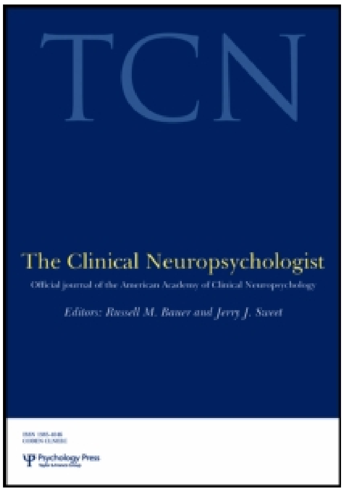

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Management of Pediatric Mild Traumatic Brain Injury: A Neuropsychological Review From Injury Through Recovery

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CE MANAGEMENT OF PEDIATRIC MILD TRAUMATIC BRAIN INJURY: A NEUROPSYCHOLOGICAL REVIEW FROM INJURY THROUGH RECOVERY

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Little scientific attention has been aimed at the non-acute clinical care of pediatric mild TBI. We propose a clinical management model focused on both evaluation and intervention from the time of injury through recovery. Intervention strategies are outlined using a framework encompassing four relevant domains: the individual youth, family, school, and athletics. Clinical management has primary value in its potential to speed recovery, minimize distress during the recovery process, and reduce the number of individuals who subjectively experience longer lasting postconcussive problems. With proper management, most children and adolescents sustaining an uncomplicated mild TBI can be expected to recover fully.

Keywords: Mild traumatic brain injury; Minor head injury; Concussion; Pediatrics; Treatment.

INTRODUCTION

Pediatric traumatic brain injury (TBI) has an estimated annual incidence in the United States of 180 cases per 100,000, accounting for over 400,000 hospital visits each year (Kraus, 1995; Langlois, Rutland-Brown, & Thomas, 2004). Traumatic brain injury is conventionally graded on a severity continuum ranging from mild to severe. Injuries on the more severe end of this continuum are

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associated with significant morbidity and mortality (Kraus, 1995; Yeates, 2000). As such, considerable attention has been devoted to their understanding and management. Both clinical and surveillance definitions indicate, however, that mild TBI (mTBI) accounts for 80–90% of all treated cases (Cassidy et al., 2004). Many more mild injuries undoubtedly go unreported or are otherwise unaccounted for (Cassidy et al., 2004; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004; Williamson & Goodman, 2006). Despite the clear public health import of mTBI, comparatively little attention has been devoted to its non-acute management in pediatric populations. At present, we lack sufficient data to derive evidenced-based management recommendations for children and adolescents. Nevertheless, sufficient scientific data do exist, at least across age and injury spectrums, to develop an empirically grounded pediatric management plan.

TERMINILOGICAL CLARIFICATION

When discussing milder head injuries, the scientific literature is filled with a confusing array of overlapping terms and constructs, among them *concussion*, *minor head injury*, *mild closed-head injury*, and *mild traumatic brain injury*. All of these terms refer to trauma to the head caused by external mechanical force. Each has at least a slightly different meaning and history, partially reflecting whether underlying cerebral injury is presumed. The term *concussion* (or *commotio cerebri*) has been used for centuries to imply a transient loss or alteration of consciousness without associated structural damage. In recent years, concussion has come to be used most frequently in reference to sport-related head trauma. *Minor head injury* is the broadest of the terms and includes not only craniocerebral trauma but extracranial injury as well. *Closed-head injury* refers specifically to head injuries that do not involve penetration of the skull and dural layer (themselves called *penetrating/perforating* or *open-head injuries*). *Mild closed-head injury* and *mild traumatic brain injury* are often used interchangeably, although technically only *mild TBI* implies the presence of cerebral injury. Throughout the present paper we use the term *mild TBI* primarily, as our focus is on individuals who have sustained trauma to the brain. Even a mild concussion involves some alteration of mental status that reflects underlying brain injury, although the injury does not necessarily result in permanent or long-lived effects.

Over the years, clinical criteria for classifying mTBI and related constructs have been proffered by multiple authors and a variety of professional groups including the American Congress of Rehabilitation Medicine (ACRM, 1993), American Academy of Neurology (AAN, 1997), American Academy of Pediatrics (AAP, 1999), World Health Organization (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004a), and Concussion in Sport Group (McCrory et al., 2005). Table 1 illustrates the various definitional criteria used in these classification schemes. Because many of these criteria were developed with adults in mind, caution is required when applying them to children. Different techniques and classification schemes are also likely necessary for infants and very young children who have sustained TBI of any severity (Hahn et al., 1988; Simpson, Cockington, Hanieh, Raftos, & Reilly, 1991).

Table 1 Definitional criteria for mild traumatic brain injury and related constructs

Professional group	Term of use	Definitional criteria
American Congress of Rehabilitation Medicine Mild TBI Committee (1993)	Mild TBI	Traumatically induced physiological disruption manifested by at least one: • LOC < 30 minutes • Loss of memory or alteration in mental state around time of accident (PTA < 24 hours) • Transient or intransient focal neurological deficit • (GCS 13–15 after 30 minutes)
American Academy of Neurology (1997)	Concussion	Trauma-induced alteration in mental status that may or may not involve LOC. Confusion and amnesia are hallmarks, occurring immediately after injury or several minutes later *Grade I* • Transient confusion; no LOC; symptoms or mental status abnormalities resolve in less than 15 minutes *Grade II* • Transient confusion; no LOC; symptoms or mental status abnormalities last more than 15 minutes *Grade III* • Any LOC
American Academy of Pediatrics (1999)	Minor closed head injury	• Normal mental status on initial examination • No abnormal or focal neurological findings • No evidence of skull fracture • LOC < 1 minute • May have had a seizure, vomited, or may exhibit other signs or symptoms (e.g., headache, lethargy)
World Health Organization Collaborating Centre Task Force on Mild TBI (2004)	Mild TBI	Acute brain injury resulting from mechanical energy to the head from external physical forces. Includes one or more of the following: • Confusion or disorientation • LOC < 30 minutes • PTA < 24 hours • Transient neurological abnormalities such as focal signs, seizure, intracranial lesion not requiring surgery (GCS 13–15 after 30 minutes)
Concussion in Sport Group (2005)	Sports concussion	Complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Common features: • Typically results in rapid onset of short lived neurological impairment • May result in neuropathological changes, but symptoms largely reflect functional disturbance • Results in graded set of clinical syndromes that may or may not involve LOC; symptom resolution typically follows sequential course • Typically associated with grossly normal structural neuroimaging studies

TBI = traumatic brain injury; LOC = loss of consciousness; PTA = post-traumatic amnesia; GCS = Glasgow Coma Scale.

