The Concussion Clinic: 
A Practical, Evidence-Based Model for Assessment and Management of Sport-Related Concussion

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This article reviews the essential components of a practical, evidenced-based approach to the management of sport-related concussion in an ambulatory care setting. The model presented is based on the core philosophy that concussion assessment and management be approached from the biopsychosocial perspective, which recognizes the medical/physiological, psychological, and sociological factors that influence recovery and outcome following concussion. Based on the biopsychosocial paradigm, we outline a care delivery model that emphasizes an interdisciplinary approach in which the clinical neuropsychologist is a key participant. We discuss the importance of nonmedical, psychoeducational interventions introduced during the acute phase to facilitate recovery after sport-related concussion. Finally, using the local experience of our “Concussion Clinic” as a backdrop, we offer two separate case studies that demonstrate the value of this model in evaluating and managing athletes after sport-related concussion. The overall objective of this paper is to provide an adaptable template that neuropsychologists and other healthcare providers can use to improve the overall care of athletes with sport-related concussion and civilians with mild traumatic brain injury.

Keywords: brain injury, concussion, neuropsychological tests, sport injuries

As is evident from the series of articles appearing in this special issue, concussion is now recognized as a hallmark injury among athletes participating in contact and collision sports (Halstead & Walter, 2010). While the majority of athletes follow an uncomplicated course of recovery after concussion (McCrea et al., 2009), it is now acknowledged that these injuries can result in significant risks during the

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acute phase (Cantu, 2003) and raise the potential for long-term detrimental effects (McKee et al., 2009). The high incidence and pathophysiology of sport-related concussion underscores the importance of developing a well-organized, evidence-based approach to clinical management. Most organized sporting institutions now rely on published consensus statements (guidelines) when implementing protocols for acute concussion triage in the field and policies for determining return to play after concussion (Guskiewicz et al., 2004; McCrory et al., 2009).

Although emergency medicine specialists are involved in the acute evaluation and treatment of sport concussion, outpatient “concussion clinics” are emerging in various ambulatory care settings across the United States. These clinics are being established to provide comprehensive follow-up evaluation and management of concussed athletes. Specialists in these clinics coordinate additional postacute diagnostic workup, direct treatments to manage symptoms, and assist in determining the athlete’s readiness to return to competition.

The chief aim of this article is to provide an overview of a practical, evidence-based interdisciplinary model for the assessment and management of sport-related concussion that we have implemented at our institution, followed by two separate case studies demonstrating the value of this model in treating patients and ultimately improving short-term and long-term outcome for patients. Our hope is that this model might provide an adaptable template that healthcare providers, in any care setting, can use when assessing and managing athletes with sport-related concussion. For purposes of this article, which focuses on sport-related concussion, we will refer to our model as the “Concussion Clinic,” though at our institution the actual designation is “TBI and Concussion Clinic” because we provide care for the full spectrum of traumatic brain injury (e.g., mild, moderate, severe) cases.

**Core Philosophy of Care**

An evidence-based approach to concussion management should be grounded in a biopsychosocial model of care (Iverson, Zasler, & Lange, 2007), which is widely presumed to be the paradigm of choice to (a) drive clinical assessment and decision making from the initial day of injury through follow-up exams and (b) navigate the complex treatment needs for athletes who experience protracted postconcussive symptoms. At its core, the biopsychosocial philosophy provides the principles needed to understand recovery after concussion and the clinical construct of postconcussive syndrome (Iverson, Zasler et al., 2007). A detailed description of the pathophysiology of concussion that represents the biological component of the biopsychosocial model is discussed in other articles contained in this special issue. That pathophysiology is basically depicted as a “neurometabolic cascade” that causes significant neurologic symptoms and functional impairments during the acute phase following concussion (Giza & Hovda, 2001). This paradigm also recognizes the role that psychological, sociological, and environmental factors sometimes play in chronic postconcussion symptom reporting and the eventual risk for PCS (Iverson, Zasler et al., 2007; McCrea, 2007).

The biopsychosocial model also defines the clinical priorities at various phases in the course of care delivery. Accordingly, the significance of any particular component of the biopsychosocial model for treatment may vary considerably when juxtaposed against the emerging symptoms of the athlete. During the acute
phase, we are focused mostly on the early neurologic injury characteristics (e.g., unconsciousness, amnesia, neuroimaging findings) and assessment results that help categorize the overall gradient of injury severity. In most instances, the risk of neurosurgical emergency (e.g., subdural hematoma, subarachnoid hemorrhage) has already been ruled out before our initial evaluation of the athlete in the Concussion Clinic. In other instances, however, that may not be the case, and we are called to act immediately to rule out an underlying neurologic process that may put the patient at risk for serious or catastrophic effects.

