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Return-to-Play Guidelines in Concussion: Revisiting the Literature

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Abstract: Return-to-play (RTP) guidelines in concussion management and treatment continue to challenge clinicians, despite recent updates to the protocols and the ongoing media attention. The current guidelines address individualized treatment planning but are difficult to apply to athletes who experience prolonged symptoms, are younger, or have sustained multiple concussions. Recent literature findings have contributed to an improved understanding and applicability of the guidelines while emphasizing a multidisciplinary paradigm in formulating an individualized RTP decision. Successful implementation of the RTP guidelines will ensure that athletes are protected from further injury and return to their baseline functional status.

Keywords: baseline functional status; concussion; concussion management; return-to-play guidelines

Introduction

Return-to-play (RTP) considerations after a sports-related traumatic brain injury continue to challenge primary care physicians, sports medicine specialists, physiatrists, neurologists, and certified athletic trainers. Over the past decade, sports concussion visits to emergency departments have doubled in the 8- to 13-year-old age group, whereas the incidence in the 14- to 19-year-old group has increased by > 200%.[1] This explosion may be related to increased awareness and education of the negative consequences of an undiagnosed concussion. Despite such efforts, a recent study showed that 26.1% of college athletes did not recognize their symptoms after a head injury as being postconcussive symptoms,[2] which suggests a need for further educational intervention. Another study conducted demonstrated that 30.5% of patients who reported having a history of an undiagnosed concussion had a significantly higher mean Post-Concussion Symptom Scale score.[3] This study further suggests that there is a cumulative effect of concussions, and if inappropriately managed it may explain why patients with recurrent concussions are significantly more likely to have a prolonged recovery or fail to be medically cleared to return to play.[4]

Despite the evolution of concussion knowledge, the understanding of the underlying pathophysiology remains unchanged. Namely, a concussion leads to a complex neurometabolic cascade involving altered blood flow, abnormal neural excitation, and ultimately cerebral metabolic disturbance.[5] This consequently results in a functional rather than structural problem, affecting physical, behavioral, emotional, and cognitive function, which is why the treatment of cognitive rest is continually recommended for the amelioration of symptoms.[6,7] Although the RTP guidelines are clinically helpful, they lack the evidence that such universally accepted guidelines should have for the

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management of sports injuries.[6,7] Nevertheless, the current RTP guidelines serve as a reasonably safe protocol that not only emphasizes an individualized approach to concussion management but also considers the known pathophysiology.

At present, questions remain as to the applicability of universal guidelines of RTP after a concussion. The guidelines assume that the treatment goal is to achieve a true asymptomatic state; thus, the guidelines endorse the use of neurocognitive testing, even though testing remains problematic in some populations and ultimately lacks evidential support.

This article explores the current RTP guidelines and evaluations, discusses specific populations, and highlights changes from the previous recommendations that clarify a complicated and multifaceted issue.

Return-to-Play Definition and Guidelines

In 2012, the 4th International Conference on Concussion in Sport updated the 2008 RTP guidelines. The updated guidelines still advocate an individualized approach to concussion management, consisting of a comprehensive evaluation, treating the athlete with physical and cognitive rest, and guiding the athlete through a graded and progressive RTP exercise regimen.[7] After symptoms resolve and neurocognitive testing returns to baseline, the postconcussion RTP exercise protocol follows 6 incremental stages of stepwise increase in exertion and physical challenges from no activity and cognitive rest to RTP (Table 1). The student-athlete advances to the next stage only if the designated exercise is completed without development of symptoms. However, if postconcussive symptoms occur at any stage, the athlete is to repeat the previous asymptomatic level of exercise and reattempt the new stage after a 24-hour rest period. This progression is designed to increase the athlete's heart rate and incorporate more complex movements, while increasing the intensity of the exercise and adding tasks of coordination.