NATURAL CLINICAL HISTORY

Despite the variability in defining and classifying mTBI, an adequate understanding of its natural history does exist. From a neuropathologic perspective, non-human animal research indicates that sufficient mechanical force to the head can set in motion a multi-layered neurometabolic response (Giza & Hovda, 2001; Shaw, 2002). This physiologic disruption can include unchecked ionic shifts, abrupt neuronal depolarization, widespread release of excitatory neurotransmitters, alteration in glucose metabolism, reduced cerebral blood flow, and disturbed axonal function. A number of newer biochemical, electrophysiological, and neuroimaging techniques have potential for characterizing these changes (Bazarian, Blyth, & Cimpello, 2006; Belanger, Vanderploeg, Curtiss, & Warden, 2007; Munson, Schroth, & Ernst, 2006), although arguably none has yet accumulated sufficient evidence to warrant routine clinical deployment (Begaz, Kyriacou, Segal, & Bazarian, 2006; Nuwer, 1997; Nuwer, Hovda, Schrader, & Vespa, 2005; Ricker, 2005; Vos et al., 2002). These investigational techniques include serum biomarkers, magnetic resonance spectroscopy (MRS), quantitative electroencephalography (QEEG), magnetoencephalography (MEG), single photon emission computed tomography (SPECT), positron emission tomography (PET), functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI), and magnetization transfer imaging (MTI).

Computed tomography (CT) and magnetic resonance imaging (MRI) remain the predominant technologies used in clinical care. Although MRI is more sensitive than CT in detecting certain types of intracranial abnormalities, noncontrast CT is still recommended as the initial choice because of its ease of use, cheaper cost, and effectiveness in detecting surgically significant lesions (AAP, 1999; Johnston, Ptito, Chankowsky, & Chen, 2001; Newberg & Alavi, 2003; Thiessen & Woolridge, 2006). Approximately 5% of individuals presenting to hospital settings with a GCS score of 15 have intracranial abnormalities identified by CT scan, with percentages considerably higher if the GCS score is 13 or 14 or MRI is utilized (Borg et al., 2004a). When mTBI is associated with identified intracranial abnormality, many experts argue the injury should be classified as a moderate or ‘‘complicated’’ mTBI, because a variety of studies have found worse outcomes for adults with such pathology (Borgaro, Prigatano, Kwasnica, & Rexer, 2003; Iverson, 2006a; Iverson, Lovell, Smith, & Franzen, 2000; Kurca, Sivak, & Kucera, 2006; Sadowski-Cron et al., 2006; Stulemeijer et al., 2006; Williams, Levin, & Eisenberg, 1990). The complicated vs uncomplicated distinction has not yet been validated in pediatric populations, despite its intuitive appeal.

The immediate post-injury signs and symptoms of mTBI can include headache, dizziness, confusion, visual disturbance, mental slowing, loss of consciousness, amnesia, and emesis. In a recently completed study described by Yeates and Taylor (2005), 186 children with mTBI were recruited from the emergency departments of two children's hospitals. Survey of the presenting indications of concussion revealed that 40% of the sample presented with a loss of consciousness at the time of injury, 76% with headache, 44% with vomiting, 41% with nausea, 32% with post-traumatic amnesia, 26% with dizziness, 12% with double or blurred vision, 10% with disorientation, and 2% with transient neurological deficits.

Although loss of consciousness has historically been considered the cardinal feature of mTBI, sport-related concussion data indicate that a much smaller proportion of these cases are likely to involve witnessed unresponsiveness (Guskiewicz, Weaver, Padua, & Garrett, 2000; McCrea et al., 2003). With or without a period of unconsciousness, in the first days and weeks after injury a constellation of neurobehavioral changes can be seen in children, not unlike those apparent in adult populations (Mittenberg, Wittner, & Miller, 1997). These changes are referred to as ''postconcussive symptoms'' and often include a combination of somatic, cognitive, and emotional/behavioral difficulties. Frequently reported subjective symptoms include headache, dizziness, fatigue, sensitivity to light and noise, difficulty concentrating, trouble remembering, and increased anxiety (Mittenberg et al., 1997; Ponsford et al., 1999; Yeates et al., 1999).

The expected duration of postconcussive problems is a topic of considerable scientific controversy. Well-controlled pediatric studies using standardized neuropsychological and academic achievement tests indicate that cognitive or achievement deficits are generally not identifiable by 2–3 months post-injury (Carroll et al., 2004b; Satz, 2001; Satz et al., 1997). In contrast, studies utilizing subjective ratings of postconcussive symptoms have revealed greater variability, with some studies suggesting that a sizable minority of pediatric patients report more persistent problems (Yeates & Taylor, 2005).

Understanding the nature of persistent symptoms following mTBI is complicated by the fact that ''postconcussive'' symptoms are nonspecific and may in part reflect premorbid difficulties, the effects of injury more generally, or specific fears and expectations associated with cerebral trauma (Bijur, Haslum, & Golding, 1996; Hawley, Ward, Magnay, & Long, 2003; Light et al., 1998; Mittenberg et al., 1997; Nacajauskaite, Endziniene, Jureniene, & Schrader, 2006). Accurate estimates will require rigorous research methods that focus on the relative risk of persistent change following mTBI in comparison to non-head-injury control groups, while accounting for baseline levels of symptomatology. Preliminary data from the study described by Yeates and Taylor (2005) involving 186 youth who sustained mild TBI and 99 with orthopedic injuries identified four distinct longitudinal trajectories in postconcussive symptoms relative to premorbid symptom levels. Children with mTBI were significantly more likely than those with orthopedic injuries to demonstrate trajectories that involved high levels of acute symptoms that either resolved or persisted over time (24% vs 7%), and less likely to show trajectories that involved no increase in postconcussive symptoms relative to premorbid levels (64% vs 79%). Ultimately, the extent to which mTBI leads to increased rates of persistent symptoms relative to controls will likely vary with the procedures used to define mTBI, those used to evaluate the postconcussive symptoms, and the particular characteristics of the sample under study.