Once the presence of serious underlying neuropathological processes has been ruled out, the biopsychosocial model focuses on components of care such as (a) objectively measuring clinical recovery of the patient’s neurological signs and symptoms, (b) monitoring for psychosocial factors that may negatively impact the patient’s natural recovery, (c) using psychological techniques to treat psychosocial factors that may be interfering with recovery, and (d) providing comprehensive education about expected recovery and outcome from concussion. Numerous studies have demonstrated the association between psychological comorbidities, stress, personal resilience, coping, and risk of poor outcome after concussion, including the incidence of postconcussive syndrome (Iverson, Zasler et al., 2007). Depression, anxiety, and somatization are the most common psychiatric comorbidities observed in civilians with chronic symptoms and poor outcome after concussion (Iverson, 2005; Iverson, Lange, Gaetz, & Zasler, 2007; Iverson, Zasler et al., 2007) and may be complicating factors following sport-related concussion.

The biopsychosocial model also lends itself particularly well to scenarios in which the athlete exhibits persistent symptoms and/or a protracted course of recovery that are considered atypical based on their initial injury severity and the balance of neurodiagnostic workup. While PCS is thought to be observed less often in athletes than civilians with concussion (McCrea et al., 2009), it is not uncommon to observe these same factors interfering with recovery and return to normal functioning after sport-related concussion. In those cases, we often look to nonmedical approaches to patient education and treatment.

Fortunately, several studies have investigated the influence of early cognitive-behavioral intervention and treatment for concussion, most of which rely on principles of cognitive-behavioral therapy and effective patient education (Borg et al., 2004; Comper, Bisschop, Carnide, & Tricco, 2005). Existing evidence clearly demonstrates that brief cognitive-behavioral therapeutic interventions delivered during early recovery following concussion reduce postconcussion symptoms and ultimately decrease the risk for PCS (Mittenberg, Tremont, Zielinski, Fichera, & Rayls, 1996; Ponsford, 2005; Ponsford et al., 2002).

The World Health Organization (WHO) Collaborating Center Task Force on Mild Traumatic Brain Injury examined the totality of evidence for nonsurgical interventions and for economic cost for MTBI patients by a systematic search of the literature and a best-evidence synthesis (Borg et al., 2004). Collectively, the evidence ultimately led the WHO Task Force on MTBI to conclude that cognitive-behavioral interventions after MTBI (a) are effective in improving outcome, (b) are most effective when introduced early after injury, and (c) need not be intensive to be effective.

The Concussion Clinic model outlined below is based on what the collective literature cites as best practice for the assessment and management of sport-related
concussion, with the ultimate aim of facilitating the athletes’ recovery, restoring their functional capacity, and safely returning them to gainful participation, when appropriate.

**Other Key Considerations**

Several other important elements underlying the core philosophy of care also warrant consideration before a discussion of the Concussion Clinic’s key providers and mechanics. Not coincidentally, the various medical specialties often involved in concussion clinic models have a significant influence on the overall philosophy of care adopted. We will reference several nuances that we believe have been critical to the overall chemistry and success of our own Concussion Clinic.

First, we consider the overriding perspective of the sports medicine community that any approach to care delivery will primarily focus on rehabilitation of athletes to maximize their functional recovery and expedite their safe return to gainful activity (i.e., sports participation). In the setting of sport-related concussion, the motivations of the athlete and pressures injected into the evaluation by parents or coaches may seem inconsistent with the healthcare provider’s obligation to protect the safety of the patient (i.e., athlete), regardless of circumstance (e.g., state football championship game in 5 days). In some instances, providers may disagree regarding how extensive an athlete’s diagnostic work-up needs be or whether an athlete is ready for competition. These conditions amplify the need for the team of providers within any concussion clinic to respect one another through open dialogue, believe in their model of care, and work hard to clearly and unequivocally present any clinical decisions regarding an athlete’s medical needs and regarding the athlete’s readiness for return. It is also fundamentally important for each member of the care team to clearly understand his or her own role (e.g., consultant, attending physician) and the chain of command defined by the care model (e.g., who ultimately makes the determination about an athlete’s fitness to return to play?).

Second, not only must a team of providers believe in their model of care, it is imperative that their approach be based on the existing evidence for best practice. This requirement calls upon the subject matter expert leading the Concussion Clinic (e.g., physician or neuropsychologist) to remain in step with the rapidly evolving scientific literature that in turn alters the definition of best practice. We strongly encourage our experts to get involved in regional and national forums involved in practice guidelines or policies for sport-related concussion so that we are early adopters of new evidence-based practice policies. By doing so, we have greater assurances that our local clinical model remains ahead of the best practice curve.

Third, the clinical utility of any concussion clinic is in large part based on the practicality of the care model. First and foremost, the clinic needs to be easily accessible to patients, referring physicians, and the organized sports community seeking such services. Perhaps the best illustration of this issue comes from our collaborative work with the emergency department at our institution, which is by far our biggest source of referrals to the Concussion Clinic. Early on, we developed streamlined portals for our emergency department to make referrals to the Concussion Clinic, with our assurances that we would promptly make contact with patients and see them in the clinic in a matter of days. We also reached out to the local sports medicine community via continuing education seminars, print
materials, and distribution of our published literature. Most importantly, the clinic must be based on a model of fast-track efficiency to accommodate a consumer base who expects relatively immediate access and follow-up over short intervals. This necessitated us to develop a clinic track (described below) alternate to our conventional Neuropsychology Clinic, where the wait time for first appointment is routinely 4–8 weeks.