When an athlete progresses through the first 5 stages and remains asymptomatic, return to play may be recommended and can occur at the earliest within 1 week. No athlete, whether elite or non-elite, should return to play on the same day that the concussion occurred,[6,7] as studies have shown that collegiate athletes are at risk of developing prolonged neurocognitive deficits if they return to play the same day.[8,9] Furthermore, no athlete should return to play while taking a pharmacological agent that may mask symptoms of a concussion.[7]

Currently, there is no evidence to determine how quickly an athlete should return to play when the athlete experiences prolonged symptoms or cannot reach an asymptomatic status. The consensus guidelines state that an athlete must be asymptomatic prior to return to play; however, the practical applicability of the "asymptomatic" status is difficult to achieve in clinical management and in progressing athletes through the RTP protocol.[10,11] Postconcussive symptoms such as fatigue, irritability, headaches, poor concentration, and sleeping difficulties can be a baseline status in the nonconcussed population at rest and with exercise.[10] For example, in patients with attention deficit disorder, it may be difficult to distinguish baseline impaired concentration from poor concentration due to concussion, particularly in young patients who are improving and are close to their baseline. Similarly, patients underestimate the severity and frequency of preinjury symptoms and attribute their postconcussive symptoms to their recent head injury, which complicates the clinical decision-making process.[10] In addition, baseline psychological distress can confound neurocognitive symptoms,[12] which may preclude athletes from return to play. Thus, it is vital to gather additional information regarding the patient's baseline status from parents, coaches, athletic trainers, and teachers. Having baseline neurocognitive and concussion symptom scores can also be of value and assist in making RTP decisions.

Although the guidelines are clear for not playing on the same day of a concussion and using a graded RTP exercise program, a precise definition of and recommendation for cognitive rest beyond the protocol is lacking. Most authorities would agree that a student-athlete must be able to engage in and perform school activities while starting an RTP exercise program; however, how cognitive rest is implemented is still being debated, and recommendations are considered by some authorities to be an art rather than a science. Thus, what approach should we recommend? Should the athlete avoid all cognitive tasks that cause symptoms, or rather be guided by these symptoms and study to the point of a minor headache before taking a rest? Or should the athlete work through minor symptoms by taking acetaminophen and continuing to do schoolwork? These approaches reflect different practice philosophies and training paradigms, but they lacked evidence or support until recently. The first prospective study on the effect of cognitive rest showed that those engaged in higher levels of cognitive activity experienced significantly longer recovery times.[13] Clinical research has begun to explore whether cognitive activity or rest leads to better clinical outcomes,[14] but there have been problems in trying to infer causation due to suboptimal study designs in investigating concussion outcomes.[15,16] Recent prospective

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Table 1. Graduated Return-to-Play Protocol

Rehabilitation stage	Functional Exercise at Each Stage of Rehabilitation	Objective of Each Stage
1. No activity	Symptom-limited physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming, or stationary cycling keeping intensity $<$ 70% of maximum permitted heart rate No resistance training	Increased heart rate
3. Sports-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 or ice hockey) Start resistance training	Exercise, coordination, and cognitive load
5. Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return-to-play	Normal game play	

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data have helped to define the type of cognitive rest that leads to shorter recovery times.[13] Additional clinical outcome measures investigating such approaches would better enable a clinician to recommend an evidence-based treatment plan that will ensure an improved recovery course.

Return-to-Play Evaluation and Approach

To arrive at an accurate RTP decision, clinicians should conduct a comprehensive postconcussive evaluation, including an accurate account of the event, a symptom history, a physical examination, a balance assessment (such as the Balance Error Scoring System or the more sophisticated force plate technology), a visuomotor assessment, and imaging and neurocognitive testing if warranted. The Sports Concussion Assessment Tool (SCAT3) is a standardized instrument used on the athletic field sideline and includes the 22-item Post-Concussion Symptom Scale to help track symptoms (Table 2). For younger athletes whose history may be more difficult to ascertain, a Child-SCAT3 was recently developed to assess those between the ages of 5 and 12 years, although the validity has not yet been determined.

Symptoms of a concussion can be grouped into 4 clusters: migraine (eg, headaches, visual problems, nausea/vomiting), neuropsychiatric (eg, sadness, nervousness, irritability), cognitive (eg, fatigue, difficulty concentrating/remembering), and sleep (eg, difficulty falling asleep, sleeping more/less than usual). There is some overlap among these clusters due to the interrelation of the symptoms; for example, difficulty sleeping at night may cause daytime fatigue, irritability, and problems with concentration. Of note, although pharmacotherapy is an additional treatment tool for prolonged concussion symptoms, medication should be prescribed only by a physician knowledgeable in the treatment of brain injury and there should be frequent follow-up visits and neurocognitive evaluations.