Research has yet to precisely establish which factors are most important in predicting individual recovery and presentation following pediatric mTBI. Studies with both adult and pediatric populations suggest that an assortment of injury and non-injury related variables could be influential, including the severity of the mTBI (Culotta, Sementilli, Gerold, & Watts, 1996; Hessen, Nestvold, & Sundet, 2006; Hsiang, Yeung, Yu, & Poon, 1997; McCrea, Kelly, Randolph, Cisler, & Berger, 2002), age at injury (Gronwall, Wrightson, & McGinn, 1997; McKinlay, Dalrymple-Alford, Horwood, & Fergusson, 2002), premorbid ''brain reserve''(Satz, 1993), genetic vulnerability (Liberman, Stewart, Wesnes, & Troncoso, 2002; Nathoo, Chetty, van Dellen, & Barnett, 2003; Teasdale, Murray, & Nicoll, 2005), premorbid learning and behavioral status (Brown, Chadwick, Shaffer, Rutter, & Traub, 1981; Light et al., 1998; Massagli et al., 2004; Ponsford et al., 1999), history of previous concussions (Collins et al., 2002; Guskiewicz et al., 2005; Guskiewicz et al., 2003; Ponsford et al., 1999; Swaine et al., 2007; Zemper, 2003; but see also Bijur et al., 1996; Broglio, Ferrara, Piland, Anderson, & Collie, 2006; Guskiewicz, Marshall, Broglio, Cantu, & Kirkendall, 2002; Iverson, Brooks, Lovell, & Collins, 2006; Macciocchi, Barth, Littlefield, & Cantu, 2001), family expectations and functioning (Anderson et al., 2001; Hawley et al., 2003; Nacajauskaite et al., 2006; Testa, Malec, Moessner, & Brown, 2006), existence of comorbid conditions such as post-injury stress or pain (Luis & Mittenberg, 2002; Smith-Seemiller, Fow, Kant, & Franzen, 2003), motivational factors and litigation status (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Bianchini, Curtis, & Greve, 2006; Binder & Rohling, 1996; Green, Rohling, Lees-Haley, & Allen, 2001; Mittenberg, Patton, Canyock, & Condit, 2002), and type of post-injury management (Comper, Bisschop, Carnide, & Tricco, 2005; Ponsford et al., 2001). In adult studies, injury-related variables account for more variance in the initial post-injury presentation and non-injury-related variables more in subsequent periods (Iverson, 2005).

In sum, after mTBI, responses of children and adolescents will differ depending on a host of personal, injury, and environmental factors. Nevertheless, converging evidence suggests that a characteristic clinical course can be expected. In the first hours to days after injury, postconcussive problems will be apparent for many youth. For a smaller percentage, problems will continue for weeks. Difficulties persisting past 2–3 months post-injury will be much less frequent, especially difficulties that can be identified by traditional psychometric tests. In other words, most youth who sustain one uncomplicated mTBI will return to their baseline level of functioning. The development of a lingering ''post-concussion syndrome'' will be relatively uncommon. However, because mTBI is a high-incidence disorder it is important to identify both short- and longer-term consequences. Optimal management has the potential to speed recovery, reduce associated morbidity, and improve public health outcomes.

CLINICAL MANAGEMENT

Mild TBI is by definition, complexion, and course a construct with both neurological and psychological features, and thus, neuropsychologists who are dually trained in the neurological principles of brain injury and the psychological principles of emotion and behavior are uniquely positioned to play an important role in its clinical management. All clinical care must be individualized, matched to the particular youth and his or her developmental level and own unique circumstances. In most cases, different management concerns will be more or less prominent at different times post-injury, rendering an understanding of the natural clinical history invaluable. The majority of individuals sustaining mTBI will recover fairly quickly, so relatively few will require intensive or long-term clinical care. The following discussion of management is focused on preschool- and school-aged children (not those under age 3 years), is framed from a public health perspective (i.e., aimed at reducing the incidence of disability resulting from mTBI), and is organized heuristically into three time periods post-injury: acute, post-acute, and long-term. Regardless of time post-injury, intervention needs to be preceded by proper evaluation and viewed in a broad-based fashion for the pediatric patient. Hence, both evaluation and intervention issues are considered within each post-injury period, and intervention strategies are outlined using a multi-tiered framework encompassing four relevant domains: the individual youth, family, school, and athletics. Given the paucity of empirical studies directly investigating the evaluation and treatment of pediatric mTBI, the following recommendations are offered not as evidenced based standards or guidelines but as scientifically informed propositions to assist in clinical planning and identifying potentially fruitful areas for future research. Table 2 provides an overview of the proposed clinical management model, arranged by time post-injury and domain of focus.

Acute (i.e., time of injury through 3 days post-injury)

Evaluation. Medical personnel have traditionally been most involved in acute evaluation, although we believe neuropsychologists can play an important role at this stage post-injury as well. In any case, the primary purposes of acute evaluation are to achieve an accurate diagnosis, rule out medical emergencies, and characterize the initial injury effects. One essential means for accomplishing these tasks is a thorough injury history.

When considering the appropriateness of any TBI diagnosis, there first needs to be evidence that the child's head was struck, struck something else, or underwent rapid acceleration–deceleration. In addition to establishing the injury mechanism, a diagnosis of underlying brain injury requires that neurologic disturbance be apparent relatively soon after the physical force has been applied to the head. At the same time, apparent neurologic signs and symptoms must be considered cautiously, to differentiate them from other factors that could have contributed to the immediate post-injury presentation. For example, one of the most common postconcussive problems is headache, but headaches can have multiple causes aside from brain injury (e.g., neck strain) and differentiating headache as a symptom of mTBI from headache as a distinct clinical entity can be challenging (Gordon, Dooley, & Wood, 2006). Many other classic features of mTBI (e.g., appearing stunned or dazed) are equally nonspecific and in some cases may be attributable to psychological factors associated with the traumatic event, such as intense anxiety or pain.

The second focus of the acute evaluation is ruling out medical emergencies. Though rare, minor trauma to the head can be associated with serious pathology, including cervical injury, skull fractures, and intracranial bleeding, contusion, or edema (Bailes & Hudson, 2001; Cantu, 2000; Thiessen & Woolridge, 2006). Identifying these complications is paramount during the initial post-injury period. Consequently, medical personnel should be immediately involved in the care of any youth who has sustained a mTBI. As most individuals experience improvement and display signs of recovery within hours of injury, worsening of headache or any other

Table 2 Mild traumatic brain injury clinical management matrix organized by time post-injury and domain of focus

	Acute (injury through 3 days post-injury)	Post-acute (4 days through 3 months post-injury)	Long-term (4 months post-injury through recovery)
Cognitive or neuropsychological evaluation	• Brief, standardized cognitive screening	• Abbreviated neuropsychological assessment	• Comprehensive neuropsychological assessment
Youth intervention	• Provide developmentally appropriate education, advice, and reassurance about mTBI	• Provide psychoeducational consultation as needed • Provide reassurance, ensure reasonable symptom attributions developed, and recommend "behavioral prescriptions" as appropriate	• Validate patient's injury experience • Consider cognitive-behavioral psychotherapy, focused on functional improvement • Reframe search for "cure" and help child develop more effective coping strategies
Family intervention	• Ensure caregivers can identify and act upon neurological emergencies • Provide parent-focused education, advice, and reassurance about mTBI • Attend to caregiver anxiety in particular	• Provide ongoing education and advice about symptoms • Emphasize preventing further injury while youth is still recovering	• Correct dualistic mind–body misconceptions and develop clear management plan • Explore post-injury family dynamics • Consider family problem-solving therapy as needed
School intervention	• Consult around when student should return to school • Ensure school is alerted to injury and monitors for neurological deterioration	• Consider graduated transition back to school • Ensure school personnel have adequate knowledge of mTBI • Recommend accommodations and modifications as needed	• Coordinate school-based services among educators and healthcare personnel • Consider non-injury related factors when developing educational plans
Athletics intervention	• Ensure earliest athlete returns to sports is when asymptomatic and neurological exam and neuroimaging (if conducted) are unremarkable • Consider restricting from high risk sports for 1–2 weeks after asymptomatic	• Attend to emotional toll restriction from sports may be having • Recommend individual or group based psychological support as needed	• Ensure individualized cost–benefit analysis conducted when considering return to play • Keep in mind persistent symptoms often at least partially reflect non-injury related factors

mTBI = mild traumatic brain injury.

symptom warrants urgent medical attention. In addition to a complete history, primary medical tools used during acute clinical management include physical and neurological examination, the Glasgow Coma Scale or a pediatric specific coma scale, and neuroimaging as indicated (AAP, 1999; Kamerling, Lutz, Posner, & Vanore, 2003; Thiessen & Woolridge, 2006).