While concussion clinic models may represent a new business stream to conventional neuropsychology practice, the services provided in these clinics will ultimately be evaluated and reimbursed based on their derived value to the patient and larger public health landscape. All healthcare services will eventually be judged based on their ultimate benefit-to-cost ratio (i.e., How did this service directly impact the overall outcome of the patient? Was that impact worth the financial cost of the service?). In addition to maximizing benefit of care, we recommend a strong arm of education, outreach, and prevention initiatives be included in a concussion clinic’s mission. From a basic public health perspective, this translates to disseminating valuable information and tools to the community, rather than simply providing it to patients seen in the clinic.

While these issues may not be so relevant to the hands-on care delivered in the Concussion Clinic, they represent dynamic nuances that require thoughtful consideration in the development of the Clinic’s care delivery model, team of providers, and comprehensive approach to care, prevention, research, and education.

**Key Role of the Neuropsychologist**

The convergence of the biopsychosocial model of concussion and the efficacy of psychoeducational interventions to improve outcome following concussion supports the theory that concussion represents a primary neuropsychological disorder. Some may go so far as to assert that neuropsychologists are uniquely suited to manage the care of concussion patients because of their knowledge and expertise on both the neurologic and psychological factors integral to concussion effects and recovery (McCrea, 2007). As such, you will find a clinical neuropsychologist often playing a lead role in most concussion clinic models, often in partnership with physicians from emergency medicine, neurology, neurosurgery, or psychiatry.

Historically, the role of the neuropsychologist was restricted to the evaluation of cognitive and other complaints following concussion and assisting in the differential diagnoses of PCS (McCrea, 2007). There is no question as to the value of a thorough evaluation by an expertly trained neuropsychologist, given the complexity in the differential diagnoses of PCS. Objective measurement of subjective cognitive complaints, however, is also crucial to documenting and tracking cognitive recovery after concussion, as well as guiding treatment planning as to the need for any occupational, academic, or other restrictions/accommodations based on patients’ cognitive functioning during the acute phase after their injury.

Beyond the acute concussion phase, the trained neuropsychologist should be aware of all factors and comorbidities (e.g., depression, anxiety, posttraumatic stress disorder, substance abuse) that may contribute to the presentation of PCS-like symptoms and consider any and all in the differential diagnoses. Most crucial is an awareness of the nonspecificity of PCS-like symptoms that may manifest in a whole assortment of medical (e.g., chronic pain, sleep disorders, other traumatic
Injuries) and psychological (e.g., depression, anxiety, posttraumatic stress) conditions separate from concussion and PCS.

In most settings, the challenge for clinicians and patients comes at the point of providing systematic, effective treatment for concussion and PCS patients. This includes the evaluating neuropsychologist whose practice often does not extend beyond neuropsychological assessment to intervention and treatment.

**Interdisciplinary Model**

Our Concussion Clinic takes a multidisciplinary approach to evaluation and treatment. Like many models around the country, the Concussion Clinic team consists of a clinical neuropsychologist, physiatrist (specialty-trained physical medicine and rehabilitation physician), and nurse (Concussion Clinic Coordinator). The key to efficient operation of our Clinic is the Concussion Clinic Coordinator, a registered nurse with background in neurosurgical and neurological critical care. The Coordinator is an invaluable liaison to the emergency department, athletic trainers, and referring physicians, while also providing a direct point of care coordination for patients. The Coordinator triages referrals to the TBI clinic and assesses the potential role of the physiatrist, neuropsychologist, or other specialists in the patient's care.

In keeping with the recommendations of the WHO Task Force (Borg et al., 2004), our model is based on the principle that effective intervention should be introduced early, made easily accessible, and be built around supportive, educational approaches that are supported by the empirical literature. As such, the Clinic is designed to accommodate referrals during the acute phase (1–5 days) postinjury. The role of the Concussion Clinic Coordinator is also vital in this regard, as she provides a direct point of contact for referrals (sometimes by a call directly from the emergency department before the patient is released) and can quickly coordinate the initial Clinic visit when the neuropsychologist and physiatrist will jointly evaluate the patient and provide treatment recommendations. Before the first Clinic visit, the Coordinator collects extensive information on the patient's injury and general history, while also securing relevant records and diagnostic studies. In the case of sport-related concussion, the intake process often involves direct communication with the certified athletic trainer or physician, who evaluated the athlete acutely.

