A Model of Current Best Practice for Managing Concussion in University Athletes: The University of Toronto Approach

Paul Comper, Michael Hutchison, Doug Richards, and Lynda Mainwaring
University of Toronto

Along with the ever growing awareness among the scientific community and the general public that concussion is a serious health care issue at all levels of sport, with potentially devastating long term health effects, the number of concussion surveillance clinical monitoring programs has significantly increased internationally over the past 10–15 years. An effective concussion program (a “best practice” model) is clinically prudent and evidence-based, one that is an interdisciplinary model involving health professionals who manage, educate, and provide psychosocial support to athletes. The integration of neuropsychological assessment is a component of many present day programs, and therefore, the neuropsychologist is an integral member of the concussion management team. The University of Toronto Concussion Program, operational since 1999, integrates best practices and current evidence into a working model of concussion management for university athletes. The model uses an interdisciplinary approach to monitor and assess athletes with concussions, as well as to educate its athletes, coaches, and administrators. A research component is also integral to the program.

Keywords: Neuropsychology, concussion, sport, athlete, mild traumatic brain injury

According to the 2009 Zurich Consensus Statement, concussion is defined as “a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces” (McCrory et al., 2009, p. 186). Although Consensus Statement authors indicate that the terms “concussion” and “mild traumatic brain injury” refer to different constructs and therefore should not be used interchangeably, most clinicians who work closely with concussed athletes in the acute and postinjury phases might argue that such a distinction is academic, one which serves to reinforce the myth that a concussion is to be regarded as a benign, largely inconsequential event.

The authors are with the Faculty of Kinesiology and Physical Education, University of Toronto, Toronto, Ontario Canada.
This point is emphasized in a recent paper by DeMatteo and colleagues (2010), who found that clinicians tended to use the “concussion” label when dealing with a pediatric head-injured population, because it was less alarming to parents than the term “mild traumatic brain injury,” but that in reality, the two terms refer to the same construct. Regardless of who identifies/diagnoses and treats the concussed athlete, whether it is the sports medicine physician, therapist (i.e., athletic therapist, physiotherapist, or trainer), or neuropsychologist, the initial, frank discussion that a concussion is equivalent to a brain trauma therefore sets the stage for “adequate management,” eventually and hopefully leading to the athlete’s full recovery.

Although concussion as a neurological phenomenon was well recognized even in ancient times, it is only in the past two decades that there has been intense public and scientific scrutiny of the condition, due no doubt in large part to the growth and international exposure of amateur and professional sports, where the associated risk and frequency of head injuries is high compared with the general population (Thurman, Branche, & Sniezek, 1998). With increased scientific inquiry has come the growing realization that concussion is a serious modern day health issue that also carries a significant potential for long-term consequences. An overwhelming amount of public and media attention portrays concussion as an epidemic in some sports, which serves on the one hand to increase public awareness, while on the other hand promotes a degree of fear. Hyperbole aside, there are grounds for concern: Recent, emerging evidence from the neuropathological studies by McKee and colleagues (McKee et al., 2009) suggests that chronic traumatic encephalopathy (CTE), clinically known for several decades as dementia pugilistica or “boxer’s encephalopathy,” may not be an aberrant, rare condition related only to the process of repeated, severe head trauma isolated to the sport of boxing. Instead, it could be due to the process of multiple, repeated subconcussive (i.e., subclinical) blows accumulated gradually, which is typical in sports such as American football (Erlanger, Kutner, Barth, & Barnes, 1999; McKee et al., 2009; Mendez, 1995).

