Return-to-Play Decisions

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KEYWORDS

• Sport • Concussion • Brain • Post-concussion syndrome

Sports concussions are mild traumatic brain injuries, and all brain injuries are serious. The most recent Concussion in Sport consensus statement states "Concussion is defined as a complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces." Concussions occur as a result of forces directed to the head or neck, or from impulsive forces transmitted from the body to the head. They result in the rapid onset and spontaneous recovery of short-lived impairment of neurologic function.[1] Concussions represent a functional disturbance and not a structural one, and do not result in abnormalities on standard structural imaging. A concussion results in a graded set of clinical symptoms that do not have to result in loss of consciousness (LOC). These symptoms resolve in a stepwise fashion in most cases. A small minority of cases result in prolonged symptoms referred to as postconcussion syndrome (PCS).[1]

The Centers for Disease Control (CDC) estimates between 1.6 and 3.8 million sports and recreation concussions occur each year, and that approximately 135,000 sports concussions are seen in emergency departments annually.[2–4] This estimate has increased greatly since the CDC's previous estimate of 300,000 sports and recreation concussions in 1997.[5] It is likely that this is because of an increased awareness of the injury rather than an intrinsic change in the rate of concussion.

The improved medical understanding of concussion, combined with an increased awareness in the nonmedical press, has pushed concussion management to the forefront of sideline and clinical sports medicine. Legislation exists in several states that addresses same-day return to play (RTP) and medical clearance before full RTP. As the number of concussion cases presenting in clinics has increased, the challenge of making evidence-based RTP decisions has become apparent.

Yard and Comstock[6] report that high school athletes returned to sport prematurely in 40.5% of cases based on data from the American Academy of Neurology (AAN), and in 15% of cases using the 2005 Prague Consensus Statement guidelines. Yard and Comstock[6] also report that 15.8% of football players suffering a concussion with

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Phys Med Rehabil Clin N Am 22 (2011) 619–634
doi:10.1016/j.pmr.2011.08.004 **pmr.theclinics.com**
1047-9651/11/$ – see front matter

LOC returned to play on the same day as their injury. The increased media attention, law changes, and overall awareness of the seriousness of the condition suggest that compliance will improve, although this remains to be seen. This article discusses a comprehensive approach to RTP in sports concussion, including managing athletes returning after prolonged PCS, multiple concussions, and intracranial hematomas and craniotomy.

PATHOPHYSIOLOGY AND RTP

An understanding of the pathophysiology of concussion and the cellular dysfunction that occurs guides the approach to an athlete's eventual RTP. Current understanding of the pathophysiology of concussion supports the neurometabolic cascade theory, which has been well described elsewhere[7,8] (please see the article by Schrey and colleagues elsewhere in this issue for details). It theorizes that concussions result in microscopic cellular damage and disruption of the normal equilibrium of the cellular membrane. This disruption and axonal stretch causes a cellular depolarization and release of excitatory amino acids and disrupts the ionic balance in the cell. The Na^+/K^+ ATP-dependent pump initiates to regain the cell's normal ionic balance. This energy-dependent, glycolytic pathway eventually leads to lactate accumulation. Ca^{2+} rushes into the mitochondria and inhibits oxidative processes. These intracellular processes lead to, and are accompanied, by secondary damage to the axonal substructure.[7]

There is an initial hyperglycolysis that occurs immediately after the injury and may last up to 30 minutes. This hyperglycolysis quickly transforms into a glucose hypometabolism that may last for days. In more severe brain injury, there is well-described impaired cerebral blood flow that limits the ability of the cells to acquire more glucose.[7,9–11] The increase in the brain's intracellular demands, combined with a supply-side limitation in glucose, is theorized to lead to the clinical features of concussion. This supply-and-demand mismatch may explain the common complaint that mental and physical exertion exacerbate or uncover symptoms in patients who are asymptomatic at rest.