The initial Clinic visit typically involves a brief evaluation by the neuropsychologist. The evaluation includes a concussion symptom checklist known as the Concussion Symptom Inventory (CSI; Randolph et al., 2009) and an abbreviated cognitive battery focused on assessing memory, cognitive processing speed, and other functions most sensitive to deficit after concussion. We use a flexible approach to assessment based on the clinical scenario and have incorporated an array of conventional (i.e., “paper and pencil”) and computerized cognitive assessment measures into our assessment model. Measures commonly included in our cognitive test battery often include subtests from the Wechsler Adult Intelligence Scale, 4th edition (WAIS-IV; Wechsler, 2009; e.g., processing speed index and working memory index); Hopkins Verbal Learning Test (HVLT; Shapiro, Benedict, Schretlen, & Brandt, 1999); Trail Making Test, parts A and B (Reitan & Wolfson, 1992); Brief Visuospatial Memory Test-Revised (BVMT-R; Benedict, 1997); Controlled Oral Word Association Test (COWAT; Iverson, Franzen, & Lovell, 1999); and Wisconsin Card Sorting Test (WCST; Wiegner & Donders, 1999). In addition, we sometimes
complement our conventional neuropsychological tests with an array of computerized neurocognitive testing (such as the Immediate Postconcussion Assessment and Cognitive Test, ImPACT). We have not adopted a single computerized battery but use a number of those currently available. The Beck Depression Inventory-2 (BDI-2; Beck, Steer, & Brown, 1996) is often included to screen for psychological distress or comorbidities. In most instances of sport-related concussion, cognitive testing is completed in 1 hr or less.

The neuropsychologist then consults with the Coordinator and physiatrist on findings from the neuropsychological examination and treatment options before providing the patient (and family) immediate feedback and recommendations. The physiatrist typically evaluates the patient from the standpoint of any injuries requiring physical rehabilitation or medical treatment (e.g., anti-inflammatories, antidepressant, mood stabilizer, sleep agent).

Also in keeping with the WHO recommendations (Borg et al., 2004), this intervention model is not typically intensive in terms of sophisticated neurologic workup, advanced neuroimaging, or aggressive medical treatment. The main intervention delivered by the core group is educational and psychological in nature. Various print materials have been developed for patients and healthcare providers, outlining in lay terms what the science tells us about the effects, expected recovery, and recommended treatments of concussion. Medical treatment is prescribed in a smaller percentage of cases.

The Concussion Clinic Coordinator also provides interim supportive follow up to patients over the course of their recovery. A follow-up care plan is arranged based on the patient’s care needs, typically involving brief follow up with the neuropsychologist, physiatrist, or both. In most instances, patients are seen for one or two visits after their initial evaluation, when their progress is evaluated. Follow-up visits consist mostly of reassurance, continued education, and addressing factors (e.g., psychological, social, medical) potentially interfering with recovery.

We have been pleased with the response of both referring physicians and patients to the Concussion Clinic. Emergency medicine physicians, sports medicine clinicians, and other healthcare providers appear to appreciate a systematic model of follow up so that patients do not “fall through the cracks.” This point was embraced more wholeheartedly when we presented to our referring community the compelling evidence on how early intervention and education ultimately improves outcome for the individual patient after MTBI.

The following case studies are presented below to illustrate the Concussion Clinic processes and ultimately the benefits of the model to the patients served. The cases presented were chosen because they highlight how different aspects of the Concussion Clinic (e.g., assessment vs. intervention) have had the potential to
improve patient care. Both cases are presented in a manner that protects the identity and confidentiality of the actual patients. The first case study demonstrates the interval value of the objective neuropsychological examination (i.e., assessment) in detecting abnormalities that otherwise were not apparent and may have created a situation in which the athlete would have otherwise prematurely returned to competition before reaching a full recovery, potentially placing him at risk. Alternatively, the second case study highlights the benefits of supportive education and nonmedical intervention for an athlete who continued to report subjective symptoms following concussion well beyond the point at which recovery was demonstrated on objective testing.

**Case Study 1**

**Reason for Referral**

Patient 1 is a 16-year-old right-handed Caucasian male high school football player referred to the Concussion Clinic for medical management following a sport-related concussion.

**History of Present Illness**

The patient was playing defensive end when he collided with another player and fell to the ground. Although he stood up immediately following the collision, his teammates promptly recognized his ataxia (i.e., severe disturbance of gait and balance) and mild confusion. The school’s athletic trainer and coaching staff quickly escorted him off the field. Witnesses did not observe any loss of consciousness associated with the injury. His last memory before the injury was standing on the sideline, which witnesses estimated was 5–10 min before the injury (representing retrograde amnesia, RTA). His first memory following the injury was leaving the emergency room with his family, which family estimated to be 3 hr postinjury (representing posttraumatic amnesia, PTA). Based on the American Academy of Neurology classification system, the patient sustained a grade 2 concussive injury (no loss of consciousness but symptoms persisting well beyond 15 min; Kelly & Rosenberg, 1997; “Practice parameter: The management of concussion in sports [summary statement]; Report of the Quality Standards Subcommittee,” 1997).

The patient reported no prior history of concussion or more severe brain injury. His medical history was otherwise unremarkable. His developmental history was noncontributory; he had no reported history of developmental learning disability or behavioral problems. His parents indicated that he had always been an above average student. Peer relationships were described as developmentally appropriate. He reported no prior psychiatric history.

**Acute Diagnostic Workup**

Following a brief sideline assessment by a certified athletic trainer, the patient’s parents brought him to a local emergency medicine department (ED) for evaluation. Neurological examination was unremarkable. There were no focal neurologic signs and ED records indicated that he was alert and oriented to person, place, and time.
He knew the month but could not recall the date. The Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) score was reported as 15 in the ED records, indicating a grossly normal neurologic status (the mild TBI range on the GCS is 13–15). Head CT was described as unremarkable. Cervical spine x-ray was ordered because the patient complained of mild neck pain in the ED, and results were normal. The patient was discharged under the care of his parents and was instructed to follow up with the hospital’s MTBI clinic for symptom management, education, and return-to-play decision making.