Because informal orientation questions (e.g., where are you? what day is it?) have not been found to be consistently sensitive to the effects of sport-related mTBI (Maddocks, Dicker, & Saling, 1995; McCrea, 2001), incorporating standardized cognitive screening into the acute evaluation may help to further objectify the injury severity and characteristics. Formal neuropsychological testing is typically unwarranted at this stage post-injury, as evidence with older athletes suggests that it is unlikely to add incremental validity beyond a brief cognitive screening (McCrea et al., 2005). Several of the most well-researched mTBI screening instruments were developed originally for sport-related concussion work. The Standardized Assessment of Concussion (SAC) is one such instrument and has normative data for children 6 years and older (McCrea, Kelly, & Randolph, 2000). The Children's Orientation and Amnesia Test (Ewing-Cobbs, Levin, Fletcher, Miner, & Eisenberg, 1990) which was adapted from the Galveston Orientation and Amnesia Test (Levin, O'Donnell, & Grossman, 1979) to evaluate orientation and memory in more seriously injured children, could potentially be used for screening purposes as well, although it lacks published sensitivity data for mTBI populations. The Mini-Mental State Examination and the Westmead Post-Traumatic Amnesia Scale have also been modified for use with children (Ouvrier, Goldsmith, Ouvrier, & Williams, 1993; Ponsford et al., 2001) although, again, relatively little research has focused on their utility with pediatric mTBI samples.

Systematically reviewing postconcussive symptoms in the acute period is also necessary to fully characterize the mTBI effects. Few published measures focus on evaluating postconcussive symptoms in children specifically, although multiple checklists and scales are available (Guskiewicz et al., 2004; King, Crawford, Wenden, Moss, & Wade, 1995; Lovell et al., 2006; McCrory et al., 2005; Piland, Motl, Ferrara, & Peterson, 2003; Roberts & Furuseth, 1997; Yeates et al., 2001). Regardless of which is used, postconcussive symptoms should be reviewed individually with both parents and children, because parent and child reports can be expected to differ to some extent (Ayr et al., 2006). Reports of postconcussive symptoms also need to be interpreted in light of the overall clinical evaluation, as adult studies clearly indicate that postconcussive symptoms occur frequently in individuals who have not sustained TBI (Iverson, 2005). To help account for the child's premorbid functioning specifically, caregivers should be asked during the acute period to rate both their child's pre- and post-injury ''postconcussive'' symptoms.

Intervention

Individual. At the individual patient level, neuropsychological treatment in the acute period should focus on ensuring that the youth has an adequate understanding of what has happened and what he or she can expect after injury. Children, even as young as 6 years of age, have well-defined expectations about the type and duration of symptoms that can follow head injury (Sengstock et al., 2004). The specific patient's expectations should therefore be explored and emphasis placed on the fact that many individuals who sustain mTBI display initial symptoms but most recover fully within a relatively short period of time. The specific content of the information that is provided and the optimal means to deliver it will depend on the clinical context, the developmental level of the child, and the severity of the symptom presentation. Generally speaking, the goals are to set the stage for a positive recovery and prevent the development of secondary psychiatric or stress-related problems (Luis & Mittenberg, 2002). In adults, early intervention focused on the provision of education, advice, and reassurance has the strongest empirical support of any medical or psychological mTBI treatment (Borg et al., 2004b; Comper et al., 2005; Mittenberg, Canyock, Condit, & Patton, 2001; Ponsford, 2005). In a pediatric population, Ponsford and colleagues (2001) documented similarly improved outcomes at 3 months post-injury after providing a child-friendly educational booklet soon after injury.

Family. In the acute period, the immediate management goals for the child's caretakers are twofold. First, if the child is not going to be observed in a hospital or other medical setting, all healthcare personnel should ensure that the family is competent to identify and act upon medical emergencies (Pardes Berger & Adelson, 2005). Most life-threatening problems after mTBI occur within the first 24 hours, although caretakers need to remain alert for any change in their child's status for several days post-injury (AAP, 1999). Second, similar to management at the individual youth level, making sure caregivers have an adequate understanding of mTBI and its typical clinical course is apt to be beneficial. Misconceptions about brain injury are common in lay populations (Gouvier, Prestholdt, & Warner, 1988a; Guilmette & Paglia, 2004; Hux, Schram, & Goeken, 2006; Mulhern & McMillan, 2006), and many parents of children who have sustained mTBI report not receiving a satisfactory amount of educational information (Hawley, Ward, Magnay, & Long, 2002; Savage, DePompei, Tyler, & Lash, 2005). Furthermore, morbidity after pediatric mTBI occurs more frequently in children of anxious parents, highlighting the need to address parental anxiety in particular soon after injury (Casey, Ludwig, & McCormick, 1986, 1987). Credible but non-empirically supported resources to assist in providing parent education include commercial publications (Savage, 2004), as well as multiple handouts available for free on the internet (e.g., from the U.S. Centers for Disease Control and Prevention www.cdc.gov/ncipc/tbi and The Children's Hospital, Denver www.thechildrenshospital.org/concussion).

School. Educationally relevant management in the acute period centers around when the student should begin the transition back to school. The development of extensive supports or accommodations during this stage post-injury is typically premature, given the rapid recovery trajectory seen in most cases. Because many children will be symptomatic within the first days of injury, healthcare providers and parents should consider keeping students home from school for an initial period of rest. No identified studies have examined the effect that returning to school has on mTBI recovery or symptom presentation. However, brief periods of rest are considered by some to be the foundation of early mTBI management, because increased cognitive or physical activity could lead to symptom exacerbation, theoretically through autonomic or cardiovascular mediated elevations in intracranial pressure (Kissick & Johnston, 2005; McCrory et al., 2005). If the child returns to school within the acute period, parents or healthcare providers should alert school personnel to the injury, so the child can be adequately monitored for evidence of neurological deterioration and for the more commonly seen postconcussive problems (e.g., headache, fatigue, concentration difficulties).