EPIDEMIOLOGY AND RTP

Concussion epidemiology data have been reported for multiple sports, age groups, and competition levels[12–17] (see the article by Jinguji and colleagues elsewhere in this issue for further details). The highest overall number of concussions occur in men's football and in women's ice hockey. Recent data indicate the overall rate of concussion in high school to be 0.23 per 1000 athlete exposures.[18] The collegiate rate is higher at 0.43 per 1000 athlete exposures.[12]

The terms simple and complex are based on duration of symptoms, and the Zurich consensus statement states that these terms have limited usefulness.[19] There is no mechanism to prospectively predict which athletes will have prolonged recoveries, making this distinction of limited value. Discussing recovery timeframes with athletes is reasonable, because 80% to 90% of youth athletes improve within 7 to 10 days.[19] However, all concussions are not equal, and a 3-month recovery is different than a 3-day recovery. It is not yet possible to factor these differences into practical management, and there is a limited amount of information available specifically for recovery from more severe concussions.[20]

Athletes with a history of previous concussion are more likely to have repeat concussions than their nonconcussed counterparts.[21] Athletes with 3 or more concussions are more than 3 times as likely to suffer a concussion than their

nonconcussed counterparts.[21] Athletes with a history of more than 3 previous concussions have a more severe sideline presentation, including LOC, anterograde amnesia, confusion, and overall number of symptoms.[22] In a large study of nearly 17,000 high school and collegiate athletes, the rate of repeat concussion within the same season is reported to be 3.8%, and 79.2% of these athletes with second concussions occurred within 7 days of the first concussion.[17] These are compelling data to suggest that even a youth athlete in whom symptoms resolve rapidly should not RTP within 7 days of the initial concussion, although this is not a defined standard of care. There is no current way to predict which athletes are at risk for the repeat first-week concussions.

Modifying factors associated with prolonged PCS include history of depression, mental health disorders, migraine, headache disorder, attention deficit and hyperactivity disorder, learning disability, and sleep disorders.[23–25] **Table 1** summarizes the full spectrum of modifying factors associated with PCS.[19] These modifying factors should be identified in athletes presenting with concussion, but there is no clear way of using them in RTP decisions.

SAME-DAY RETURN-TO-PLAY

There is consensus that no youth athlete with a concussion should return to play on the same day as the initial injury.[19] Multiple national and international organizations have position statements or clinical papers that support this position, including the National Athletic Trainer's Association and American Academy of Pediatrics.[26] The AAN has issued a practice reference sheet and is preparing an updated guideline for late 2011.[27] The National Collegiate Activities Association (NCAA) has mandated that schools have concussion management plans and have precluded same-day

Table 1
Modifying factors in concussion

Factors	Modifiers
Symptoms	Number Duration (>10 d) Severity
Signs	Prolonged LOC, amnesia
Sequelae	Convulsions
Temporal	Frequency Timing Recency
Threshold	Repeated concussions with less impact Slower recovery
Age	Children and adolescents
Comorbidity	Migraine, depression, or other mental health disorders, ADHD, LD, sleep disorders
Medications	Psychoactive drugs, anticoagulants
Behavior	Dangerous style of play
Sport	High-risk activity, contact and collision sport, high sporting level

Abbreviations: ADHD, attention deficit hyperactivity disorder; LD, learning disability.

From McCrory P, Meeuwisse W, Johnston K, et al. Consensus statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. Br J Sports Med 2009;43(Suppl 1):i79.