### The Diagnosis of Concussion

Concussion is a syndromal diagnosis that is absent a reliable hallmark indicator; it is a constellation of various somatic, psychological, and cognitive symptoms of significant clinical concern (some or all of which may wax and wane), that most frequently (but not always) involves head trauma (Aubry et al., 2002; Kissick & Johnston, 2005; McCrory et al., 2009). Concussion typically causes only transient neurological signs, such as a brief loss of consciousness, loss of awareness and orientation, amnesia for the circumstances of injury, impaired balance, vacant stare, etc., although symptoms can be much longer lasting (McCrory et al., 2009). Establishing the diagnosis of concussion can be challenging, not only because neurological signs, if present at all, are usually fleeting, but because in the majority of cases (a) there is no other hard evidence of injury; (b) the neurological examination is usually unremarkable; and (c) if undertaken, computed axial tomography (CT) or magnetic resonance imaging (MRI) scans are most frequently negative for evidence of intracranial injury (Baker & Patel, 2000; Difiori & Giza, 2010; Pulsipher, Campbell, Thoma, & King, 2011). Consequently, it is most often the case that the clinician, who is almost never present at the time of injury (the exception perhaps being the team doctor who is watching from the sidelines when
the athlete is injured), is left to establish the diagnosis after the fact and is entirely reliant on the injured person’s description of the event as it is recalled, as well as his or her subjective symptoms. To make matters more complicated, an athlete with head trauma might be fully conscious, aware, and initially asymptomatic, only to develop one or more symptoms such as headache, dizziness, and cognitive dysfunction with the progression of time, possibly hours or days later. Or the person may never develop any lingering symptoms at all. Moreover, each concussion event may produce a unique set of symptoms for different people and even for the same person. This phenomenon is perhaps related to the variable combination of biomechanical forces, biochemical processes, and possibly the psychosocial vulnerabilities of the individual(s) involved.

If it is difficult for specialist health care professionals to establish the diagnosis of concussion under “ideal” circumstances (if such circumstances indeed exist), it can be much more difficult to make such a determination in the context of high performance, fast-paced sports, where athletes may collide with opponents, be struck by projectiles, fall into obstacles, or otherwise be exposed to energy, mass, and velocity. In such cases, the athlete’s symptoms might reasonably be attributed after the fact to several possibilities, including head trauma, dehydration, exhaustion, neck pain, or perhaps a combination of these factors.

Once the diagnosis is established, the syndrome of concussion falls within the continuum of traumatic brain injury that is typically referred to as “mild,” which is somewhat misleading since it is not a uniformly mild or benign disorder. While concussion is historically and frequently regarded as a transient inconsequential injury, and 85% of athletes with concussion are thought to recover within 7–10 days of injury (Bleiberg et al., 2004; Collins et al., 1999; Field, Lovell, & Maroon, 2003; Macciocchi, Barth, Alves, Rimel, & Jane, 1996; McCrea et al., 2005; McCrea et al., 2003), a minority of athletes (the 15% frequently referred to as the “miserable minority”) nonetheless will experience chronic debilitating symptoms (Mittenberg & Strauman, 2000; Ryan & Warden, 2003). Once thought to be entirely a function of psychological/psychosocial factors, research has shown that the underlying injury substrate in concussion (and possibly the reason symptoms do persist in a subset of victims) is likely driven by biochemical disturbance and possibly axonal injury (Difiori & Giza, 2010; Giza & Hovda, 2001). Since so-called “mild” concussions occur most frequently of all traumatic brain injuries, even the minority of those who develop chronic symptoms probably number in the hundreds of thousands annually in North America (Cassidy et al., 2004). More to the point, an athlete who suffers head trauma without any loss of consciousness, and then subsequently misses 3 months of the competitive season because of persistent or recurring severe headaches, dizziness, and cognitive dysfunction, might disagree that he or she only suffered a mild injury. The paradox of concussion is that “mild” injuries can result in apparently severe symptoms. This is why the experienced clinician, beyond voicing optimistic generalities, often advises the concussed athlete that he or she will have to rest and “wait and see.”

Although technologically advanced techniques such as hydrogen-nuclear magnetic resonance (H-NMR) spectroscopy, diffusion tensor imaging (DTI), and functional magnetic resonance imaging (fMRI) offer great potential for understanding the underlying mechanism of concussion as well as the impact concussion has on behavior, cognition, and normal functioning (Difiori & Giza,
234  Comper et al.