Concussion Clinic Course

The patient presented to his initial MTBI clinic evaluation 3 days following his injury. He was oriented to the Clinic by our nurse coordinator and then underwent a neuropsychological evaluation by one of the authors (MRP). The neuropsychologist (MRP) provided education about concussion to the patient and his parents and discussed typical recovery from concussion, with the goal of shaping the patient’s expectations and self-appraisals about his injury and expected outcome. The neuropsychologist also administered a brief cognitive test battery to objectively assess neurocognitive functioning. The focused cognitive battery assessed psychomotor and information processing speed (e.g., Trail Making Test-Form A; Reitan & Wolfson, 1992); the Wechsler Adult Intelligence Scale-IV Coding subtests (Wechsler, 2008); complex/divided attention (Wechsler Adult Intelligence Scale-IV Digit Span; Trail Making Test-Form B; Reitan & Wolfson, 1992); verbal fluency (Controlled Oral Word Association Test; COWAT; Benton, Hamsher, & Sivan, 1983); and new learning and memory (Hopkins Verbal Learning Test-Revised; Benedict, Schretlen, Groninger, & Brandt, 1998). Following the neuropsychological examination, the patient underwent a physical examination by a physical medicine and rehabilitation physician.

Initial Examination Findings

The patient denied any postconcussive symptoms during his initial evaluation. He reported a strong desire to return to football immediately. His parents were concerned about his injury and thought that he may be more “spacey” and “sleeping more” but overall conceded that he must be recovered. He had not been complaining of symptoms at home and tolerated a full day of school without complaints.

Table 1 lists the specific tests administered and presents the objective data from the initial neuropsychological evaluation. Relative to premorbid expectations based on this patient’s prior academic history (above average), results from the initial evaluation seemed mildly below expectations, suggesting that the patient is likely still recovering from the concussion he sustained just 3 days earlier.

Initial Clinical Impressions/Recommendations

The patient had suffered a grade 2 concussion. Given our concern that the patient was still symptomatic (cognitively) at the time of his initial examination, coupled with the observations noted by the patient’s parents, he was not cleared to start a return-to-play protocol. Instead, it was recommended that the patient refrain from
physical exertion, particularly contact sports or activities, and resume his academics with moderation. He was instructed to follow up with the Clinic in 1 week. We talked with his parents and his school guidance counselor about the importance of minimizing the likelihood of repeat concussion and our recommendation of moderation in his academic and extracurricular schedule during the recovery period. The school guidance counselor forwarded our recommendations to his teachers.

Follow-up Examination Findings

When the patient presented to his follow-up exam 1 week later, he once again denied subjective symptoms. His parents stated that his cognition seemed clearer and indicated that he was having no difficulties at school since the last evaluation. He complied with our recommendation to avoid contact sports. His mood was described as mildly irritable, which was attributed to not being able to play in last week’s football game, but otherwise his personality and behavior were believed to be at baseline. His parents also believed that his sleep had normalized and did not believe he was experiencing any usual degree of fatigue. Follow-up neurocognitive test results are provided in Table 1 alongside results from the patient’s initial evaluation. Of note, the follow-up test battery consisted of alternate test forms to reduce error associated with practice effects.

### Table 1 Case Study 1: Neuropsychological Test Results for Initial and 1-Week Follow-up Evaluation Through the Concussion Clinic

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Initial Evaluation</th>
<th>1-week Follow-up Evaluation*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw Score Mean (SD)</td>
<td>Raw Score Mean (SD)</td>
</tr>
<tr>
<td></td>
<td>z-score</td>
<td>z-score</td>
</tr>
<tr>
<td>TMT A</td>
<td>20” 24.4” (8.0)</td>
<td>12” 24.4” (8.0)</td>
</tr>
<tr>
<td>TMT B</td>
<td>44” 56.4” (18.4)</td>
<td>29” 56.4” (18.4)</td>
</tr>
<tr>
<td>SDMTw</td>
<td>49 55.9 (10.9)</td>
<td>68 55.9 (10.9)</td>
</tr>
<tr>
<td>LNS</td>
<td>12 12.2 (2.3)</td>
<td>15 12.2 (2.3)</td>
</tr>
<tr>
<td>HVL T-R LRN</td>
<td>22 25.1 (4.0)</td>
<td>30 25.1 (4.0)</td>
</tr>
<tr>
<td>HVL T-R DEL</td>
<td>8 8.6 (2.2)</td>
<td>11 8.6 (2.2)</td>
</tr>
<tr>
<td>HVL T-R RECOG</td>
<td>22/24 22.8 (1.2)</td>
<td>24/24 22.8 (1.2)</td>
</tr>
<tr>
<td>COWAT</td>
<td>30 32.6 (7.8)</td>
<td>41 32.6 (7.8)</td>
</tr>
</tbody>
</table>

*All tests administered during follow-up were alternate forms. Alternate forms were created for measures that do not have published alternate forms. Alternate forms created for the sport-concussion study are equivalent.

