. noise, distractions) and fatigue (e.g. sleep disturbance, time of day), there is consensus that neuropsychologists are uniquely qualified to interpret these tests (Echemendia & Gioia, 2018; Giza et al., 2013; Lumba-Brown et al., 2018; McCrory et al., 2017).

The Standardized Assessment of Concussion (SAC) is a commonly used tool for on-field assessments for sports-related mTBI for older teens and young adults (McCrea et al., 1998). The SAC is intended for use as a brief tool to assess mental status during the acute phase of mTBI. It is not a comprehensive neurocognitive assessment, and as such, should not be used as the sole diagnostic tool to diagnose mTBI. Importantly, the sensitivity of the SAC decreases after 48–72 hours and should not be used beyond that point to track recovery (Grubenhoff, Kirkwood, Gao, Deakyne, & Wathen, 2010). The Child-SCAT is used for the on-field assessment of sports-related mTBI among children aged 5–12 years (Davis, Anderson, et al., 2017; Davis, Purcell, et al., 2017). The Child-SCAT assesses mTBI signs and symptoms, motor/vestibular functions, orientation, neurologic signs, and cognition, as well as signs of deteriorating neurologic dysfunction that should prompt emergency evaluation (Davis, Anderson, et al., 2017; Davis, Purcell, et al., 2017). Recently several studies have explored baseline normative values of the Child-SCAT, which includes the SAC-Child, HBI, and balance testing (Balance Error Scoring System, BESS) (Chin, Nelson, Barr, McCrory, & McCrea, 2016; Downey, Hutchison, & Comper, 2018; Nelson et al., 2017; Yengo-Kahn et al., 2016).

Prognosis

Neuropsychologists can more effectively counsel patients with mTBI when they have assessed risk factors for outcome and recovery. Though no single factor is strongly predictive of outcome, neuropsychologists should screen for known risk factors of prolonged recovery to aid in providing counseling to patients and families (Lumba-Brown et al., 2018). Examples of risk factors associated with prolonged recovery, include: older age (i.e. adolescent vs. younger child) (Barlow et al., 2010; Chrisman, Rivara, Schiff, Zhou, & Comstock, 2013; Zonfrillo et al., 2014); lower socioeconomic status (Olsson et al., 2013); more severe presentation of mTBI, including intracranial hemorrhage (Barlow et al., 2010; Levin et al., 2008); higher levels of acute postconcussive symptoms (Barlow et al., 2010); lower cognitive ability (Fay et al., 2010); family and social stressors (Olsson et al., 2013), and female sex (Covassin, Elbin, Larson, & Kontos, 2012). Neuropsychologists may assess the social supports already present in the child's life, including people who provide emotional support, problem-solving advice, constructive feedback, and positive affirmations (McCauley, Boake, Levin, Contant, & Song, 2001; Mittenberg, Canyock, Condit, & Patton, 2001). Social support may be emphasized as a key element of recovery when educating families and school professionals who will be interacting with the child during recovery (Iverson & Gioia, 2016; Kirkwood et al., 2008).

Management and treatment

The speed and success of a child's recovery from mTBI is likely to depend on appropriate management of their injury. Neuropsychologists should counsel patients and their families that nearly all children who sustain mTBI will recover by 1–3 months (Barlow et al., 2010). Patient and family education about mTBI, symptom monitoring, graded return to activity shortly after the injury, and modified school activities are associated with improved health outcomes for patients with mTBI (Arbogast et al., 2017; Lumba-Brown et al., 2018; Zemek et al., 2016; Zuckerbraun, Atabaki, Collins, Thomas, & Gioia, 2014). The CDC Pediatric mTBI Guideline recommends that healthcare providers provide assurance and instructions to the family that is inclusive of warning signs for more severe injury, symptom monitoring tips, the return to activity process (such as return to school and sport), and when to follow up for additional care (Centers for Disease Control and Prevention, 2018a). Both oral and written instructions may be beneficial.