Symptom assessment is inherently difficult as the nature of symptom reporting is subjective and can be affected by the patient's age, motivation, or gender, or by a learning disability. Some athletes may purposely misrepresent their symptoms for fear of losing playing time or due to their misunderstanding of the severity of their head injury. Clinicians should be sensitive to the emotional changes experienced by athletes, and knowing their baseline psychological symptoms can aid in detecting differences in symptoms, as discussed previously. Neurocognitive testing can often provide an objective assessment of an athlete's mental and cognitive health. The more commonly used tests are CogSport, Immediate Postconcussion and Cognitive Test (ImPACT), Headminder Concussion Resolution Index, and Automated Neurocognitive Assessment Matrices, all of which have been validated for a concussion evaluation.[17] These tests assess cognitive functions such as psychomotor and information processing speed, decision making, attention, memory, and learning. Compared with traditional pencil-and-paper tests, computerized neurocognitive tests are easier to administer to large groups and provide a means to gather and store data for future collection and interpretation, while minimizing practice effects.[14] In addition, computerized tests may detect deficits 2 to 3 days after the athlete has recovered from symptoms.[6]

The 4th International Conference on Concussion in Sport acknowledged that neurocognitive testing is of "clinical value and contributes significant information"[7,18,19] for concussion assessment and management. Neurocognitive testing is thought to be sensitive and specific and can demonstrate

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Table 2. Post-Concussion Symptom Scale[a]

Dizziness	0 1 2 3 4 5 6
Headache	0 1 2 3 4 5 6
Nausea	0 1 2 3 4 5 6
Vomiting	0 1 2 3 4 5 6
Balance problems	0 1 2 3 4 5 6
Trouble falling asleep	0 1 2 3 4 5 6
Sleeping more than usual	0 1 2 3 4 5 6
Drowsiness	0 1 2 3 4 5 6
Sensitivity to light	0 1 2 3 4 5 6
Sensitivity to noise	0 1 2 3 4 5 6
More emotional than usual	0 1 2 3 4 5 6
Irritability	0 1 2 3 4 5 6
Sadness	0 1 2 3 4 5 6
Nervousness	0 1 2 3 4 5 6
Numbness or tingling	0 1 2 3 4 5 6
Feeling slowed down	0 1 2 3 4 5 6
Feeling like 'in a fog'	0 1 2 3 4 5 6
Difficulty concentrating	0 1 2 3 4 5 6
Difficulty remembering	0 1 2 3 4 5 6

[a]Severity grade: 0 = none, 1–2 = mild, 3–5 = moderate, 6 = severe.
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deficits that are still present despite the athlete's reporting symptom resolution.[20] One study showed that if athletes received ImPACT testing within 2 to 3 days of the concussion and if results were combined with symptom assessment, a short or prolonged recovery could be predicted in approximately 73% of the athletes tested.[21] Usually, cognitive recovery coincides with recovery from symptoms, but when it does not, cognitive recovery more often follows symptom recovery rather than preceding it.[6] Even when the patient is "asymptomatic," there is no guarantee that full recovery has been achieved.[22,23] Makdissi et al[24] found that approximately 35% of athletes continued to display significant cognitive deficits after symptoms had resolved. Hence, neurocognitive testing aids in preventing an asymptomatic and seemingly recovered postconcussive athlete from returning to play prior to cognitive recovery.

Neurocognitive testing should be interpreted only by experienced clinicians, as inaccurate assessment of the results can lead to an athlete's being cleared for play prior to achieving recovery or, conversely, an athlete's being kept from returning to play when recovery has been achieved. Although not necessary for RTP, having baseline neurocognitive testing can be helpful in the overall interpretation of the results and making appropriate recommendations for the patient.