Comper et al. (2010; Pulsipher et al., 2011), such techniques currently are still experimental, expensive, and generally are not accessible to clinicians and/or the general public. Although CT and MRI scans are more widely available, as noted, the reality is that in the vast majority of suspected concussion cases, such scans are reported as “normal,” with no indication of structural damage or intracranial pathology (Baker & Patel, 2000; Difiori & Giza, 2010; Pulsipher et al., 2011). Consequently, health care providers currently remain largely dependent on the athlete’s self-report of concussion symptoms as a postinjury health status determinant. This obviously carries the risk that the motivated but perhaps still-symptomatic (and ill informed) athlete will perhaps underreport or even misreport his or her symptoms to return to play earlier than should occur, thereby increasing the risk of additional injury, prolonging symptom duration, or possibly leading to worse outcomes. In rare circumstances, an athlete who suffers a second concussion before the first has healed may be at risk for catastrophic swelling of the brain, a condition referred to as second impact syndrome.

Research Informing Best Practice in Concussion Management

Thankfully, current practice in the clinical management of concussion is evolving from the days of having dazed or stunned athletes inhale ammonium carbonate to revive them or simply asking, “how many fingers do you see?” As late as 2006, however, McCrory surprisingly noted that some sports organizations were still embracing this approach. Intensive medical, public, and media interest in concussions over the past two decades has resulted in a virtual explosion of research in the area of sports-related concussion (Comper, Hutchison, Magrys, Mainwaring, & Richards, 2010). A significant methodological shift in concussion assessment was introduced in the late 1980s, pioneered by Barth and colleagues at the University of Virginia (Barth et al., 1989). Referred to as the “Sports as a Laboratory Model” (or SLAM) paradigm, the approach assessed athletes with neuropsychological (NP) tests before they started their competitive seasons and then, knowing that a certain percentage would unfortunately suffer concussions during the coming competitive year, measured them with same NP tests after a concussion occurred. This approach freed the psychologist from being entirely reliant on population norms (although normative data could still be used), and in effect made each athlete his or her own case-control. Consequently, changes in cognitive functioning from pre- to postinjury and into recovery could be directly measured. The SLAM approach had significant practical appeal, not only for neuropsychologists, but also for therapists/trainers, physicians, and others who worked directly with concussed athletes, because it offered a much higher degree of objectivity and certainty—as well as economy of scale—for the assessment and management of concussions, far beyond simply asking the concussed athlete basic questions. By the early 1990s, several colleges and universities in the United States had adopted such testing programs, often referring to them as “baseline” testing programs.

Collectively, interdisciplinary prospective research studies have demonstrated that the majority of athletes achieve complete symptom resolution, including cognitive recovery over a period of approximately 7–10 days (Bleiberg et al., 2004;
Collins et al., 1999; Field, 2003; Macciocchi et al., 1996; McCrea et al., 2005; McCrea et al., 2003). As noted previously, however, the effects of concussion are unique to the individual in each case, and this means that symptom manifestation can range from singular, isolated, and time limited minor annoyances to numerous, broad spectrum complaints with persistent impairment and disability.

Yet, although the clinical understanding of the natural history of concussion has made significant advancements in the past three decades, the physiological understanding of recovery after concussion remains less clear (McCrea, Prichep, Powell, Chabot, & Barr, 2010). The few studies that have used advanced functional neuroimaging techniques suggest that physiological abnormalities can be identified beyond the resolution of symptoms and cognitive dysfunction (McCrea et al., 2010; Vagnozzi et al., 2010). Furthermore, recent research has also shown that biochemical changes that occur in the brain following concussion can persist even after the person is asymptomatic, resulting in a window of vulnerability, whereby the risk of further brain trauma is increased, unbeknownst to the injured person (Vagnozzi et al., 2008). Therefore, determining the time course of physiological recovery after concussion has significant implications in the clinical decision making process (McCrea et al., 2010). At this point in time, however, the precise physiology of the effects of concussion, including recovery, is still emerging. Consequently, apart from the contribution of NP testing, current best practice for the management of sport-related concussion recommends a symptom-free waiting period followed by gradual exercise progression with no return of symptoms (McCrory et al., 2009).