Tracking recovery over time is a key role for the neuropsychologist—especially for children determined to be at high risk for persistent symptoms based on their premorbid history, demographics, or injury characteristics. No single assessment tool suffices to track recovery. Instead, neuropsychologists should use a combination of evidencebased tools (Lumba-Brown et al., 2018). These tools may include cognitive tests, balance tests, and validated symptom scales. The Guideline specifically recognizes that comprehensive neuropsychological evaluations (e.g. cognitive, social, behavioral assessments) can assist in determining the etiology of cognitive impairment and directing treatment for such impairment based on the patient's symptoms. In addition, neuropsychologists' multi-disciplinary training allows for the assessment of cognitive and emotional symptoms and their relationship to the physical/somatic and sleep problems that may be present (Plourde et al., 2018). Although guidance on when to conduct neuropsychological evaluation varies, an

abbreviated neuropsychological evaluation with pediatric patients who remain symptomatic 2-weeks post-injury is generally considered appropriate (Echemendia & Gioia, 2018; Kirkwood et al., 2008). In its guideline, CDC recommends that children with mTBI whose symptoms do not resolve as expected with standard care within 4–6 weeks be referred to an appropriate specialist for further assessments or interventions (Lumba-Brown et al., 2018), suggesting a longer waiting period for comprehensive neuropsychological evaluation.

Neuropsychologists should customize a child's return to activity based on their specific symptoms and level of severity. Children and their families should be counseled that acute symptoms of concussion may take 1–2 days to appear and ongoing symptoms can wax and wane over the expected short recovery period (Silverberg et al., 2016). Short-term increases in symptoms (or "symptom spikes") may occur in as many as a 30% of pediatric patients with concussion, but are not likely detrimental to the patient's recovery (Silverberg et al., 2016). Research suggests that symptom spikes are more common among pediatric patients with a high symptom burden immediately following the injury and are associated with a sharp increase in mental activity over the preceding 24 hours (e.g. returning to school and extracurricular activities relatively abruptly) (Silverberg et al., 2016). Emotional symptoms may be particularly challenging, as they can be present prior to the injury or appear later in time, likely as a psychological response to delayed recovery rather than as a direct consequence of injury (Brooks et al., 2019; Eisenberg, Meehan, & Mannix, 2014). Importantly, families need to be reassured that concussion symptoms will generally improve over time (Kirkwood et al., 2008); nonetheless, previous studies suggest that as many as a 25% of pediatric patient with mTBI experience psychological distress after concussion (Brooks et al., 2019). By providing oral and written education, reassurance about the likelihood of recovery, and helping pediatric patients and their families to understand the importance of post-injury care and behavior modification, patients will be better positioned to have positive health outcomes (Ponsford et al., 2001, 2002).

For the majority of children, their return to activity should be preceded by a brief period of rest (about 2–3 days) from physical and cognitive activities (Centers for Disease Control and Prevention, 2018a; Zemek et al., 2016). Too much rest beyond this period may worsen a child's symptoms and prolong recovery (Zemek et al., 2016). Children should be counseled about good sleep hygiene and advised to take brief naps during the day as needed, as long as they do not interfere with falling asleep at night (Centers for Disease Control and Prevention, 2018b). They should avoid activities that put them at risk for another injury to the head and brain throughout the course of recovery (Centers for Disease Control and Prevention, 2018b; Giza et al., 2013; McCrory et al., 2017).

Within a few days, the child can begin cognitive and nonstrenuous physical activities that do not substantially exacerbate their symptoms (Zemek et al., 2016). This may include brisk walking for 15–20 minutes each day. During this time, parents should closely monitor their child's symptoms and any changes in severity, and report any concerns to their healthcare provider. Children should be encouraged to return to school after the brief period of initial rest (Halstead et al., 2013). Communication with the school regarding the types and severity of symptoms, as well as recommendations for student supports, is often indicated, and can be facilitated via a return-to-school letter (Centers for Disease Control and Prevention,

2018a, 2018b, 2018c; Zuckerbraun et al., 2014). Examples of such support include breaks and adjustments to the classroom workload to minimize worsening of symptoms while at school. Good communication with the school is essential to help make the school transition easier for the child (Halstead et al., 2013). Of note, some students will recover within a few days of their injury and will not need any school adjustments, although increased monitoring of these students remains important.