Neurocognitive testing cannot be used as the sole source for concussion management and RTP decisions because the tests have limitations. For example, tests such as ImPACT are criticized for the lack of prospective controlled studies for detecting "impairments in a significant percentage of athletes once symptom-free, as measured by a symptom checklist."[25] In addition, there is a lack of evidence in the medical literature that baseline neurocognitive testing in the management of sports-related concussion can modify any RTP risks.[25] One study found that 38% of athletes scored either in the normal range or within their baseline ImPACT score when they were "clearly" symptomatic, attributing the findings to learning effects of the athlete, operator error, or lack of sensitivity inherent to the test.[21] Further research is needed to help determine the utility and limitations of neurocognitive testing in the postconcussive athlete. In the absence of neurocognitive or other formal testing, the 4th International Conference on Concussion in Sport guidelines recommend a more conservative approach.[7] The literature shows that there is no single direct measure for recovery, and clinical RTP decisions are based on multifactorial assessments[26,27] and require a multidisciplinary approach for the appropriate management and treatment of concussion over several follow-up evaluations.

Management Considerations in Specific Populations

With RTP guidelines, it is difficult to establish a standardized plan that can be implemented for all athletes. Research continues to show that specific populations may have complicated recoveries, notably athletes who have had a previous concussion,[28] have migraine-like symptoms at presentation,[29] have a learning disability,[30] or are young[31] or female.[30,32] Clinicians should be familiar with these populations and with the types of patients who tend to have a prolonged recovery. Specific management and treatment for special populations can assist in preventing long-term comorbidities.

Multiple Concussions

Return-to-play decisions can be more challenging with athletes who have sustained multiple concussions, who participate in high-risk contact sports such as soccer, football, hockey, lacrosse, wrestling, rugby, and boxing, and with athletes who are playing positions that make them more vulnerable to injury. Clinicians should gather important details regarding each concussion, such as the nature and severity of the injury, and the time frame of the postconcussive symptoms. In addition, the time frame for when each successive concussion was sustained is also important, as management differs if concussions are sustained weeks, months, or years apart.

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Clinical studies have shown that sustaining a head injury is correlated with ≤ a 4-fold increased risk of reinjury.[33] Guskiewicz et al[8] noted that collegiate athletes had a positive correlation of reinjury with each subsequent concussion; 1 concussion increased the risk of reinjury by 1.5, 2 concussions by 2.8, and ≥ 3 concussions by 3.4. In addition, reinjury was noted to occur within 7 to 10 days following a concussion.[8] Another study noted that ≥ 3 concussions increased the risk of experiencing on-field markers, such as loss of consciousness, anterograde amnesia, and confusion after a subsequent concussion.[28] Other studies have demonstrated increased time lost from athletic participation for each subsequent concussion sustained,[7] a prolonged recovery,[4,8,34–36] and a longer duration of symptoms and time to return to play.[4,26] It is unknown if these findings are a consequence of athletes being returned to play prior to full recovery or of athletes having an incomplete rehabilitative treatment, as the symptoms of a concussion, such as slowed processing and reaction time, predisposes one to reinjury.

The number of concussions sustained has also been associated with athletes who report an increased number of postconcussive symptoms at baseline with no recent history of a concussion.[37,38] It is unclear if this is a result of a causal relationship or whether athletes with a history of a concussion are more likely to report symptoms or are more sensitive to the symptoms experienced.[38] Although a history of only 1 concussion does not appear to result in prolonged neurocognitive impairments, a history of ≥ 2 concussions sustained has been associated with a prolonged postconcussive symptoms and neurocognitive recovery[8,39,40] in addition to prolonged recovery of balance or visuokinetic integration.[41] Decreased neurocognitive function has also been associated with a higher number of concussions[42]; however, this has not been consistently reported.[43–45] Long-term prospective studies are necessary to determine the possibility of cumulative effects of concussions on neurocognitive function.

Evidence regarding the potential for cumulative effects of concussions on neurocognitive function has been evaluated by functional magnetic resonance imaging (fMRI). A study compared 20 male athletes with ≥ 2 concussions with matched controls on neuropsychological assessment and fMRI scanning when performing a task. Minimal differences were noted between the 2 groups.[46] In another study, Elbin et al[47] did not identify differences in activation patterns on fMRI between athletes with multiple concussion and controls.

Long-term consequences of repetitive concussive injuries could potentially increase the risk of depression, memory difficulties, and early onset of Alzheimer's disease.[48] More recently, the possibility that repetitive brain injuries can lead to neurodegenerative diseases such as chronic traumatic encephalopathy (CTE) has been recently highlighted by the media. Chronic traumatic encephalopathy results from tau protein deposition in the brain, which causes a progressive neurodegenerative decline in memory, cognition, and mood. At this time, evidence of CTE is based on a clinical examination of the constellation of symptoms and can only be confirmed via autopsy and pathologic findings. Currently, the incidence is unknown. Prospective studies are needed to determine if CTE is a manifestation of long-term cumulative effects of multiple concussions.