Athletics. Sport-based management of mTBI is most often focused on whether an athlete is safe to return to participate in relatively high-risk athletic activities. When athletes should be allowed to return to play has been the subject of a good deal of attention in recent years, with ongoing disagreement apparent in part because evidenced-based guidelines still do not exist (Peloso et al., 2004). Many experts would now agree, however, that three criteria should be met before pediatric athletes return to play: (1) the athlete should be asymptomatic physically, cognitively, and behaviorally, both at rest and with exertion; (2) the neurological examination should be unremarkable; and (3) no findings should be apparent on neuroimaging, if conducted (Kirkwood, Yeates, & Wilson, 2006).

Once these three criteria are met, recommendations differ for how much longer, if at all, an athlete should refrain from high-risk activities. Certain protocols permit a return to play on the day of injury, which could be appropriate for the older athlete (Pellman, Viano, Casson, Arfken, & Feuer, 2005). A more conservative approach is warranted for the pediatric athlete for a number of reasons, including that catastrophic outcomes are more common in young athletes (though still extremely rare overall) and that the ‘‘cost’’ of removing young athletes from competition is relatively low. Therefore, consistent with other authors (Guskiewicz et al., 2004), we recommend that pediatric athletes always be removed from the day’s competition after a concussion and not be allowed to return to play until cleared medically, regardless of how minor the concussion was. Although not evidence-based, we believe a further restriction of high-risk activities for at least 1 to 2 weeks after the child is asymptomatic is a reasonable position to take for the younger athlete with a still immature, actively developing brain. In other words, we believe that young concussed athletes should not return to play during the acute period in most situations and should never return before proper evaluation has been completed.

Post-acute (i.e., 4 days through 3 months post-injury)

Evaluation. The aims of the acute post-injury evaluation include achieving an accurate diagnosis and identifying medical emergencies. While these goals still need consideration at later time points, the primary purpose of the post-acute evaluation shifts to understanding the individual symptom profile for those patients who have not yet recovered fully. Because the youth’s neuropsychological profile is not necessarily stable in the post-acute period, a comprehensive neuropsychological evaluation may not yet be routinely indicated. Of course, each case requires prudent judgment and a balancing of the multiple needs of the individual child and family.

In many cases, a relatively abbreviated neuropsychological evaluation could be appropriate, one that is more extensive than a very brief cognitive screening but less extensive than a traditional, comprehensive neuropsychological assessment.

The length of time a neuropsychologist should wait before conducting this abbreviated neuropsychological evaluation is debatable. We believe methodologically rigorous sport-related concussion research provides empirical guidance for making this determination. The vast majority of concussed high-school and older athletes demonstrate complete cognitive and symptom recovery within 1–2 weeks of injury (Belanger & Vanderploeg, 2005). Although data involving younger children and non-sport-related mTBI are less well established, we would expect many pediatric patients to return to their baseline level within approximately 2 weeks of injury as well and believe this is a sensible waiting period in most cases.

If a child still seems to be experiencing postconcussive problems after approximately 1 to 2 weeks, a relatively abbreviated neuropsychological evaluation is likely to be justifiable and cost-effective, because it can help to identify reasons for problems, assist in the creation of an appropriate clinical management plan, and reduce the risk of prolonged patient distress or secondary psychosocial problems. Albeit abbreviated, the evaluation still must allow for sufficient breadth to properly interpret any findings. The accurate collection of injury-related information continues to be essential. Evidence from adult studies demonstrates that TBI does not necessarily produce a diagnostically distinct profile on neurocognitive testing or symptom checklists, so mTBI diagnoses or injury severity judgments can never be based solely on neuropsychological or symptom ratings weeks or months after injury (Chan, 2001; Dikmen, Machamer, & Temkin, 2001; Gouvier, Cubic, Jones, Brantley, & Cutlip, 1992; Gouvier, Uddo-Crane, & Brown, 1988b; Iverson, 2006b; Iverson & Lange, 2003; Kashluba, Casey, & Paniak, 2006; Lees-Haley, Fox, & Courtney, 2001). At this point post-injury, more comprehensive developmental and educational information should also be gathered through interviews and objective records (e.g., school records), to better understand the child's pre-injury functioning and to identify any factors that could be influencing post-injury presentation (e.g., premorbid attention or learning problems, psychiatric issues, family stressors). Accurate historical information is especially important in evaluating mTBI populations because children who sustain head injuries display a relatively high frequency of pre-existing behavioral problems, hampering identification of injury-specific difficulties (Light et al., 1998; Ponsford et al., 1999).

When choosing the actual post-acute assessment instruments, a measure of postconcussive symptomatology should be included. Any of the previously referenced checklists or scales could be appropriate. Select cognitive domains will also need explicit coverage. In general, speeded responding and aspects of memory, attention, and executive functioning have demonstrated the most sensitivity in the initial period after mTBI (Belanger et al., 2005; Binder, Rohling, & Larrabee, 1997; Frencham, Fox, & Maybery, 2005; Yeates et al., 1999). Multiple abbreviated batteries have been developed to examine these and related domains in adult populations. Limited work in this regard has been conducted with younger populations, although Shurtleff, Massagli, Hays, Ross, and Sprunk-Greenfield (1995) proposed an abbreviated battery specific to pediatric mild to moderate TBI. Regardless of the instruments that are deemed most suitable for evaluating the mTBI effects, the results must be interpreted in the context of the TBI outcome research, technical weaknesses of the chosen instruments, and limitations of using an abbreviated battery or test of any kind.

To facilitate proper interpretation, the post-acute neuropsychological battery also needs to include coverage of domains that are likely to be *insensitive* to TBI. Most well-established or crystallized skills (e.g., single word reading for older children) should remain relatively preserved after mTBI. If performance on these measures is poor, consideration needs to be given to whether the injury was actually more severe than a mild injury or whether pre-injury problems or other non-injury-related factors may be contributing to the findings. Consideration should also be given to formally evaluating motivation to perform well during the post-acute evaluation. This is an area that has historically received minimal attention in pediatric populations, and one we cover in more depth within the long-term evaluation section. To examine the contribution of executive function and behavioral adjustment difficulties, parent-, youth-, and teacher-based behavior rating scales could be incorporated into the evaluation as well; for these measures, ratings of premorbid status could be requested if the evaluation occurs soon after injury, or ratings of current status could be requested if the evaluation takes place later in the post-acute period. Post-traumatic anxiety, pain, and sleep disturbance also need to be explicitly considered, as these are often associated with events that produce mTBI (e.g., motor vehicle accidents). Studies with both adults and children suggest that these problems can affect neuropsychological and symptom presentation independent of the TBI (Bryant, 2001; Landre, Poppe, Davis, Schmaus, & Hobbs, 2006; Moore, Terryberry-Spohr, & Hope, 2006; Nicholson, 2000; Nicholson, Martelli, & Zasler, 2001; O'Brien & Gozal, 2004).