Educational supports should be adjusted on an ongoing basis until the student is able to engage in regular school activities without significant exacerbation of symptoms (i.e. has returned to their pre-injury status). Students who demonstrate persistent symptoms and academic difficulties despite an active treatment approach over a period of 4 to 6 weeks should be referred by their healthcare provider for a formal evaluation by a specialist in pediatric mTBI, such as a neuropsychologist (Lumba-Brown et al., 2018). School-based teams should also assess the educational needs of those students and determine their need for additional educational supports, including those described under pertinent federal statutes (Iverson & Gioia, 2016).

For children who have not shown symptomatic improvement, despite active treatment for 4–6 weeks, neuropsychologists may also recommend a Section 504 Plan. Section 504 Plans are implemented when students have a disability, temporary or permanent, which affects their academic performance (Office of the Assistant Secretary for Administration and Management, 1973). Of course, prior to developing a 504 for mTBI, neuropsychologists should help ensure that the student's difficulties are not better explained by factors such as depression, anxiety, symptom exaggeration/feigning, learning disability, or attention-deficit, hyperactivity disorder (ADHD), any of which might independently warrant a 504 (Halstead et al., 2013; Kirkwood et al., 2008). Educational services and accommodations for students may include environmental modifications (e.g. reduced light and sound), curriculum changes (reduced or targeted load), organizational changes (policy, practice pathways), behavioral interventions (reinforcing work production), and presentation strategies (e.g. paper materials versus smartboard for light-sensitive students) (Halstead et al., 2013; Iverson & Gioia, 2016).

When symptoms are mild and nearly gone, relative to pre-injury status, a child can return to most regular activities that are not high-risk for repeat head injury. At this point, children should return to a regular school schedule. The return to contact sports should only be initiated once the child has met all recovery criteria, having successfully returned to their pre-injury status in school, and after written healthcare clearance (McCrory et al., 2017). The Consensus Statement on Concussion in Sport describes a gradual, stepwise progression that should be followed to safely return an athlete to play (McCrory et al., 2017). The return to play progression is best completed using a team approach, overseen by a health professional who has worked with the athlete and knows the athlete's background and physical abilities (Giza et al., 2013; McCrory et al., 2017).

Sleep disturbances are common after mTBI and may lead to ongoing problems (Landry-Roy, Bernier, Gravel, & Beauchamp, 2017). Adequate sleep has been shown to improve overall health and should be an important part of treatment for children with mTBI. The CDC

Pediatric mTBI Guideline recommends providing patients and their families with guidance on proper sleep hygiene methods to facilitate recovery (Lumba-Brown et al., 2018). If sleep problems emerge or continue despite appropriate sleep hygiene measures, neuropsychologists may refer children with mTBI to a sleep disorder specialist for further assessment.

Problems with attention, memory and learning, response speed, and other cognitive abilities can occur following mTBI. These disturbances, albeit time limited in most cases, can result in significant problems with learning in school performance or social interactions (Arbogast et al., 2017). Neuropsychologists can play an important role in determining the etiology of cognitive dysfunction, within the context of other mTBI symptoms (e.g. headache or fatigue possibly impairing cognition) and recommending treatment that reflects its presumed etiology (Lumba-Brown et al., 2018). For example, as multifactorial causes are common, patients with persistent symptoms may benefit from a comprehensive neuropsychological evaluation that includes a clinical interview, assessment of preinjury symptoms and current functioning, cognitive testing covering a range of domains, assessments of social cognition and skills, adaptive skills, problem-solving, familial and academic functioning, and intellectual abilities (Plourde et al., 2018). Neuropsychological evaluation can provide critical value to the management of a pediatric patient with persistent symptoms, as treatment plans can be tailored to a patient's unique symptoms and may comprise behavioral interventions, such as cognitive behavioral therapy (Plourde et al., 2018).

Discussion

The CDC Pediatric mTBI Guideline and Systematic Review provide important information and guidance for neuropsychologists engaged in the assessment and management of children with mTBI, as well as those involved in research on this common injury. However, the Systematic Review also identified several important gaps in the knowledge base about mTBI, and the CDC Pediatric mTBI Guideline did not address all issues of import to neuropsychologists working with this population clinically. We hope presenting some of these gaps below will inspire further examination and create a springboard for future research and guideline efforts.