Return-to-play guidelines are difficult to apply for athletes who have sustained multiple concussions. Because we know that concussions increase the risk of sustaining additional concussions, when an athlete presents with such a history clinicians should take a detailed history, monitor symptom progression and neurocognitive recovery closely, and, more importantly, be conservative in their management. The clinician must also discuss with the athlete and/or parents/guardians the issue that returning to play in a contact sport, even after resolution of symptoms, continues to predispose the athlete to reinjury. Educating patients on reinjury and the potential risks of developing worsened concussion symptoms and prolonged recovery with reinjury is essential.

Younger Athletes

Concussions in children must be addressed differently from those in adults for several reasons. Comparatively, younger athletes who sustain a concussion exhibit delayed recovery[31,49] and have more significant neurocognitive impairments[14,22,50] that can persist after resolution of clinical symptoms. It is believed that having an underdeveloped skull, increased head-to-neck proportion, and poorly developed cervical musculature results in greater injury to a child's brain when subjected to the same impact force.[51–53] Children are typically evaluated not in a professional setting but rather in the community, where treatment knowledge and expertise may be limited.[51] This necessitates a more conservative approach to care, as recovery inherently takes longer in children and adolescent athletes.[51] Most concerning is that children are more likely to develop more severe symptoms if they sustain a new injury prior to complete resolution of the initial head injury. All states now require young athletes to be removed from play if they are suspected of having a concussion and they cannot return to play until cleared by a health care professional knowledgeable in the treatment of concussion.

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The 4th International Conference on Concussion in Sport questioned the applicability of RTP guidelines in 10- to 13-year-old athletes. Because children describe their symptoms differently from adults, the Child-SCAT3 was developed to assess these differences.[7] This test is similar to the SCAT3, but differs in that it uses simpler questions to assess cognitive deficits; for example, it asks the child to state the days of the week in reverse order, whereas the SCAT3 asks for the months of the year. The Child-SCAT3 also considers the parent's or guardian's report of the child's symptoms in addition to the child's report, but clinicians should note that symptoms may be underreported by parents as well as by children.[54–57]

Neurocognitive testing may also assist in determining when it is appropriate for the child to return to school. But it is important to recognize that children and adolescents undergo rapid cognitive development and therefore the testing may need to be performed several times during the course of their recovery. Also, the testing is useful only if the results are interpreted by a trained professional who can make age-appropriate recommendations. School personnel should understand that recovering students may not be able to perform at expected levels until they return to their neurocognitive baseline.[58] When possible, important tests such as final examinations or the Scholastic Assessment Test (SAT) should be postponed, as lower-than-expected test scores may occur that are not representative of the student's true abilities.[58–60] For younger students for whom college preparation is not currently an issue, further testing may be suspended while they are still symptomatic, with their grades instead being based on homework and the test scores obtained prior to the concussion.[58]

Once concussion symptoms have improved and the child is able to perform cognitive tasks without exacerbation of symptoms, a gradual return to school is warranted,[51,59–61] although complete resolution of symptoms is not necessary.[61] The 4th International Conference on Concussion in Sport recommends that a young athlete should be able to perform schoolwork prior to resuming sports activities (ie, be asymptomatic in activities of daily living before returning to play). However, the statement did not address return-to-school guidelines or recommend modifications while in school. An interdisciplinary approach is especially needed for school reintegration and may at times require a 504 plan (a plan developed by the school and parents that provides school accommodations for a child with a disability) for effective implementation. Modifications in the young athlete's school attendance can include temporarily limiting the class schedule to partial days or to only a few core classes. Depending on the timing of symptoms, young athletes may need to arrive at school later in the morning to allow for more sleep or leave earlier in the day to prevent excessive mental fatigue.[58,59] Regardless of the schedule, it must be individualized to assist patients in meeting their academic demands without worsening their symptoms.[58,60]