Intervention

Individual. No specific symptom pattern predominates in the days or weeks after mTBI. For all symptomatic youth, physician involvement will continue to be necessary, to rule out medical complications and to determine whether pharmacological treatment, rehabilitation therapies, or other medical interventions are indicated. As highlighted above, the only intervention that has been empirically well shown to reduce postconcussive symptoms after mTBI is the provision of proper education and reassurance soon after injury. Limited single-session treatment in adult populations within several weeks of injury has been found to be as effective as more intensive interventions (Paniak, Toller-Lobe, Durand, & Nagy, 1998; Paniak, Toller-Lobe, Reynolds, Melnyk, & Nagy, 2000). During the post-acute period, then, a practical treatment plan for the symptomatic youth is to provide brief psychoeducational consultation as needed.

Mittenberg and colleagues (2001) have described several strategies that could be beneficial during this consultation including providing reassurance that symptoms are part of the normal recovery process (not a sign of permanent damage or dysfunction) and ensuring that reasonable attributions about symptom cause have been developed. Adult patients and athletes with mild head injury often underestimate their premorbid postconcussive symptoms and thus can place too much emphasis on injury-related factors as the cause of post-injury problems (Ferguson, Mittenberg, Barone, & Schneider, 1999; Mittenberg, DiGiulio, Perrin, & Bass, 1992). Kay (1993) has suggested using "behavioral prescription" to manage symptoms after mTBI, an idea that may be of additional assistance for some youth during the post-acute consultation. Essentially, behavioral prescriptions are specific recommendations to assist the patient in effectively balancing symptoms with the environmental demands that are faced. Such recommendations for children and adolescents could include how and when to begin school again, cope with schoolwork and household demands, and re-engage in social activities. Finally, if the post-acute evaluation reveals any serious psychological problems (e.g., post-traumatic stress disorder), more comprehensive individually based psychological intervention is obviously indicated.

Family. As discussed, a number of studies indicate that early post-injury education for both children and caregivers may reduce mTBI morbidity. Throughout the post-acute weeks, an acceptable familial management plan is to continue to make certain that caregivers are provided with sufficient education so that they recognize common postconcussive symptoms, understand postconcussive symptoms are typically self-limiting, and are making suitable accommodations within the home environment to support any difficulties. While the youth remains symptomatic, specifically emphasizing the importance of preventing another head injury is also sensible, taking care not to unduly increase caregiver anxiety.

A second blow to the head while a youth is still recovering from a previous concussion has been described in the sport-related concussion literature as having the potential to produce "second impact syndrome" (SIS), which is characterized by diffuse cerebral swelling, increased intracranial pressure, and residual permanent neurological damage or death (Cantu, 1998). Experts agree that any type of catastrophic response after a mild head injury is exceptionally rare (Carroll et al., 2004b). For apparent SIS cases, disagreement exists as to whether the second blow is actually responsible for triggering the neurological deterioration, and thus, whether SIS should be regarded as a distinct clinical entity (McCrory, 2001). Some data also suggest that this catastrophic outcome could ensue from a rare genetic abnormality related to familial hemiplegic migraine (Kors et al., 2001). Regardless, symptom intensification from increased post-injury activity is plausible (Kissick & Johnston, 2005), and repeated mTBI in close succession has been found to have a cumulative effect in animal models (Huh, Widing, & Raghupathi, 2007; Laurer et al., 2001; Longhi et al., 2005; Yoshiyama et al., 2005). These data collectively provide reason enough during the post-acute period to consider having caregivers encourage their children to "take it easy" for a while, at least until symptoms resolve and proper medical evaluation has been completed.

School. No controlled research is available to direct a student's re-engagement into school after mTBI. However, Ylvisaker, Feeney, and Mullins (1995) have proposed a comprehensive, well-reasoned protocol for transitioning students with mTBI back to school from a hospital setting. As mentioned previously, after mTBI, some students may benefit from remaining home for a day or more to encourage an initial period of intensive rest and recovery. On the other hand, studies with adults indicate complete bed rest for more than a short period of time is unlikely to be effective in managing mTBI (de Kruijk, Leffers, Meerhoff, Rutten, & Twijnstra, 2002; Relander, Troupp, & Af Bjorkesten, 1972). In some

Table 3 Potential strategies to support the transition back to school

Initial transitional support
- School personnel alerted to injury and potential consequences
- Re-integration into school occurs gradually
- Student not expected to do all work completed in absence
- Extra assistance provided to facilitate completion of make-up work

General school-based support
- Monitor student carefully for a period of at least a few weeks
- Ensure rest time and breaks available as needed
- Reduce overall homework and classwork load
- Reduce cognitively demanding in-school tasks (e.g., no more than one test each day)
- Extra assistance provided to help student remain organized

Specific classroom-based support
- Delay standardized and classroom tests
- Waive time constraints for tests
- Increase flexibility for assignment due dates
- Provide preferential seating to allow for closer monitoring and decreased distractions
- Allow access to a model peer's or teacher's notes

Adapted from "Pediatric sport-related concussion: A review of the clinical management of an oft-neglected population" by Kirkwood, Yeates, and Wilson, 2006, *Pediatrics*, *117*, 1366.

cases, we believe too slow a return to school could even serve to protract a child's recovery (e.g., by causing undue stress secondary to feelings of falling behind, being away from friends, disrupting the family's routine). Whenever it is clinically indicated for the student to return, consideration should be given to recommending a graduated transition, which might better foster post-injury feelings of success and reduce feelings of being overwhelmed or frustrated, particularly for those students who remain symptomatic.

Soon after injury, school personnel should be notified of the injury, what to generally expect, the need to monitor the student for at least several weeks, and how best to support the student's recovery. A variety of materials have been developed to assist with this task, including both commercial products (Lash, Savage, & DePompei, 1998) and the information published by Ylvisaker and colleagues (1995). For most symptomatic youth, a few temporary informal accommodations and modifications in the first days after injury should suffice. If evaluation reveals more significant difficulties, consideration should be given to documenting the supports in a formal, but likely temporary, educational plan. Several potential non-empirically validated supports that could be provided either informally or within a formal plan are outlined in Table 3.

Athletics. The major sport-related concern during the post-acute period continues to be whether the athlete should be allowed to return to relatively high-risk physical activities. Until the athlete is cleared to play, attention needs to be given to the emotional toll the activity restrictions are taking on the athlete. A variety of psychosocial problems have been documented after athletic injury in general including anxiety, depression, lowered self-esteem, and a loss of contact with teammates, friends, and coaches (Bloom, Horton, McCrory, & Johnston, 2004;

Broshek & Freeman, 2005). Recommendations to prevent or lessen these problems include providing education and reassurance about the typical recovery course, setting realistic goals, and encouraging continued participation in athletic or team events in a manner that will not increase the risk of re-injury (Podlog & Eklund, 2004), for example, by designating the athlete a temporary assistant or "coach." If indicated and available, consideration could also be given to having the athlete participate in an injury support group, which has demonstrated positive psychological effects for older concussed athletes (Horton, Bloom, & Johnston, 2002).