**Development and Evolution of Current Concussion Programs**

As previously noted, before the implementation of NP testing in concussion management, best practice involved giving advice of complete rest until the athlete was asymptomatic by self report, which meant that the doctor was exclusively reliant on subjective symptoms as an indicator of recovery (Cantu, 1992; Kelly et al., 1991). The advent of the SLAM paradigm afforded the clinician with an important, additional level of objectivity. The introduction of NP testing also brought the neuropsychologist into the athlete’s care team, and NP testing provided a relatively economical alternative to the disparate gap between “hi-tech” diagnostic neuroimaging techniques and basic questions such as “how do you feel?” Indeed, it can be argued convincingly that the introduction of NP testing to the field of sports concussion management not only allowed for the widespread implementation of concussion surveillance programs, but more importantly helped bring a serious public health issue to the fore. It is now widely recognized that the NP assessment of athletes following concussion plays an important role in the identification, management, and (hopefully) eventual resolution of the person’s symptoms, leading to a successful and safe return to play. The concurrent development of computerized NP testing in the early 1990s significantly reduced many of the practical issues related to paper and pencil NP testing, while also increasing sensitivity and reliability (Schatz & Zillmer, 2003). By the late 1990s and into the early 2000s, several commercially available computerized NP screening programs became widely available (e.g., ImPACT, CogSport, ANAM). The availability of computerized NP screening has
allowed for broad based NP testing (i.e., “concussion programs”) to proliferate internationally. For the purpose of the present article, we scanned approximately 40–50 websites of major colleges and universities in the USA and Canada and found that many institutions address concussion management to some degree. Of course, some appear to be more comprehensive than others, and it is sometimes difficult to separate a public relations initiative from programmatic reality. In addition, variability exists in several ways, such that not all programs appear to include a baseline testing element; some programs incorporate research protocols to monitor outcome, etc.

Apart from colleges and universities, several professional and amateur level sports have also instituted concussion surveillance programs, including the National Hockey League (NHL), the National Football League (NFL), NASCAR, the Ontario Hockey League (OHL), and the Australian Football League (AFL), to name only a few. Each concussion program appears to have many positive aspects. Moreover, apart from one or two of those scanned, each program appears to go well beyond the simple premise of using computerized or paper and pencil NP tests at baseline and thereafter at some point postinjury to determine the crucial “go, no-go” return to play (RTP) decision.

The University of Toronto Concussion Program

With the above context established, the remainder of this article describes a model of current best practice for managing concussion among university athletes, which is the University of Toronto’s approach. The University of Toronto (U of T) Concussion Program was initiated in 1999. The program incorporates the essential elements that are currently considered to be the cornerstones of proper concussion management, including preseason or baseline NP screening, postinjury, interdisciplinary (e.g., medical, neuropsychological, and physical monitoring) follow up, education, and research; the latter element is incorporated so that a proper evidence base can be established for our population of university athletes. Within this broad rubric, U of T has attempted to incorporate what are considered to be the best, practical features of similar programs at other universities and has also included the evolving concussion management tenets of the various Consensus Conferences over the past 12 years (i.e., Vienna in 2001, Aubry et al., 2002; Prague in 2004, McCrory et al., 2005; and Zurich in 2008, McCrory et al., 2009). However, as will be discussed, it is important to assert that the U of T approach departs somewhat from the current consensus guidelines of not permitting an athlete to engage in any physical activity until he or she is asymptomatic.

The interdisciplinary concussion program at U of T is an athlete-centered hybridized model that draws from many programs considered to be excellent, including those currently operating at Penn State University, the University of Pittsburgh, the University of Virginia, the University of Oklahoma, and the University of North Carolina at Chapel Hill. More recently, U of T has also introduced an exercise-during-recovery protocol adapted from the program at the University of Buffalo. The U of T program is not without its limitations. For example, once athletes graduate from the university, the resources to track and monitor them over the much longer term are simply not available. Still, the model has evolved with
time. With all of this in mind, the rest of this article describes the current U of T program as a suggested model for best practice in concussion management.