Avoidance of overstimulating environments, such as the school cafeteria, which may exacerbate photophobia or phonophobia, can be helpful. Physical exertion, such as in physical education class or from carrying heavy backpacks, should be limited.[58] Additional modifications can include untimed examinations, taking examinations in a separate room, individualized homework assignments, extended time for completing homework, tutoring assistance, and note-taking services. It can be challenging for student athletes to comply with recommendations that limit their recreational activities or are socially isolating. Parents and teachers must balance enforcing these limitations to prevent symptom exacerbation with engaging the student in appropriate academic and social activities.[60]

Behavioral and Learning Disorders

Young athletes with behavioral and learning disorders pose a unique problem in assessing cognitive impairment following concussion. Neurocognitive testing may be useful to assist with RTP decisions as well as with return-to-school decisions, but most published studies regarding cognitive status following a concussion exclude those with attention-deficit hyperactivity disorder (ADHD) or learning disorders (LDs), 2 of the most common behavioral conditions in children.[62] One study found that, at baseline, athletes with ADHD perform worse than their peers in verbal memory, visual memory, and visuomotor processing, and demonstrated longer reaction times and poorer impulse control on ImPACT testing.[62] Athletes with LDs scored similarly to those with ADHD, but impulse control was not affected.[62] Overall, young athletes with ADHD or LD had lower baseline ImPACT neurocognitive scores and higher symptom scores compared with their non-disordered peers.[62,63] Comparison of postinjury scores with baseline scores may provide more accurate information when determining whether such athletes can return to play. Unfortunately, there is a scarcity of information regarding how young athletes with ADHD or LD recover cognitively following a concussion, compared with their non-disordered peers. When baseline neurocognitive measures are not available, RTP decisions are more difficult to make. Establishing

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separate normative data for these populations would be useful.

Gender Differences

Differences in concussion rates continue to vary between male and female athletes, with studies finding that female athletes sustain more concussions than male athletes. Older studies noted a higher risk and incidence of concussion in females compared with their male counterparts,[64–67] and during the course of a 10-year survey of brain injuries sustained in basketball, injuries tripled in girls and doubled in boys.[68] Lincoln and colleagues[69] also reported a higher rate of concussion in female soccer, basketball, and softball participants than in male participants. In contrast, a recent multicentered analysis of self-reported concussion found no difference between male and females for any number of concussions.[39]

There are several theories for the increased risk of concussion in female athletes than in male athletes: (1) female athletes have weaker neck muscles and decreased neck girth[70]; (2) females have different head–neck segment stabilization during head movements, with higher peak acceleration and displacement than in males[70]; and (3) females have a larger playing-ball size to head-size ratio than do males,[71] which predisposes them to concussions.[39] The incidence may also be higher because females are more likely to report more symptoms not only after a concussion[32,72] but also during baseline screenings.[73] Another theory is that the athletic community may be more protective of and concerned about female athletes,[64] in addition to the finding that males are more likely to underreport their symptoms so that they can return to play faster.[39,64]

Studies have also found that concussion symptom presentation differs between male and female athletes. A 2011 epidemiologic study on high-school athletes found no difference between male and female athletes on the number of symptoms reported, time to resolution of symptom, or RTP time.[74] However, females reported more neurobehavioral and somatic symptoms (drowsiness and noise sensitivity) and fewer cognitive symptoms (amnesia and confusion) than males.[74] A study on postconcussion migraines found that females were approximately 2 times more likely than males to report posttraumatic migraine after a concussion and more likely to have prolonged symptom recovery.[75] In another study, female athletes who were matched to males based on the prior number of concussions and age reported a significantly higher aggregate of symptoms at baseline and after a concussion, with a longer return to baseline.[76] Differences in hormones and cerebral blood flow may play a role in concussion severity and outcomes.[77] Neurocognitive testing may also differ between female and male athletes following a concussion. One study reported that females scored higher in verbal memory and lower in visual memory than males,[73] whereas another study reported that females outperformed males on multiple cognitive domains with a similar number of previous concussions.[39]

There is a substantial amount of literature on how gender can affects risks, presentation, and recovery of athletes after a concussion. The 4th International Conference on Concussion in Sport could not reach unanimous agreement on the current evidence available for gender to be a modifying factor for the management of concussion.[7] Whether or not differences exist between female and male athletes, clinicians should consider the studies noting a gender distinction. Future research should focus on examining the clinical aspects of concussion to better individualize treatment paradigms.