Another chief neuropsychological concern in the post-acute period is the role that neuropsychological testing should play in determining whether an athlete is safe to return to athletic competition. A number of experts and groups have suggested that neuropsychological testing within a "baseline model" can be useful for this purpose. The baseline model involves pre-injury testing for all team athletes and follow-up testing for those athletes who sustain concussions during the season. Sound scientific data have yet to justify the financial costs, time, and energy needed to implement such a baseline model for younger athletes. Serious psychometric and methodological questions remain about the model's implementation, and studies have not yet found that such testing actually leads to a reduction in the risks associated with returning athletes to play (Grindel, 2006; Randolph, McCrea, & Barr, 2005). Although recognizably controversial (see Lovell, 2006, and Randolph, 2006), until these data become available we recommend that neuropsychological testing within the baseline model be considered an investigational methodology for pediatric athletes, certainly worthy of ongoing research but not yet justified for making clinical decisions regarding the return to play. Of course, neuropsychological evaluation can be useful for clinical management more broadly, even if it is not especially germane at present for the return to play decision.

Long term (i.e., 4 months post-injury through recovery)

Evaluation. Neuropsychologists are frequently first asked to conduct evaluations months to years after a mTBI has occurred. At this point post-injury, some might argue a neuropsychological evaluation is unwarranted, given that most studies have concluded that measurable neurocognitive deficits completely resolve in this population within a matter of weeks. However, for those youth who have apparently not returned to their baseline level of functioning, we believe a comprehensive neuropsychological evaluation is justified, to assist in identifying factors that may be producing problems, to ensure accurate diagnostic decisions are made, and to help develop an appropriate clinical management plan.

When conducting evaluations during the long-term period, one of the first tasks continues to be establishing that the patient did indeed suffer a TBI and, if so, what the immediate injury characteristics were. Because of the potential for biased reporting this distant from the injury, child and caregiver accounts during the long-term stage should consistently be supplemented by objective records (e.g., day-of-injury emergency transport or hospital records). In reviewing these data, careful consideration needs to be given to information that can be used to determine injury severity specifically. Injuries associated with a GCS score lower than 13, neuroimaging abnormalities, a period of unconsciousness longer than 15–30 minutes, or PTA longer than 24 hours could all suggest a moderate TBI or complicated mTBI, for which persistent problems might not be unexpected.

Non-injury-related factors need detailed consideration at this point post-injury as well. Pre-existing or concurrent psychosocial problems, such as depression, anxiety, or general stress, have been shown in adult studies to mimic or exacerbate postconcussive symptoms and also impact neuropsychological performance (Goldstrohm & Arffa, 2005; Gouvier et al., 1992; Iverson & Lange, 2003; Machulda, Bergquist, Ito, & Chew, 1998; Suhr & Gunstad, 2002). Premorbid learning and attentional difficulties can have obvious effects on post-injury presentation. Obtaining pre-injury educational records and conducting interviews with school personnel can be especially helpful in objectively evaluating these difficulties. Because family factors can impact TBI recovery, family stressors and functioning should additionally be considered. Lastly, the child's and family's own expected course of recovery and litigation status need to be explored, because expectations and selective attentional biases after injury can have important effects on the mTBI recovery process (Gunstad & Suhr, 2001; Mittenberg et al., 1992; Sengstock et al., 2004).

The neuropsychological battery should continue to ensure adequate evaluation of postconcussive symptoms, general somatic issues (e.g., pain), and those cognitive domains shown to be sensitive to TBI more generally. During the long-term stage, broader-based coverage of neurocognitive, psychosocial, and achievement functioning is also indicated, to allow for a complete picture of the youth's functional status and to help identify difficulties that may be contributing to persistent problems. Numerous resources are available to assist in the development of a comprehensive pediatric-focused test battery (Baron, 2004; Sattler, 2001; Sattler & Hoge, 2006; Strauss, Sherman, & Spreen, 2006).

Traditionally, pediatric sources have not extensively covered the need to formally evaluate effort as part of the neuropsychological assessment. With few exceptions (Donders, 2005a), scant attention has been paid to how motivational factors affect test performance after pediatric TBI, despite the fact that children are capable of deception and poor test effort (Faust, Hart, & Guilmette, 1988b; Kirkwood, 2007; Lu & Boone, 2002; Oldershaw & Bagby, 1997; Peebles, Sabella, Franco, & Goldfarb, 2005) and negative response bias accounts for substantial performance variance in adult mTBI populations (Green et al., 2001; Mittenberg et al., 2002). Because clinician judgment is unlikely to be consistently effective in identifying nonoptimal effort in children (Faust et al., 1988a, 1988b), we believe consideration should be given to using formal symptom validity testing when evaluating school-aged youth after mTBI. Of course, poor performance on effort tests does not necessarily imply an individual is malingering, and poor performance on any one test is insufficient to determine biased responding (Slick, Sherman, & Iverson, 1999). Failed performance on an effort test does, however, call into question the validity of other collected data and requires further investigation. Several measures of response bias used primarily with adults have demonstrated utility in younger populations as well, including the Word Memory Test (Courtney, Dinkins, Allen, & Kuroski, 2003; Green & Flaro, 2003), Medical Symptom Validity

Test (Green, 2004; Kirkwood, 2007), Computerized Assessment of Response Bias (Courtney et al., 2003), and Test of Memory Malingering (Constantinou & McCaffrey, 2003; Donders, 2005b). When deciding on the suitability of symptom validity tests for children, the youth's age, intelligence, and reading level must all be taken into account (Rohling, 2004).

Intervention

Individual. Because there are a multitude of reasons patients may still be having difficulties months to years post-injury, no generic management plan or treatment protocol will be appropriate for all youth. Management during the long-term stage will need to be individually tailored, driven by the results of thorough evaluation. Given that long-term problems after mTBI are atypical, steps should be taken to ensure appropriate medical follow-up has occurred, to help identify any medical explanations for persistent problems (e.g., intracranial lesion, musculoskeletal injury, post-traumatic migraines).

Relatively little literature is available to direct the treatment of pediatric patients who experience persistent problems. For adult populations, numerous authors have discussed relevant management approaches (e.g., Kay, 1993; Mittenberg et al., 2001; Raskin & Mateer, 2000; Ruff, Camenzuli, & Mueller, 1996), although little randomized controlled research has been conducted (Borg et al., 2004b). The available literature and our clinical experience suggest that a variety of interventions could be worthwhile for youth at this stage. Validating the patient's injury experience is a logical first step (Kay, 1993), because by this point post-injury the youth may be feeling as though the traumatic event, injury, or symptoms are not being taken seriously—by family members, school personnel, peers, or healthcare professionals. Psychotherapy may also be productive, as persistent pediatric health problems of any kind increase the risk for psychological difficulties (Wallander, Thompson, & Alriksson-Schmidt, 2003). Cognitive-behavioral psychotherapy in particular has empirical support to address pediatric mood and behavioral difficulties (McClellan & Werry, 2003) and the added benefit of being supported to address many common postconcussive complaints such as headache and sleep problems (Gurr & Coetzer, 2005; Holden, Deichmann, & Levy, 1999; Sadeh, 2005). If medically indicated, during therapy the postconcussive symptoms could usefully be reframed for the child through a rehabilitative lens, de-emphasizing the search for a "cure" and emphasizing the acquisition of problem-solving and other coping skills to reduce the symptoms' functional impact. Finally, some authors have recommended cognitive rehabilitation as a treatment strategy for persistent symptoms following mTBI. The initial effectiveness of cognitive remediation in pediatric populations has been documented in the context of significant acquired brain injuries (Butler & Copeland, 2002; Penkman, 2004; van't Hooft et al., 2005). However, these techniques have not yet been rigorously investigated following less severe injuries, and clinical experience suggests that their use in mTBI populations may have iatrogenic consequences in certain situations (e.g., cases with a significant somatization component). Thus, although cognitive rehabilitation may eventually show empirical utility in treating attention and memory complaints in youth following mTBI, at this point it should be used with caution and only after the potential costs and benefits have been considered for the individual patient.