Initial Steps and Current Practice

Establishing a concussion program, regardless of whether it is at a high school or college/university level, initially requires a proactive, concerted effort to have key stakeholders both engaged in and cooperating on all issues, with one main principle in mind: Concussion as a health concern should be treated no less importantly than other athletic injuries that can cause impairment and/or disability. Because of potential long term consequences to the students who are essentially sports ambassadors representing, in our case, the university, and owing to the fact that most university athletes will not progress to the professional rank in sports, those who engage in this type of work are duty bound to protect their student athletes’ health. In retrospect, and especially given the current groundswell of media attention as well as existing and proposed legislation in several states within the United States and several Canadian provinces to enact mandatory concussion education programs, this now seems like common sense. Nevertheless, when the U of T program was initiated in 1999, the concept of an interdisciplinary concussion management protocol was still a fairly novel idea that required both “selling” and considerable “buy in” and validation, not only with the administration, but also with coaches, managers, therapists/trainers, and even the athletes.

Initially, part of the U of T concussion program included a significant research component in which we wanted to prospectively test the validity of the return to play (RTP) clinical guideline, currently in use at U of T at the time, which was as follows: Each athlete who suffered a first-time diagnosed concussion could not return to play until symptom free at rest and with provocation exercise testing for twice the duration of his or her symptoms plus 24 hr. This meant that if an athlete was symptomatic with headache for 3 days in total (including at rest and following an exercise protocol), he or she would not be cleared for RTP for 7 days (i.e., twice the duration of symptoms plus 1 day). To test the validity of this RTP guideline, which was arguably no better or worse than any other RTP guideline of the time (none of which, as of 2012, have yet to be empirically validated), physicians were blinded to the results of NP testing and eventually the two databases (i.e., the results of NP testing for concussed athletes and the database of physicians’ clinical RTP decisions) were brought together to see if the guideline was effective. Although the results of that study are a topic for a future paper, suffice it to say that the RTP guideline we initially developed proved to be imprecise as a useful clinical approach, mainly because too many athletes, though asymptomatic via self-report and with provocative exercise, were cleared for RTP when their NP testing was deemed “abnormal” compared with their baseline results. This meant that we were seeing athletes in the recovery phase who no longer had symptoms, but whose NP test profiles were nonetheless abnormal; this was an obvious “flag.” In any event, incorporating a large research component into the clinical concussion management protocol proved to be important on many levels and continues to this day, with research informing best practice.

Currently, principally because of resource constraints, the U of T clinical and research efforts are restricted to those varsity sports deemed to be “at-risk” for
Comper et al.

Concussion (e.g., football, ice hockey, field hockey, rugby, soccer, volleyball, basketball). The U of T population consists of a greater proportion of male-to-female athletes, primarily driven by a large number of athletes entering the football program each year. In the past, the number of previously reported concussions has not been significantly different between male and female athletes (Hutchison, Comper, Mainwaring, & Richards, unpublished). What constitutes at-risk athletes is based on epidemiological data related to the incidence and frequency of concussions within those sports, but in no instance have we refused to exclude any sport (or any athlete) upon request. Moreover, regardless of whether any athlete participates in an at-risk sport and is therefore eligible for inclusion in baseline testing and follow up postconcussion management, any athlete with a concussion is welcomed into the concussion program following injury, even if there are no baseline data for that person. Although this presents challenges, standard group norms (as opposed to individual baselines) can still be used and care is still delivered; and in such cases, brief NP testing, education, and follow up are still undertaken. In this way, we believe that the U of T program best serves the university community under most sets of circumstances; we do not want our process to be a stumbling block to athletes in need of proper medical or neuropsychological assistance.