As previously described by McCrea and Manley (2018), few methodologically strong studies have focused on the clinical management of pediatric mTBI, such as treatments effective in facilitating recovery, maximizing functional outcome, and preventing long-term disability. Even some of the historically common management recommendations incorporated into return-to-learn and return-to-play protocols (e.g. limiting screen time) lack a firm evidence base and have the potential for iatrogenesis. Building an evidence base on treatment and management is critical to ensuring positive health outcomes for the thousands of children who sustain mTBI each year (McCrea & Manley, 2018).

In addition, among the more important knowledge gaps are the relative lack of research pertaining to girls and to younger children, especially those under age 8 (Suskauer et al., 2019). While the CDC Pediatric mTBI Guideline only included research on patients age 18 years and under, recent evidence suggests that further differentiation of care by age may be

beneficial (Davis, Anderson, et al., 2017; Davis, Purcell, et al., 2017; McCrory et al., 2017). A systematic review on sports-related concussion among children by Davis et al. recommends that, “Child-specific paradigms for sport-related concussion management should apply to children ages 5–12 years and adolescent-specific paradigms should apply to those ages 13–18 years” (Davis, Anderson, et al., 2017; Davis, Purcell, et al., 2017). In addition, the authors of that review called for further research to determine the roles of age and development on sports-related concussion management paradigms. Future iterations of the CDC guideline should take these issues into consideration.

The CDC guideline does not speak to all issues of relevance to clinical neuropsychologists, such as psychological responses to “persistent” mTBI and the risks of iatrogenesis. Moreover, the Guideline does not address the controversy about the utility of baseline testing, especially for children engaged in contact and collision sports. Other guidelines, including the most recent iteration of the Consensus Statement on Concussion in Sport (McCrory et al., 2017) and the Canadian Concussion in Sport Guideline (“Guidelines for assessment and management of sport-related concussion. Canadian Academy of Sport Medicine Concussion Committee,” 2000), have recommended that baseline testing not be employed routinely, especially with children, and is not required to provide post-injury care of those who sustain a suspected or diagnosed concussion, but acknowledge that baseline testing may be considered in some unique athlete populations and sport environments.

In the future, the CDC Pediatric mTBI Guideline will need to be updated to stay current with research and clinical practice. The Systematic Review was based on research published through 2015, and advances have occurred since then in a variety of domains. For example, since the publication of the Guideline, several studies have demonstrated vestibular/ocular-motor and autonomic abnormalities in children with mTBI (Anzalone et al., 2017; Hoffer et al., 2017; Moran, Covassin, Elbin, Gould, & Nogle, 2018; Whitney & Sparto, 2019; Yorke, Smith, Babcock, & Alsalaheen, 2017). Findings from these studies suggest the potential benefits of screening for vestibular/ocular-motor and autonomic dysfunction in diagnosing mTBI, as well as identifying those children at risk for prolonged recovery (Moran et al., 2018; Mucha et al., 2014; Yorke et al., 2017). Future iterations of the CDC Pediatric mTBI Guideline should seek to provide more guidance for neuropsychologists and others on the implementation and use of nontraditional tools as part of a comprehensive concussion assessment.

Concern also is emerging about psychiatric and psychological difficulties (e.g. ADHD, depression, anxiety) that can precede and possibly follow mTBI (Brent & Max, 2017; Ellis et al., 2015; Stazyk, DeMatteo, Moll, & Missiuna, 2017; Stein et al., 2017). Since the publication of the CDC Pediatric mTBI Guideline, for example, research has shown that somatization is correlated with the severity of postconcussive symptoms, although it does not clearly exacerbate the effects of mTBI versus other injuries (Perrine & Gibaldi, 2016). The CDC Pediatric mTBI Guideline recommends that healthcare providers provide assurance regarding the likelihood of a good recovery and the benefits of social support (McCauley et al., 2001). However, limited guidance is available for healthcare providers on assessing for and managing patients who experience psychiatric and psychological sequelae prior to or following their injury. In the meantime, neuropsychologists can play a critical role

in filling this information gap. By providing biopsychosocial evaluation and treatment services, such as cognitive restructuring and emotional reassurance early post injury, (Echemendia & Gioia, 2018; Giza et al., 2013; McCrory et al., 2017), neuropsychologists can assist in identifying and caring for patients in need of additional mental health support (Ellis et al., 2015).