Note. The norms used for high school and college athletes in our clinic are unpublished but derived from several large studies exploring the effects of sport-concussion in high school athletes. More than 5,000 athletes were enrolled in the study. Normal control subjects were matched to injured players on demographic and other important variables and underwent neuropsychological evaluation, thereby generating a normative database to use for evaluation of injured athletes in our region.
Follow-up Impressions and Recommendations

The patient performed considerably better at follow up than at this initial examination. The patient’s subjective report, his parent’s observations, and objective neuropsychological findings all suggested good healing postinjury. The Clinic’s physician granted the patient clearance to begin a return-to-play protocol supervised by an athletic trainer (McCrory et al., 2009). He remained symptom free at rest and under exertion as he progressed through his weaklong return-to-play protocol, which included some contact during practice drills by the end of the weaklong protocol. Because he remained symptom free during exertion throughout the protocol, he was subsequently cleared to play competitive football, which was 17 days after his concussive injury.

Case Study 1: Summary and Outcome

Patient 1 suffered a grade 2 sport-related concussion playing defensive end during a football game. His acute injury characteristics consisted of a Glasgow Coma Scale score of 15, approximately 3 hr of PTA, 5–10 min of RTA, and no loss of consciousness. Although he remained cognitively symptomatic during his initial examination that was conducted just 3 days postinjury, his cognitive symptoms seemed to resolve by his day 10 follow-up examination, at which time he started a weeklong return-to-play protocol. After an additional week of slowly and gradually increasing physical exertion under the supervision of an athletic trainer, which culminated with some contact exercises during practice, the patient was released to play competitive football. He completed the remainder of the football season without incident.

Case Study 1: Key Take-away Points

If clinical management of Patient 1’s concussion hinged on patient self-report alone, Patient 1 would likely have been returned to play football prematurely. The neuropsychological testing provided a very useful and pragmatic source of objective data to shape clinical management of this patient’s sport-related concussion.

Case Study 2

Reason for Referral

Patient 2 is a 20-year-old left-handed Caucasian male collegiate ice hockey player referred to the Concussion Clinic for evaluation and management after a sport-related concussion.

History of Present Illness

The patient described that he collided with an opponent near mid ice while skating at relatively high speed during a college hockey game 5 days prior. He was uncertain if there was head-to-head contact in the collision, but recalled falling and striking his head against the surface. According to the patient and the team’s athletic trainer, there reportedly was no observed period of unconsciousness, but the patient described a period of posttraumatic amnesia estimated at 20 min maximum
duration. Although not formally recorded, every indication is that the Glasgow Coma Scale (Teasdale & Jennett, 1974) was 15.

The patient immediately felt stunned, dazed, and mildly confused. He was immediately removed from the contest and did not return to competition that evening. He reportedly experienced headache, dizziness, memory problems, and mental “fogginess,” with little improvement in his symptoms over the first 10 day leading up to his first clinic visit. He had also experienced neck soreness since his injury. He was not taking any medications or over-the-counter products for his symptoms. His parents had also observed the patient to be notably anxious and emotional since his concussion, which they reported as a significant change from his normal personality.

The patient’s history was remarkable for one prior concussion in hockey at age 18. That injury reportedly involved no unconsciousness or measurable amnesia. He had symptoms of headache, dizziness, and mild cognitive dysfunction that apparently resolved in approximately 4 days. He resumed participation in hockey without difficulty approximately 7 days postinjury.

**Acute Diagnostic Workup**

The head athletic trainer administered the Standardized Assessment of Concussion (SAC; McCrea, Randolph, & Kelly, 2000) in the locker room immediately following injury. He received a total score of 22, which was more than two standard deviations below the normal mean for college athletes, indicating considerable deficits in memory, attention, and orientation. His total score on the Concussion Symptom Inventory (CSI; Randolph et al., 2009) was 79 approximately 2 hr postinjury, indicating significant postconcussive symptoms. The team physician ordered a head CT the day following injury, which was negative. His symptom score on the CSI diminished modestly but remained relative high over the last 5 days.

**Initial Examination Findings**

At his initial visit, the patient was evaluated by the physiatrist and neuropsychologist. The physiatrist conducted a physical examination of the patient, which revealed significant neck tenderness and mildly restricted range of motion, reflective of a “whiplash” type of injury.

The neuropsychologist administered a brief neuropsychological test battery designed to assess memory, working memory, cognitive processing speed, reaction time, and executive functions. A combination of traditional (paper and pencil) and computerized cognitive measures was administered. The specific tests administered are listed in Table 2.