RTP, stating in their most recent Sports Medicine Handbook that "Student-athletes diagnosed with a concussion shall not return to activity for the remainder of that day. Medical clearance shall be determined by the team physician or his or her designee according to the concussion management plan."[28]

The current Concussion in Sport consensus statement states that same-day RTP can be considered in select, adult populations in which there is sideline access to experienced physicians, neuropsychologists, neuroimaging, and sideline access to neurocognitive assessment. The National Football League has stated that "Once removed for the duration of a practice or game, the player should not be considered for return-to-football activities until he is fully asymptomatic, both at rest and after exertion, has a normal neurologic examination, normal neuropsychological testing, and has been cleared to return by both his team physician(s) and the independent neurologic consultant."[29] The principles of asymptomatic RTP are still in effect in this select scenario, and full symptom and cognitive recovery must take place before same-day RTP may be considered. In clinical practice, this scenario is limited to professional sports and an adult population.

SECOND-IMPACT SYNDROME

The most devastating complication in sports concussion is second-impact syndrome (SIS). This is a clinical syndrome in which an athlete suffers a concussion and returns to play before the symptoms have resolved. A second traumatic insult occurs, usually involving a smaller impact, and a rapid deterioration in neurologic status is observed, leading to death within minutes from primary cerebral swelling and cerebellar herniation. Imaging and autopsy classically reveal no intracranial bleeding. These clinical factors define SIS.[30] There are increasing numbers of cases that involve a small amount of intracranial bleeding in the presence of massive cerebral swelling. These small hematomas do not account for the severity of the clinical outcomes. Most of the reported cases have been in athletes less than 18 years old, although there are cases of older athletes within the literature.[31,32]

The rapidity of neurologic decline and the extreme nature of the brain swelling suggest a problem with the brain's ability to autoregulate, which corresponds with the current understanding of concussion pathophysiology. In a rat mild traumatic brain injury (mTBI) model, all animals received a first mTBI and then a second was induced at intervals of 1, 3, or 7 days after the first. No rat deaths were reported in the control group (single mTBI), whereas 10% of rats died in the double-impact group. In addition, the cellular and mitochondrial changes seen were more significant than those with a single injury.[10] Rat model data suggest that the glucose metabolism may be altered up to 10 days after the initial injury and Ca^{2+} derangements up to 4 days after single injury, and concerns exist that these time periods may be longer in humans.[7] These animal model findings help support the concept of no same-day RTP, although further research is necessary to help identify the application of this theory in humans.

Probable or definite SIS is exceedingly rare and no true incidence is known. Arguments have been made that RTP protocols are based largely on fear of SIS.[33] The cases of SIS are devastating to families and communities and are highly publicized in the medical and lay press. It is the most severe outcome of concussion and cannot be ignored. There is no evidence to suggest that athletes with a history of multiple concussions have a greater likelihood of SIS, although the small number of reported SIS cases makes this a tentative statement. Nonetheless, there are many more common consequences of premature RTP and early exertion, like prolongation of symptoms and poor neurocognitive performance.[34,35]

CURRENT RTP PROTOCOL

No athlete should RTP while still suffering from symptoms. This recommendation is consistent throughout the literature. The Zurich consensus statement outlines a framework from which to approach an athlete who has recovered from the symptoms of a concussion and is ready to begin working toward a return to competition (**Table 2**).[1] Each stage should take 24 hours before advancing to the next stage. If athletes experiences a return of their symptoms, they should stop advancing and return to the previous stage. They should remain at the previous stage for 24 hours before attempting the next stage in the RTP protocol. This protocol takes approximately 1 week to complete, assuming that the athlete remains asymptomatic. However, this protocol may take weeks or months to complete depending on the athlete's response to the increasing exertion.

There is some discussion in the Zurich consensus statement that the elite, adult athlete may RTP more rapidly than the nonelite athlete.[1] This concept was recently echoed by Putukian and colleagues.[36] This idea is based more on access to experienced medical professionals than on a difference in pathology or recovery. For example, a professional or NCAA athlete may have immediate, daily access to a trainer, neuropsychologist, physician, and concussion specialist. This access combined with the high experience level of the medical team may translate into faster RTP. However, this concept of rapid RTP is controversial and currently has no level I evidence to support it. This expedited model of RTP currently has no role for the nonelite, youth athlete.