mTBI is considered a clinical diagnosis and is not dependent on imaging (Kuppermann et al., 2009). The current CDC Pediatric mTBI Guideline recommends healthcare providers not routinely image a pediatric patient with suspected mTBI for diagnostic purposes (Lumba-Brown et al., 2018). This includes the use of CT, MRI, SPECT, and skull x-ray. Instead, to avoid unnecessary exposure to radiation (by using CT, for example) while balancing the importance of identifying children at risk for ICI, the Guideline recommends that validated decision rules, such as the Pediatric Emergency Care Applied Research Network (PECARN) decision rules, be used (Kuppermann et al., 2009). The PECARN decision rules evaluate for a variety of factors that, when assessed together, may increase the risk for more serious injury (Kuppermann et al., 2009). While neuropsychologists are generally not involved in decision-making regarding imaging during the acute period, some research suggests that advanced imaging may be beneficial in identifying pathologies not visible through standard imaging modalities such as CT scans (Keightley et al., 2014; Sinopoli et al., 2014). Due to the potential to assist with assessment of patient with persistent symptoms, imaging may play a role in assisting patients with return to activity in the future. As evidence is limited, advanced imaging modalities (e.g. functional MRI and diffusion tensor imaging) are not covered in the CDC Pediatric mTBI Guideline. However, advanced imaging modalities have positive and negative aspects that should be considered (Wintermark, Sanelli, Anzai, Tsiouris, & Whitlow, 2015). While recommended in other guidelines, the use of imaging to assess patients with persistent symptoms is also not addressed in the CDC guideline (Wintermark et al., 2015). As more research on these topics becomes available, further discussion on the use of imaging and its role in mTBI diagnosis and management may be beneficial for neuropsychologists and other healthcare providers.

CDC developed several tools for neuropsychologists and others to help support implementation of the Guideline's evidence-based recommendations into clinical practice. These tools include handouts for patients and their families ("Caring for Your Child's Concussion" and "How Can I Help My Child Recover After a Concussion"), as well as checklist for healthcare providers and a letter to share with the patient's school ("Returning to School After a Concussion"). To review and download these tools, visit: https://www.cdc.gov/HEADSUP.

Conclusion

Recommendations in the CDC Pediatric mTBI Guideline highlight multiple opportunities for neuropsychologists to take action to improve the care of young patients with this injury and to advance research in the field. In addition, multiple resources and tools are available to support implementation of these recommendations into clinical practice (Centers for Disease Control and Prevention, 2018a, 2018b). Still, as noted in this commentary, the CDC Pediatric mTBI Guideline will need to be updated to stay current with research and clinical

practice. Future iterations of the Guideline should encompass a review and guidance on care of patients with psychiatric and psychological difficulties, as well as the potential use of imaging to assess patients with persistent symptoms. In addition, the field should pursue expanded research on mTBI among girls, children age 8 and under, and effective treatments for pediatric mTBI (Davis, Anderson, et al., 2017; Davis, Purcell, et al., 2017; McCrea & Manley, 2018; Suskauer et al., 2019).

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Conflict of interest

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Table 1.

Clinical questions for the CDC pediatric mTBI guideline (Lumba-Brown et al., 2018).

1. For children (18 years of age and younger) with suspected mTBI, do specific tools, as compared with a reference standard, assist in accurately diagnosing mTBI?
2. For children (18 years of age and younger) presenting to the emergency department (or other acute care setting) with mTBI, how often does routine head imaging identify intracranial injury?
3. For children (18 years of age and younger) presenting to the emergency department (or other acute care setting) with mTBI, which features identify patients at risk for important intracranial injury (iICI)?
4. For children (18 years of age and younger) with mTBI, what factors identify patients at increased risk for ongoing impairment, more severe symptoms, or delayed recovery (< 1 year post-injury)?
5. For children (18 years of age and younger) with mTBI, which factors identify patients at increased risk of long-term (≥1 year) sequelae?
6. For children (18 years of age and younger) with mTBI (with ongoing symptoms), which treatments improve mTBI-related outcomes?

Table 2.