Prolonged Symptoms

Most studies have found that complete recovery from a concussion occurs during a period of approximately 1 to 2 weeks.[8,78,79] Up to 20% of patients have a protracted recovery, with postconcussive symptoms lasting $>$ 3 weeks.[80] A qualitative review of the literature found that symptoms lasting $>$ 10 days were generally reported in 10% to 15% of concussions.[51] Various studies found that those with a protracted recovery were more likely to have a preexisting learning disability,[34] migraines,[29] fogginess,[81] psychiatric difficulties such as anxiety or depression,[82] amnesia,[83–85] or loss of consciousness associated with their injury,[8,28] or to be of younger age.[31] In 1 study, athletes who were found to be unconscious after a concussion had a 4.15 higher odds ratio of having a prolonged recovery.[84] In contrast, a multicentered prospective cohort study found that the Post-Concussion Symptom Scale score and all composite scores on ImPACT testing were associated with prolonged symptom duration but not with sex, age, loss of consciousness, or amnesia.[86] Other studies found varying associations between specific symptoms as predictors for recovery time; one found headaches, low energy/fatigue, amnesia, and an abnormal neurologic exam,[7] whereas another study found prolonged headaches (lasting $>$ 60 hours), fatigue/tiredness/fogginess, or the presence of $>$ 3 symptoms.[24]

Given the wide variance in association of specific symptoms with prolonged recovery, clinicians should note that many of the postconcussive symptoms can occur at baseline in patients who did not sustain a concussion. In addition, clinicians should take into consideration that higher

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and more severe ranges of postconcussive symptoms are indicators of prolonged recovery and the need for aggressive management. However, the current RTP guidelines do not address those individuals who do not recover rapidly. The guidelines recommend that concussed athletes not return to play until they are asymptomatic at rest and are able to exercise to the maximum without exacerbation of symptoms. Moreover, there is no evidence that prolonged rest is appropriate in patients with a prolonged recovery. However, athletes who are unable to return to physical activity because rest is indicated, as per the RTP protocol, can experience additional fatigue, reactive depression, and physiological deconditioning.[87] One study found that adolescents with a protracted recovery who participated in a gradual and closely supervised rehabilitation program during the postacute period were able to return to normal lifestyles and sports participation.[88] A similar study published by Leddy et al[89] found that threshold levels of exercise are safe with close monitoring for recurrence of symptoms. Therefore, an individualized program that balances both rest and physical activity should be considered, as it may play an important part in improving some postconcussive patients psychologically.

Leddy et al[89] proposed that postconcussive symptoms are consequently caused by a physiologic dysfunction that fails to return to normal after a concussion. Concussed athletes have been found to have an exaggerated sympathetic nervous system with increased heart rates when compared with controls.[90] In addition, in response to a brain injury, cerebral autoregulation (ability to maintain adequate perfusion with changes in arterial pressure) and blood flow are disturbed,[91] which may explain why symptoms worsen with physical exertion.[89] However, when athletes were exercised near to, or at, the age-predicted heart rate maximum, they did not have adverse reactions, and the overall mean symptom score decreased from baseline and treatment periods.[89] A rehabilitation program that consists of quantitative, individualized, and progressive subsymptom threshold aerobic exercise protocols can improve prolonged postconcussive symptoms and return athletes to full activity.[89] An RTP protocol that is designed to meet the needs of athletes with prolonged postconcussive symptoms should be established as a guide to aid the athlete in safe physical activity and returning to play.

Conclusion

The 4th International Conference on Concussion in Sport contributed minor changes to their 2008 recommendations. Return-to-play guidelines remain clinically helpful and are appropriately conservative while keeping with the known pathophysiology but are yet to be substantiated by clinical evidence. Future research must be prospective and include randomization and control groups to facilitate more clinically applicable conclusions. Although guidelines for evaluation and management of concussion continue to evolve, the current RTP protocol can serve as a guide to apply an individualized treatment plan while protecting athletes from further injury or long-term sequelae.

Conflict of Interest Statement

Rosanna C. Sabini, DO, Dennis N. Nutini, MD, and Marykatharine Nutini, DO, have no conflicts of interest to disclose.

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