Athletes who have had prolonged postconcussion syndrome may take longer to progress through these stages, although this may be because of underlying deconditioning from lack of activity rather than a difference in neurocognitive recovery. The provider should be aware of these issues to prevent other injuries from overzealous

Table 2
RTP progression

Rehabilitation Stage	Functional Exercise at Each Stage of Rehabilitation	Objective of Each Stage
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming, or stationary cycling keeping intensity <70% MPHR. No resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head-impact activities	Add movement
4. Noncontact training drills	Progression to more complex training drills (eg, passing drills in football and ice hockey). May start progressive resistance training	Exercise, coordination, cognitive load
5. Full-contact practice	Following medical clearance, participate in normal training activities	Restore confidence, assessment of functional skills by coaching staff
6. RTP	Normal game play	

Abbreviations: HR, heart rate; MPHR, maximum predicted heart rate.

From McCrory P, Meeuwisse W, Johnston K, et al. Consensus statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. Br J Sports Med 2009;43(Suppl 1):i79.

athletes returning to full competition before they are physically prepared. Athletes who have months of symptoms should start a conditioning and training program similar to athletes with musculoskeletal injuries that require significant loss of participation time.

NEUROPSYCHOLOGICAL DATA AND RTP

Neuropsychological (NP) testing abnormalities are well described in the literature, and the National Academy of Neuropsychology has issued a position paper on the use in concussed athletes.[37–39] Because the treatment protocols have changed to restrict any symptomatic athlete from returning, the role of NP testing is still debated. Several studies have found that NP abnormalities resolve in parallel with symptom resolution. If this were true in every case of concussion, the usefulness of NP testing might be called into question. There are several other studies that indicate that NP testing may resolve more slowly than symptoms.[40–42] This would suggest that NP testing offers another degree of assurance that an athlete has fully recovered and can begin an RTP program. Athletes who undergo NP testing tend to RTP more slowly than their nontested counterparts.[43]

NP testing results are not a substitute for clinical judgment and a return to baseline on NP testing is only 1 component of RTP decision making. NP testing becomes increasingly useful as the duration of symptoms expands to track neurocognitive improvement. The neuropsychologist also has the ability to screen for comorbid and preexisting conditions like anxiety, depression, undiagnosed learning disability, and others that may affect clinical decision making and potential interventions. In student athletes, NP testing may help guide school accommodations and help more objectively document cognitive dysfunction. Student athletes who have severely prolonged PCS should have clear medical and NP documentation of their condition as they move forward to prevent problems during the high school or college admissions process.

PSYCHOLOGICAL CONSIDERATIONS

As acute symptoms move into chronic PCS, the interplay of nonorganic, social, and psychological factors becomes increasingly important. Jacobson discusses the issues of physiogenesis and psychogenesis as they relate to PCS.[44] Premorbid mental and physical health status were more predictive of persistent PCS than head injury severity (as defined by LOC and posttraumatic amnesia) in a study of adults with mild TBI.[45] PCS has also been described as an environmental stress combined with an individual predisposition to the injury or syndrome.[46] Preconcussion depressive symptoms may alter baseline neuropsychological testing.[47] Interventions to help an athlete address these issues include consulting a sports psychologist, biofeedback, visualization exercises, support groups, and reintegration into social groups.

Recovery from sports injuries are classically believed to follow the stages of grief hypothesized by Kübler-Ross,[48] including denial, anger, bargaining, depression, and acceptance.[48] The grief model in athletes tends not to involve the denial stage prominently.[49] Wiese-bjornstal and colleagues[50] created a model to identify the factors affecting an athlete with a sports injury. A comparison study between athletes with anterior cruciate ligament (ACL) injuries and concussion found that both groups had increased depression scores. The ACL group had more significant and longer-lasting changes. The concussed group had depression scores that lasted approximately 1 week and a more severe total mood disturbance at day 4.[51] This finding may reflect that the depression experience by the acutely concussed athlete is a direct