The patient’s neuropsychological profile was remarkable for a pattern of mild to moderate impairments across multiple neurocognitive domains, primarily implicating cognitive processing speed, mental reaction time, working memory, and new learning and memory. There was significant slowing of simple reaction time and cognitive processing speed, which was more evident on more demanding cognitive tasks. There were deficits in the encoding and delayed recall of new information, evident on measures of both auditory and visual memory. Auditory working memory was mildly impaired. Results of his initial and follow-up neuropsychological examinations are presented in Table 2. The patient also endorsed a high degree of postconcussive symptoms, with a total symptom checklist score of 67 on the CSI.
Table 2 Case Study 2: Neuropsychological Test Results for Initial and Follow-up Evaluations Through the Concussion Clinic

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Initial Evaluation—5 Days Post</th>
<th>Follow-up Evaluation—15 Days Post</th>
<th>Follow-up Evaluation—30 Days Post</th>
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<tr>
<td></td>
<td>Raw Score</td>
<td>Mean (SD)</td>
<td>z-score</td>
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<td>TMT A</td>
<td>36”</td>
<td>24.1 (8.3)</td>
<td>-1.4</td>
</tr>
<tr>
<td>TMT B</td>
<td>84”</td>
<td>65.0 (21.7)</td>
<td>-0.9</td>
</tr>
<tr>
<td>SDMTw</td>
<td>47</td>
<td>56.2 (10.2)</td>
<td>-0.9</td>
</tr>
<tr>
<td>LNS</td>
<td>9</td>
<td>12.4 (2.4)</td>
<td>-1.4</td>
</tr>
<tr>
<td>HVLT-R LRN</td>
<td>20</td>
<td>24.6 (4.1)</td>
<td>-1.1</td>
</tr>
<tr>
<td>HVLT-R DEL</td>
<td>6</td>
<td>8.6 (2.3)</td>
<td>-1.1</td>
</tr>
<tr>
<td>HVLT-R RECOG</td>
<td>20</td>
<td>22.7 (1.7)</td>
<td>-1.6</td>
</tr>
<tr>
<td>COWAT</td>
<td>27</td>
<td>33.7 (7.9)</td>
<td>-0.8</td>
</tr>
</tbody>
</table>

Note. The norms used for high school and college athletes in our clinic are unpublished but derived from several large studies exploring the effects of sport-concussion in high school athletes. More than 5,000 athletes were enrolled in the study. Normal control subjects were matched to injured players on demographic and other important variables and underwent neuropsychological evaluation, thereby generating a normative database to use for evaluation of injured athletes in our region.

*All tests administered during follow-up were alternate forms. Alternate forms were created for measures that do not have published alternate forms. Alternate forms created for the sport-concussion study are equivalent.

TMT A = Trail Making Test-Form A; TMT B = Trail Making Test-Form B; SDMTw = Symbol Digit Modalities Test-Written version; LNS = Letter Number Sequencing; HVLT-R LRN = Hopkins Verbal Learning Test Learning Score; HVLT-R DEL = Hopkins Verbal Learning Test Delayed Score; HVLT-R RECOG = Hopkins Verbal Learning Test Recognition; COWAT = Controlled Oral Word Association Test.
During the clinical interview and discussion of the examination findings with the patient and his parents, he became emotionally upset, tearful, and notably anxious. He expressed his fears and concerns that his concussion may be resulting in chronic effects that would preclude him from a promising career in professional hockey, which his parents confirmed was likely at that point based on his level of success at the college level.

Initial Clinical Impressions/Recommendations

Based on physical examination findings, the physiatrist diagnosed a mild neck strain, which his sports medicine providers were already treating with massage and physical therapies. No narcotics or other medical treatments were recommended.

The patient’s head injury was classified as a grade 2 concussion according to the American Academy of Neurology (AAN) guideline (Kelly & Rosenberg, 1997), characterized by continued symptoms and cognitive dysfunction on objective testing. Signs of anxiety and psychological distress were also evident, without any prior psychiatric history. His psychological distress was best characterized as an adjustment reaction to the effects of his injury (e.g., withheld from his primary interest, fears of potentially ending his dream of playing professional hockey).

In addition to reviewing the findings and impression from the current examination, the neuropsychologists discussed the following with the patient and his family: (a) the acute characteristics of his concussion, (b) the existing scientific literature base on the acute effects and typical course of recovery following a concussion of this type, and (c) factors that positively and negatively influence recovery. It was made clear that our approach to injury management would be empirically-driven by the literature on best practice directed at positively influencing his recovery and gradual return to gainful activity, including hockey, once appropriate. The patient and his parents were given strong assurance that we predicted a complete recovery in his symptoms and cognitive functioning and that his history was not reflective of cases that prompt discussions about permanent disqualification from collision sports.

It was recommended that the patient observe a more extended period of complete physical rest due to the level of his symptoms. The nurse coordinator also spoke with school officials about modest academic accommodations for the short-term, due to his mild cognitive dysfunction, which were granted. Follow-up evaluation in 10 days was recommended.

Follow-Up Examination Findings

The patient was seen again in the Concussion Clinic 10 days after his initial visit (15 days postinjury). His neck soreness had gradually improved with continued massage therapy and was now completely resolved. The neuropsychologist readministered the alternate forms of the neurocognitive test battery, which showed a completely normal cognitive profile, with measureable improvement in all areas of deficit on the prior examination. Although formal preinjury baseline test results were not available, the follow-up test results were considered consistent with the patient’s normal level of functioning. He continued, however, to report subjective cognitive difficulties in memory and concentration. In addition, his symptom checklist total score was 60, down somewhat from his acute score of 79 and initial visit score of 67. Yet, it was still well above the normative range for noninjured individuals (normal score 0–10).
The patient’s parents expressed their concerns about continued signs of anxiety and depression, and the patient acknowledged his frustrations over what he considered a slow recovery, particularly relative to his previous concussion 2 years earlier. He admitted to a pattern of worry and rumination about his future during his “down time” away from hockey.