Components of the Model

The overall framework for concussion management at the University of Toronto currently includes the following essential components: (a) an annual preseason education seminar for coaches and sports administration personnel where the protocol for evaluating suspected concussions on the sidelines during team play is reviewed, (b) a mandatory annual update in-service for sports medicine physicians and therapists/trainers who deal directly with athletes regarding the acceptable and expected protocol for managing concussions, and (c) mandatory preseason baseline neuropsychological screening for at-risk athletes.

Because baseline NP testing is mandatory at the University of Toronto for at-risk athletes, the members of each varsity team must make adequate time available to the concussion program coordinator (MH) during preseason training camp. This has become routine over the past 13 years and consequently, there is a high compliance rate. Still, some athletes may join a team late and inevitably there are a few missed baselines that elude detection until a concussed athlete arrives at clinic with no prior baseline NP test data. In such cases, there is still much useful information to be learned through a thorough clinical interview and subsequently via administration of a brief NP testing protocol that can be compared with general normative data.

The U of T current baseline NP protocol involves a brief health survey interview followed by administration of the Automated Neuropsychological Assessment Metrics (ANAM) protocol (Reeves, Winter, Bleiberg, & Kane, 2007), developed for use in a variety of situations to assess several aspects of cognitive functioning and postevent cognitive change using several putative measures of reaction time, speed of cognitive processing, executive functioning, visual spatial identification, visual scanning, and memory. We currently use the sports medicine version of ANAM with University of Toronto normative data developed with colleagues at the Center for Human Operator Performance (C-SHOP) at the University of Oklahoma. The
Concussion in University Athletes

entire NP baseline protocol, including administration of the health survey and test administration, takes approximately 50 min; athletes are tested in groups of no more than 10 per session. Importantly, all baseline tests are reviewed after training camps to determine reliability of the data as well as to look for any possible “flags” (i.e., clearly below average or impaired scores) that might require further elucidation. For example, a player with a known history of prior concussions, who shows lower than average scores on one or more of the ANAM subtests, would be interviewed by the psychologist and possibly retested to establish a repeat baseline and possibly additional consultation with the physician.

During the season, if there is any suspicion that an athlete sustains a concussion during practice or play (i.e., if there are any observable signs of impairment, or if the athlete reports any symptoms), the athlete is removed from play and may not return until medical clearance is obtained. A brief sideline assessment using the University of Toronto Sideline Assessment of Concussion is administered, most frequently by the team’s therapist/trainer. Due to the nature of their competitive schedules, athletes most frequently suffer concussions during the evenings or on weekends (or while performing other extracurricular activities). Therapists/trainers are required to report the event as soon as possible to clinic physicians, who then follow up with each athlete during an office visit (in most cases within 1 or 2 days postinjury), at which time the diagnosis is established and further medical workup might be ordered. Each athlete is seen in follow up medical consultation until he or she is asymptomatic at rest and upon exertion.

Once asymptomatic at rest, gradual exercise progression under the supervision of the therapist/trainer begins; if symptoms return, the athlete returns to the resting phase until asymptomatic, followed again by reintroduction to graduated exercises. If an athlete becomes asymptomatic—or at the 14 day point, even if still symptomatic—the athlete (a) undergoes postconcussion neuropsychological and balance testing using the ANAM sports medicine battery (Cernich, Reeves, Sun, & Bleiberg, 2007) and the firm surface BESS protocol (Guskiewicz, 2001), with feedback provided to the medical clinic and (b) is provided with education, counseling, and support during the recovery process by the neuropsychologist. Follow up monitoring is undertaken, if required. The flow of concussion management is presented in Figure 1.