result of the concussion, rather than a situational depression. There is significant overlap between the symptoms of depression and those of PCS as shown by Iverson[52] who found that almost 50% of depressed patients without current concussion endorsed symptoms at a clinically significant level for PCS as defined by the DSM-IV. Alternative diagnoses must be ruled out to decrease attribution error (ie, all subsequent symptoms attributed to the concussion). To some extent, stigma still surrounds anxiety and depression and it may be more socially acceptable for an athlete and/or their families to attribute symptoms to a sports injury rather than to an underlying psychiatric condition.

In the professional athlete, these issues include the concern of loss of livelihood. Media exposure of the injury adds to the pressure on both the athlete and the treating physician to return an athlete as quickly as possible. As with all team physicians, the primary responsibility is to athletes and their health.

Athletes returning to play face several issues not directly related to their concussion. These issues commonly include fear of repeat concussion, concern for future disability, and performance anxiety. Many athletes suffer from the loss of a sense of invincibility and decrease in overall health during the recovery from concussion. Isolation and lack of social support during the removal from practice and play is a common stressor for concussed athletes. There is increasing awareness about the role of anxiety and depression as direct sequelae of concussion. Concern exists that the treatment of concussion (prolonged rest) may lead to depressed mood, fatigue, and irritability. Aerobic, anaerobic, and resistance exercise have beneficial mood effects and alter the brain's neurochemistry. The removal of exercise combined with the cascade of neurometabolic changes may exacerbate these mood disturbances. Athletes in whom low-grade symptoms linger for several weeks may consider a trial of gentle aerobic exercise in efforts to remove these iatrogenic causes for prolonged PCS. A recent preliminary safety study on concussed patients with more than 6 weeks of symptoms using an incremental treadmill protocol showed that the athletes were able to exercise at near age-predicted heart rate maximum without symptom exacerbation. The patients had symptom improvement that corresponded with their peak heart rate.[53] This study is promising but small ($n = 12$). Larger numbers of patients and reproducible results are needed before expanding this to nonexperimental populations. Athletes should not be returned to a contact situation until they are fully asymptomatic.

It is wise to discuss these issues proactively with an athlete as they are beginning their RTP protocols and intervening early to limit any undue psychological distress that an athlete may encounter.

PERSISTING HEADACHE AND RTP

The most common symptom after concussion and in PCS is headache (please see the article by Blume and colleagues elsewhere in this issue for further details). Given the functional problems caused by headache, increasing numbers of concussed athletes are started on prescription medications. As these athletes improve and become asymptomatic, the question arises as to how to return medicated athletes to play (ie, are they asymptomatic simply because of the medication?). To the author's knowledge, no literature exists to guide this decision. Several of the medications used for headache in this population may require several days to weeks to taper. It is this author's recommendation to allow athletes with PCS who are started on medications beyond simple over-the-counter medications to remain asymptomatic for at least 1 month before progressing aerobic exercise. If symptoms return, it is up to the treating

physician to use clinical judgment to determine whether the symptoms are caused by incomplete resolution of symptoms, deconditioning, or a newly diagnosed posttraumatic headache disorder. Consultation with a headache specialist can help guide these decisions.

LONG-TERM SEQUELAE

A significant concern for athletes with multiple concussions is the possibility for long-term deficits. Although most athletes with concussion have no lasting deficits, there are increasing reports of long-term effects of concussion in certain athletes. These effects may include neuropsychiatric, somatic, and cognitive impairment.[21,54] Chronic traumatic encephalopathy (CTE) has become an increasingly recognized phenomenon. It is likely that CTE was the cause of dementia pugilistica and punch-drunk syndromes. Omalu and colleagues[55–58] have published several case reports with confirmed CTE. Cantu and colleagues[59] at the Sports Legacy Institute have published widely on this as well.[60] Factors common to cases with confirmed CTE include professional sporting career, a history of multiple subconcussive head impacts, and symptomatic concussions.