Family. Few systematic studies are available to guide familial intervention months to years after mTBI. As a starting point, the family's injury-related treatment experience could be reviewed, because caregivers, like their children, may feel as though their concerns have not received adequate attention by some of the previously encountered professionals. If proper medical examination has been conducted, reassurance that ongoing symptoms are unlikely to be associated with serious pathology should be useful in and of itself. Caregivers' subjective perception of medical problems can powerfully influence child outcomes (Kazak, Rourke, & Crump, 2003). Discussing the multifaceted nature of the symptoms in a manner that corrects for any dualistic mind–body misconceptions, while simultaneously conveying a strong sense of hope through the development of a clear management plan, may additionally help to foster caregiver understanding, alleviate anxiety, and set the stage for any needed further treatment.

For those families faced with chronic stressors or poor coping, structured family-based problem-solving therapy could be recommended. No identified studies have examined these interventions after mTBI, but research has demonstrated positive effects subsequent to more severe pediatric TBI and with other childhood medical disorders (Robins, Smith, Glutting, & Bishop, 2005; Sanders, Shepherd, Cleghorn, & Woolford, 1994; Wade, Michaud, & Brown, 2006). Whether family therapy is recommended or not, the post-injury dynamics of the family should be explored. After any childhood trauma or illness, many caregivers have a tendency to overprotect, a natural and initially adaptive response (Walker & Zeman, 1992). Yet, if continued, these family patterns can become less adaptive, leading to an implicit or explicit belief that the child is overly fragile or vulnerable (Green & Solnit, 1964). For the child, the sick role in the family can also be associated with a number of self-sustaining secondary benefits including attention, avoidance of unpleasant activities such as schoolwork, and ego-protecting explanations for why performance might be substandard (Campo & Fritz, 2001). In these situations, parents and other family members could be encouraged to lessen the focus on the youth's problems and shift more attention to the steps the child is taking toward health and recovery, while assuring that an appropriate network of support is in place. The development of a coordinated rehabilitation plan focused on fully reintegrating the child into school if not yet achieved and reintroducing typical routines and medically permissible physical activities should be productive.

School. If problems are still apparent many months or years after mTBI, coordinating school-based supportive services with educators will be necessary. Whether supports are needed from an academic or psychosocial perspective (or both), documenting them in an educational plan is likely indicated. The nature of the educational plan will depend largely on the evaluation results, including a detailed characterization of the student's difficulties and an accurate determination of their likely etiology. Mild TBI does not typically result in lasting academic problems, so in the face of persistent school difficulties clinicians and educators must be mindful of the contribution of both injury complications (e.g., intracranial lesions) and non-injury-related problems (e.g., underlying learning, attention, or psychiatric problems). Research has not supported specific programming strategies or instructional practices that are beneficial for students who have sustained TBI of any severity (Savage et al., 2005). Educators must rely on best teaching practices and interventions shown to be successful for students with special needs in general, and then tailor these to the individual student based on the neuropsychological and other assessment information.

Athletics. For those youth who display long-term problems after mTBI, whether or not to allow a return to relatively high-risk sports and other physical activities is an extremely complicated decision. Medical personnel will ultimately decide on the safety of permitting participation in the face of persistent symptoms or abnormalities on neurological examination or neuroimaging. Expert opinion generally indicates that athletes who display any of these problems should be restricted from high-risk physical activities, although most of these recommendations have been developed for the initial days or weeks after injury. Research is lacking to suggest that those athletes who experience difficulties many months or years after injury are at the same return to play risk as those who display initial problems. Moreover, in many cases, persistent symptoms at least partially reflect non-injury-related factors. Activity restriction itself can also have adverse effects on both mood and lifestyle (Bloom et al., 2004; Dunn, Trivedi, & O'Neal, 2001). Despite these complexities, a conservative approach is appropriate when making decisions about return to play for young athletes, all the more so for those athletes with a history of repeated concussions and evidence of either a lowered threshold for sustaining additional concussive injury or cumulative effects from the experienced injuries. In the end, the return to play decision should rest on a careful, individualized cost-benefit analysis weighing the potential risks of multiple insults to an actively developing brain with the psychosocial and other benefits of allowing a return to play.

CONCLUSION

Few neurologic disorders have engendered as much historical controversy as mTBI, whether in adult or pediatric populations. Although select topics continue to be debated, in recent years scientific opinion has begun to converge. Mild TBI is no longer viewed as a "silent" problem or one that is assumed to produce lasting brain damage. When measured by objective psychometric tests, research has now well established that the long-term outcome after a single, uncomplicated mild injury for most children and adolescents is quite positive. Studies utilizing subjective ratings of postconcussive symptoms reveal that a more sizable minority of pediatric patients report persistent problems, although further research will be necessary to fully characterize the nature of these difficulties.

Mild TBI clinical management has primary value in its potential to speed recovery, minimize distress during the recovery process, and reduce the number of youth who subjectively experience longer-lasting postconcussive problems. Despite the potential clinical and public health import of proper management, to date strikingly little scientific attention has been aimed at non-acute clinical care. Pediatric mTBI management must still rely heavily on indirect empirical data, including from adult and more severely injured pediatric populations. Within the clinical management matrix proposed here, we have attempted to summarize the most recent and relevant of this literature, as well as draw implications for management from our own professional experiences. We recognize that the resources needed to implement the described model will not be available to all children in all settings, and therefore we view the model as aspirational rather than as a minimum standard of care. At the same time, many of the model's specific recommendations are likely to be stopgaps, to be replaced eventually by methods demonstrated to be effective through prospective, randomized controlled trials. We believe two general features of the described model will endure and will distinguish worthwhile pediatric non-acute management in the future: resource expenditure will be informed by, and yoked to, the natural clinical history of mTBI, and postconcussive problems will be inherently conceptualized as developing and persisting within a dynamic biopychosocial context rather than on a more singular psychologic or physiogenic dimension.

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