Summary of clinical recommendations contained in the CDC guideline relevant to neuropsychologists.

Summary of CDC pediatric mTBI guideline recommendations	Level of evidence[a]	Available resources to support implementation
DIAGNOSIS		
mTBI is a clinical diagnosis and is not dependent on imaging or skull X-rays.	B	PECARN decision rules (Kuppermann et al., 2009) Examples of validated assessment scales: (Gioia et al., 2009) • Post-Concussion Symptom Inventory • Health and Behavior Inventory • Post-Concussion Symptom Scale • Acute Concussion Evaluation
Validated decision rules assessing a combination of risk factors should be used to assess the likelihood of mTBI prior to obtaining head CT.	B	
Age-appropriate, validated postconcussive symptom rating scales should be used acutely to assist with diagnosis.	B	
The SAC should not be used exclusively to identify pediatric mTBI.	B	
Age-appropriate computerized cognitive testing may be used in the acute period.	C	
In cases of acutely worsening symptoms of headache, especially in the setting of other risk factors, consider emergent neuroimaging to assess for more severe intracranial injuries.	B	
Insufficient evidence supports the routine use of MRI, SPECT, or serum biomarkers for diagnostic purposes.	B, B, R (respectively)	
PROGNOSIS		
Healthcare providers should counsel patients/families that the large majority of children who sustain mTBI will recover by 1–3 months.	B	CDC HEADS UP handouts: • “Caring for Your Child’s Concussion” (Centers for Disease Control and Prevention, 2018a) • “How Can I Help My Child Recover After a Concussion” (Centers for Disease Control and Prevention, 2018b)
Premorbid history should be assessed because recovery might be delayed in those with:	B	
• history of mTBI		
• increased pre-injury “postconcussive” symptoms		
• pre-injury neurological or psychiatric disorder		
• learning difficulties		
• lower cognitive ability		
• family and social stressors		
Though no single factor is strongly predictive of outcome, providers should screen for known risk factors of prolonged recovery to aid in providing counseling to patients and families. Prolonged recovery is associated with the following risk factors:	B	

Summary of CDC pediatric mTBI guideline recommendations	Level of evidence[a]	Available resources to support implementation
• older ages (i.e. adolescence)		
• Hispanic ethnicity		
• lower socioeconomic status		
• more severe presentation of mTBI, including intracranial hemorrhage		
• higher levels of acute postconcussive symptoms		
• female sex		
MANAGEMENT AND TREATMENT		
A combination of tools should be used to monitor recovery including age-appropriate, validated postconcussive symptom rating scales.	B	CDC HEADS UP handouts: • "Caring for Your Child's Concussion" (Centers for Disease Control and Prevention, 2018a) • "How Can I Help My Child Recover After a Concussion" (Centers for Disease Control and Prevention, 2018b) Consensus Statement on Concussion in Sport (McCrory et al., 2017)
Validated cognitive and balance tests may be used.	C	
Healthcare providers should encourage some restriction on activities in the first few days after mTBI, but then encourage activities (including school) that do not significantly exacerbate symptoms. An active rehabilitation program should be offered thereafter as needed.	B	
Patients should be cleared to return to all activities when they return to their pre-injury status.	B	
Educational supports should be adjusted on an ongoing basis until the patient has returned to pre-injury levels.	B	
Patients who demonstrate prolonged symptoms and academic difficulties should be referred for evaluation by a specialist in pediatric mTBI.	B	
Chronic headache following mTBI is likely multifactorial, so providers should refer for multidisciplinary evaluation and treatment, with consideration of analgesic overuse.	B	
Healthcare providers should give recommendations for sleep hygiene to facilitate recovery.	B	
Understanding the etiology of cognitive dysfunction after mTBI is important in determining appropriate treatment and management.	B	
Neuropsychological evaluation can assist in determining etiology of cognitive dysfunction and directing treatment.	C	

[a]Through the modified GRADE process, CDC assigned one of the action levels to each recommendation: Level A: (Must do) Almost all patients in almost all circumstances would want the recommendation followed; Level B: (Should/Should not do) Most patients in most circumstances would want the recommendation followed; Level C: (May do) Some patients in some circumstances would want the recommendation followed; Level R: Do only in a research setting.