SEASON TERMINATION AND RETIREMENT CONSIDERATIONS

Several published guidelines for the termination of a season exist, although they are based on concussion grading scales that are no longer the standard of care (**Table 3**).[61–63] There are also published reviews that have addressed this topic.[64,65] As previously discussed, concussion management is individualized and algorithmic approaches to retirement should be avoided. Nevertheless, an understanding of the historical framework may help the clinician to formulate management plans for their multiply concussed athletes. The previously published guidelines are based heavily on LOC, which has limited correlation with symptom duration or severity. The AAN is issuing new guidelines later in 2011 and no longer uses concussion grades.[66]

Decisions regarding RTP in athletes with multiple concussions are based on multiple factors. Each subsequent concussion makes an athlete statistically more likely to sustain a further concussion, and concerns exist regarding the potential for progressively long symptom duration after multiple concussions.[21,67,68] There is no defined number of concussions that is too many. Many of the data available on epidemiology indicate that previous history of concussion increases the risk for future injury. These factors should be discussed at length with the patient. The 3-strikes-and-out paradigm is still a commonly held approach toward concussion management. As with most RTP concepts, this is based on expert opinion and a paucity of literature. There is no evidence to suggest that athletes with more than 3 concussions are at increased risk for PCS.[69] There is an absence of evidence regarding athletes with prolonged symptoms after a first concussion to suggest that they are at risk of similar clinical trajectories for subsequent concussions.

Zemper[68] prospectively found that high school and college athletes with a history of self-reported concussion had a nearly sixfold relative risk of future concussions in the following 2 seasons. This study did not analyze for a history of multiple concussions, so dose-response information is unknown. Guskiewicz and colleagues[21] reported that athletes with history of 3 previous concussions were 3 times more likely to have a subsequent concussion. Athletes with 3 or more concussions have more severe on-field presentations after subsequent concussions.[22] Athletes with 3 or more concussions have longer postconcussion symptom duration than athletes without

Table 3
Previous recommendations regarding multiple concussions

	Grade	First Concussion	Second Concussion	Third Concussion
Cantu[63] (2001 revised)	Grade 1 (mild)	May RTP if asymptomatic for 1 wk	May return to play in 2 wk, if asymptomatic for 1 wk	Terminate season, return if asymptomatic next season
	Grade 2 (moderate)	May return to play if asymptomatic for 1 wk	Minimum 1 mo, may return to play if asymptomatic for 1 wk. Consider terminating season	Terminate season, return if asymptomatic next season
	Grade 3 (severe)	Minimum of 1 mo, may return to play if asymptomatic for 1 wk	Terminate season, return if asymptomatic next season	
AAN[81]	Grade 1: no LOC, confusion lasting <15 min	RTP in 15 min if asymptomatic	RTP in 1 wk if asymptomatic. Remove from play if 2 concussions in same day	RTP in 1 wk if asymptomatic
	Grade 2: no LOC, confusion lasting longer than 15 min	RTP when asymptomatic for 1 wk	RTP in 2 wk if asymptomatic	RTP in 2 wk if asymptomatic
	Grade 3: any LOC	RTP when asymptomatic for 1 wk	RTP after 1 mo	RTP after 1 mo or longer, at provider's discretion
Colorado[82]	Grade 1: no LOC, confusion, or amnesia	RTP in 20 min if asymptomatic	RTP if asymptomatic for 1 wk	Terminate season. RTP next season if asymptomatic
	Grade 2: no LOC, confusion, amnesia	RTP after a minimum of 1 wk with no symptoms	RTP after a minimum of 1 mo with no symptoms for 1 wk	Terminate season. RTP next season if asymptomatic
	Grade 3: any duration of LOC	RTP after a minimum of 2 wk with no symptoms	Terminate season. RTP next season if asymptomatic	Terminate season. RTP next season if asymptomatic