University of Toronto Return to Play Schematic of Concussion Management

As can be seen in Figure 1, the main components of the RTP flowchart include input from the neuropsychologist, the physician, and the therapist/trainer. To elucidate the specific roles of each team member, the athletic therapist/trainer is responsible for the identification of concussed athletes and monitoring and assisting with the recovery progress; the team physician establishes the diagnosis of concussion at the outset and provides clearance for RTP; and the neuropsychologist acts as a consultant to both the therapist and the team physician by supervising and interpreting NP testing and, especially in cases of prolonged recovery (i.e., greater than 14 days), meets with athletes to undertake a thorough clinical interview to understand potential barriers to recovery. In this respect, although there is no known “cure” for concussion, in their systematic review of treatments for mild brain injury, Comper
and colleagues reported that education, support, and reassurance are indicated as effectively benefitting those patients with somatic and psychological complaints following mild traumatic brain injury (Comper, Bisschop, Carnide, & Tricco, 2005). This is why we spend a considerable amount of time with each athlete, informing them of the nature and probable mechanism of concussive injury and the likelihood of improvement and recovery and advocating for them if required.

It should be emphasized that although NP testing is a very important part of the overall process in RTP (since an athlete with a diagnosed concussion must be at or above baseline NP values before being cleared from a neuropsychological perspective), ultimately, the “value-added” portion of neuropsychology lies in the clinical involvement of the psychologist to act as an advisor and mentor to injured athletes who might feel isolated and “lost” during the rehabilitation process, especially if that process becomes prolonged. Yet ultimately, the final decision regarding RTP rests with the physician. Effective communication along the rehabilitation continuum is therefore essential.

As noted, although many clinicians advise the athlete against engaging in any type of physical or cognitive activity until he or she is asymptomatic, we have implemented a variation of the approach currently in use at the University of Buffalo, as follows: If an athlete still has somatic (but not neurocognitive) symptoms at 14 days postinjury, neuropsychological screening is completed as a precaution, such as to evaluate for possible occult cognitive deficits. If neuropsychological screening does not identify objective deficits, a supervised (but cautious) exercise regimen might then be introduced at that point, as the presence of vague, nonspecific

<table>
<thead>
<tr>
<th>Therapist</th>
<th>Physician</th>
<th>Neuropsychologist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sideline Evaluation</td>
<td>Initial MD Assessment</td>
<td></td>
</tr>
<tr>
<td><strong>Therapist Monitoring</strong></td>
<td>Routinely assesses symptom status while awaiting symptom resolution</td>
<td></td>
</tr>
<tr>
<td>Exercise progression</td>
<td>Exercise progression</td>
<td>Supervised (but cautious) exercise regimen</td>
</tr>
<tr>
<td>Continue neck rehab</td>
<td>Continue neck rehab</td>
<td></td>
</tr>
<tr>
<td>Completes exercise progression</td>
<td>Completes exercise progression without symptoms</td>
<td></td>
</tr>
<tr>
<td>Symptomatic at 2 weeks</td>
<td>No symptoms</td>
<td></td>
</tr>
<tr>
<td>NP: Normal</td>
<td>NP: Abnormal</td>
<td>Neupyschological Assessment</td>
</tr>
</tbody>
</table>

Figure 1 — University of Toronto return-to-play schematic of concussion management.
(especially “mild”) physical symptoms are believed to be related to concussion comorbidity factors such as neck pain, sleep disturbance, depression, etc. (i.e., symptoms that are potentially not directly related to brain trauma). Obviously, this step is individualized and is highly dependent on several factors, including the relative severity of each athlete’s complaints; but when an athlete’s symptoms are vague and/or mild, the initiation of aerobic exercise is done as an effort to increase tolerance and essentially “pull” athletes along, as these other factors may have become barriers to recovery. This approach is based on research that indicates exercise (even a single session) is often associated with improved mood (Hansen, Stevens, & Coast, 2001; Lane & Lovejoy, 2001) and more recently, the work by Leddy and colleagues (Leddy et al., 2010), which has shown that controlled aerobic exercise rehabilitation has helped athletes’ persistent postconcussion symptoms achieve recovery. We might also argue that the benefits of establishing milestone targets for concussed athletes promotes proactive rather than passive rehabilitation and is thought to be of significant psychological benefit to the concussed player when, after 2 weeks of inactivity, boredom and frustration often set in.