The patient was seen for follow up once again 2 weeks later (approximately 1 month postinjury). He reported significant improvement in his symptoms, with a total symptom checklist score of 6, which was within the normal base rate for college athletes. He considered himself to have been completely symptom free at rest for the past 6 days.

His profile on objective neurocognitive testing was again completely normal and stable from his last follow-up visit. Subjectively, he felt that he had returned to his normal baseline level of cognitive functioning and had resumed his routine academic course work without accommodations.

He acknowledged that he was much less worried and had a much more positive outlook based on the trajectory of his recovery over the previous 2 weeks. His parents reported their observation that he was “back to himself again” in terms of personality and mood. He had not resumed any physical activity, but had discussed this prospect with the head athletic trainer over the last 2 days. He was eager to resume exercise and eventual full participation in hockey.

Interestingly, both the patient and his parents spontaneously offered the following observations about their recent care experience:

- That his recent recovery progressed along a course very similar to what we predicted based on the science on the true natural history of recovery after concussion.
- That seeing objective evidence of his recovery on formal cognitive testing provided reassurance about his prognosis and reduced his concerns about the potential for long-term effects from his concussion.
- That the reassurance from our feedback and educational materials during his first two clinic visits reduced his anxiety and concerns a great deal.
- That there appeared to be a correlation between the recovery in his symptoms and a reduction in his level of psychological distress.

**Follow-Up Impressions and Recommendations**

Our impression was that there had been significant improvement in the patient’s symptoms between 2 and 4 weeks postinjury, such that he was now completely symptom free at rest for the past 5 days. Based on his symptom recovery and stability of normal neurocognitive profile, the following recommendations were made:

1. Begin a program of gradual exertion under the supervision of the head athletic trainer and team physician, starting with low intensity, noncontact activities (e.g., elliptical equipment, walking).
2. Gradually increase the intensity of noncontact exertion, as tolerated without any recurrent or worsening symptoms. No contact or hockey drills were recommended until symptom free under maximum cardiovascular exertion without contact.
3. Reintroduce hockey-related activities (e.g., skating) without contact once completely symptom free under exertion and then gradually transition to full hockey participation. Final return-to-play decision making is the authority of the team physician and head athletic trainer.

4. Follow-up neurocognitive testing or evaluation at the Concussion Clinic was not indicated but would be arranged as needed per the request of the team physician, athletic trainer, or patient.

5. Although the patient’s mood and outlook had improved significantly with his ongoing recovery and regaining of normal function, monitor for signs of any lingering anxiety, depression, or psychological distress that would warrant the need for further evaluation and treatment.

6. There was no indication of any focal or acute findings that would indicate the need for neuroimaging studies at that time.

7. Continued massage therapy and other treatments for the patient’s neck strain, per the team medical staff.

8. There was no apparent need for further academic accommodations or specialty care provisions based on the patient’s level of recovery.

9. Overall, prognosis for an uncomplicated recovery in this case was considered highly favorable.

Case Study 2: Summary and Outcome

Patient 2 sustained a grade 2 concussion based on the AAN guideline, characterized by brief amnesia and acute symptoms without any period of unconsciousness. Initial examination revealed a high degree of postconcussive symptoms and mild impairment on objective cognitive testing. Follow-up evaluation demonstrated normal cognitive testing, but persistent symptoms beyond 2 weeks postinjury. The player reported (and his parents observed) signs of a difficult psychological adjustment to the effects of his concussion in terms of his symptoms, restrictions on his activity (i.e., hockey), and potential long-term implications. Objective testing and supportive educational interventions provided assurance that reduced the patient’s anxiety and facilitated his overall symptom recovery. While only correlational, it was the clinician’s observation that these low-intensity interventions may have abated a more protracted symptom course or a case of persistent PCS.

Case Study 2: Key Take-away Points

In contrast to Patient 1, where objective cognitive testing identified impairments in an athlete who was otherwise symptom free and requesting return to competition, formal assessment in the case of Patient 2 provided the patient with encouraging evidence of recovery that reduced his anxiety, which, in turn, was considered to facilitate his eventual symptom recovery.

Conclusion

This article presented a practical model for concussion evaluation and management in the setting of a hospital-based clinic. The clinical model is based on a biopsychosocial approach to understanding the neurologic and psychological factors that
influence recovery following concussion, which also underscores the vital role of the neuropsychologist in concussion clinics. In accordance with the scientific literature, a combination of brief, standardized assessments and low-intensity, supportive interventions has been effective in our setting. The two case studies herein demonstrate different presentations of sport-related concussion, and how the assessment/interventional model facilitates outcomes in varied fashion, depending on the individual case. We hope that the Concussion Clinic’s work will help advance the larger public health mission associated with sport-related concussion through educational, scientific, public policy, and preventative initiatives.

References