Please note that grades of concussions are no longer used for decision making for individual players. This table is presented for historical perspective.

concussion history. Thirty percent of multiply concussed athletes had more than 7 days of symptoms compared with 14.6% of athletes with no history of concussion.[21]

Collins and colleagues[70] found that athletes with $\geq$ 2 concussions had more deficits on the Trailmaking Test and the Symbol Digit Modalities Test when compared to athletes with 1 concussion and athletes with no history of concussion. De Beaumont and colleagues[71] found that retired university-level athletes had deficits on cognitive and motor testing decades after their last reported concussion. This study also revealed abnormalities on neuropsychological and electrophysiologic measures of memory.[71] Covassin and colleagues[72] found a dose-response relationship on ImPACT testing in male and female athletes with more than 2 previous self-reported concussions. Kuehl and colleagues[73] found that athletes with more than 3 concussions scored lower on the bodily pain, vitality, and social functioning sections of the Short Form 36 than did their nonconcussed counterparts.

There are several circumstances in which retirement should be recommended to an athlete. All of the retirement recommendations can be considered level IV evidence and are based largely on expert opinion. Absolute contraindications to return to competition include ongoing symptoms, abnormal neurologic examination, NP testing that has not returned to baseline, or imaging that indicates that the athlete is at increased risk for repeat injury.[64] Given that NP testing is used to determine appropriateness of retirement, it is reasonable to obtain high-quality NP baseline data in athletes with a history of multiple or severe concussions in whom retirement is a potential outcome, as a reference for subsequent RTP decisions. These absolute contraindications are rare but should not be missed. Relative contraindications include symptoms that last months and not days, or decreased injury threshold (concussions that arise from minimal contact).[64]

Cantu[74] proposed that retirement should be considered in the presence of more than 3 concussions combined with increasing recovery times (especially >3 months) and decreasing injury threshold forces. Of similar concern is the athlete who displays several months of symptoms after the first concussion. This scenario has not been well addressed in the literature and no evidence-based conclusions can be made. The literature is beginning to support the widely held clinical assumption that multiple concussions create the potential for long-term sequelae, including cognitive dysfunction, increased symptom report, depression, and, potentially, CTE.[21,59,60,75–77] These concerns should be part of the informed consent as an athlete considers RTP after multiple concussions.

INTRACRANIAL LESIONS AND RTP

Intracranial bleeding is a serious and potentially life-threatening injury. Improved medical care and access to trauma centers ensures that athletes who suffer intracranial hematomas are more likely to survive and may recover without significant disability. In these athletes, the question remains as to when, whether, and how to return them to contact sports.

There is no level I evidence to guide these decisions. The case reports and editorial by Davis and colleagues[78] is an excellent discussion of the considerations for RTP in an athlete with an intracranial bleed. Before consideration of RTP, an extradural hematoma must be fully resolved and the fracture fully healed. In subdural hematomas, the hematoma must be resolved, the brain reexpanded to fill the subdural space, and there must be no residual hygroma. A thorough workup for risk factors must be negative, to include coagulopathy and risk-producing brain abnormalities.[78] It is reasonable to add that a return to normal NP baseline should also be

a prerequisite for RTP consideration. The timeframes mentioned are based largely on healing times for the fracture and the reabsorption times of the hematoma, and are estimated to be 1 year.

There is also no level I evidence to guide a physician considering RTP in athletes after craniotomy. There have been few reports on return to collision or contact sport after craniotomy and many of them are in the lay press. There have been cases of a professional hockey player, professional boxers, an amateur soccer player, and a professional footballer returning to their sport after craniotomy.[79] Expert opinion is that RTP can be considered after complete bony union is documented and neurologic, radiological, and neuropsychological evidence of recovery is documented. RTP may depend on to which sport the athlete is returning. For example, Davis and colleagues[78] did not agree on whether to return a boxer to competition after complete resolution after craniotomy, whereas a soccer player would be returned provided a well-fitted helmet be worn during competition. Rigid bone flap fixation methods are perhaps more stable and may allow athletes to return more quickly, although this has not been studied.

In the author's experience, the decision to return an athlete to competition after an intracranial bleed or craniotomy is done no earlier than 1 year after the injury and is based on the input of a team consisting of a neurosurgeon, neuroradiologist, neuropsychologist, and sports medicine physician.

MEDIOCOLEGAL ASPECTS OF RTP

The Health Information Privacy and Portability Act (HIPPA) defines the framework for communication of patient information. The team physician and the consulting physician are both bound by HIPPA. It is recommended that providers obtain written consent regarding disclosure of patient information as it relates to a concussed athlete. It is common for providers caring for concussed athletes to be asked to discuss the case with trainers, coaches, teachers, guidance counselors, and other physicians. It must be clearly documented that consent to release medical information has been granted before these discussions. Consider having a formal policy based on state law and your institution's legal counsel. Pearsall and colleagues[80] review this and similar issues.

Multiple states now require written clearance before an athlete may return to competition after an acute concussion. In states with legislation regarding written RTP clearance, an athlete may not return without clearance. The difficulty arises in cases in which the team physician or coach is aware that a physician has cleared an athlete and another has recommended no RTP. The team physician should adhere to the standards of care discussed within this article and elsewhere to guide decisions on RTP and obtain specialist consultation in complicated cases. Even in the presence of written physician clearance, if a coach or team physician has concerns that the athlete is still symptomatic, the athlete should be removed from play until it is clear that the athlete is safe to return.

The medicolegal aspects of RTP in multiply concussed athletes or athletes with prolonged PCS are less clear. The main questions in disputed cases are whether an athlete can decide to return to competition despite a medical recommendation to retire or terminate a season, and whether an athlete can sign a liability waiver that removes the risk of future litigation. Both scenarios are fraught with potential for litigation. An athlete returning to sport in a disputed case relies on the team physician and the institution governing that athletic endeavor, combined with expert medical opinion and legal advice.

DISCUSSION

Concussion management needs to expand its literature base to help guide clinical decisions. Current RTP recommendations are based on expert opinion using the available epidemiologic data, pathophysiology theories, NP testing literature, and retrospective clinical studies. The strongest recommendation is that no athlete should RTP while symptomatic. Most youth athletes improve within 7 to 10 days and are unlikely to require specific medical interventions beyond education on acute concussion management and avoidance of repeat injury. RTP should be a medically supervised, stepwise plan that occurs in the course of a week (see **Table 2**).

Athletes with prolonged symptoms require more complex management plans. These athletes may be removed from their activities and social groups, experience difficulties in school and home life, and may suffer from reactive anxiety, depression, and the cardiovascular consequences of prolonged rest. A comprehensive approach to concussion care is vital and aids in smooth RTP and minimizes the effects on school or work. Athletes with multiple concussions or with prolonged PCS should have access to NP testing, psychological intervention, headache management, and expert medical advice.

Given the implications of multiple concussions on future concussion rates and potential for long-term consequences, it is this author's recommendation that athletes with more than 2 to 3 concussions, or with symptoms lasting longer than 2 to 3 weeks, be referred to a physician specializing in concussion, if available. These cases are likely to require further workup, imaging, NP testing, school accommodations, and more involved RTP protocols. Accurate documentation regarding initial activity limitation and eventual RTP guidelines and clearance is a clear part of the current management of concussion, and this is even more critical in states that have passed legislation regarding concussion management.

The future of safe RTP in concussed athletes will ideally involve objective measures of injury and recovery, determination of individual risk based on genetic susceptibility, and a better understanding of the risks for long-term sequelae after multiple concussions. High-quality research is a necessity and will be a responsibility of the overlapping specialties caring for these individuals as concussion management moves forward.

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