Discussion

The concussion surveillance model at the University of Toronto has evolved as research evidence in the area of concussions has emerged over the past 20 years. Currently, our model includes a combination of common sense clinical judgment, careful monitoring, and evidence-based physical, medical, and psychological therapies. Our program also generates normative data stratified by age and sex; overall, the data figure into short- and long-term management decisions.

Unfortunately, there is no “magic bullet” to cure concussions. The evidence suggests that apart from rest and recovery, there is currently no known definitive treatment regimen that promotes healing from concussion (McCrory et al., 2009). Moreover, there are good reasons for athletes to be cautious following concussions: Emerging evidence indicates that athletes are often ill advised to try to “play through” symptoms in the early stages of recovery. Disrupted metabolic processes need time to settle. This process is unique to the individual but typically occurs within 7–10 days for the majority of athletes. Finally, caution during recovery is well advised, as there is also a growing body of literature indicating that even when asymptomatic, athletes may experience lingering neurocognitive impairment exhibited as declines or deficits on NP tests (McCrea et al., 2005; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). Further, it is also widely recognized that an athlete who sustains a concussion is at increased risk of suffering from future concussions, with the potential for delayed recovery following successive concussions (Delaney, Lacroix, Leclerc, & Johnston, 2000; Guskiewicz et al., 2003; Iverson, Gaetz, Lovell, & Collins, 2004; Macciocchi, Barth, Littlefield, & Cantu, 2001; Zemper, 2003). There is also a growing body of evidence that suggests the effects of concussions in some individuals may be deleterious to cognition later in life (Guskiewicz et al., 2005; Guskiewicz et al., 2007), a process that might be related to the frequency of concussive injuries over time.

Beyond the typical 7–10 day healing period, there is some limited evidence that invoking a graduated exercise program at specific time intervals postinjury can be beneficial (Leddy et al., 2010). In this respect, while it might make sense in the
acute recovery period to prescribe complete cognitive and physical rest, the effect of isolating a motivated, highly athletic individual from his or her teammates can be detrimental for some, a factor that needs to be carefully considered in the overall rehabilitation process. Moreover, comorbidities such as depression, anxiety, and fear of reinjury can obscure or intensify the symptom complex (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009; Mainwaring et al., 2004; Mainwaring, Hutchison, Bisschop, Comper, & Richards, 2010). The literature on recovery from mild traumatic brain injury also strongly supports early psychosocial interventions such as education and positive assurances, indicating that athletes may benefit from learning about the nature of the injury as well a probable favorable outcome (Comper et al., 2005).

In summary, the literature suggests that athletes with a single uncomplicated concussion usually experience full symptom resolution within a relatively short period of time (but this is a generalization that does not hold in a minority of cases). Active concussion treatment is limited to very benign interventions that concussion frequently manifests with psychological and emotional signs and symptoms, that a person may be asymptomatic but show declines and deficits on NP tests, and that there are risks associated with repeated injuries and possible risks over the long term.

A central component of any comprehensive concussion surveillance program is neuropsychological testing, both at baseline and after an athlete has been injured. It is important to note that currently (but incorrectly) regarded by many as computerized “concussion tests,” these programs in fact do not test for concussion, although they are well suited to accurately and reliably measure cognitive changes between two (or more) time points (Kane, Roebuck-Spencer, Short, Kabat, & Wilken, 2007). Consequently, the added value of neuropsychological testing is important. On the other hand, neuropsychological assessment and monitoring should not be regarded as a stand-alone gold standard in concussion management or recovery, because it is often the case that baseline to postinjury NP measurements are not clear-cut. In our experience, considerable variability in ANAM subtest scores both at baseline and after an athlete has suffered a concussion means that NP test results need to be carefully interpreted in context, with sufficient consideration given to any number of factors that might (and could) influence test scores. This is an important point: While the ease and accessibility of computerized NP testing protocols have allowed for the rapid and relatively inexpensive assessment of large numbers of athletes following concussion, it must be remembered that NP testing is not a panacea that allows an inexperienced clinician (or anyone for that matter) to render RTP decisions in the absence of or without careful consideration of other important collateral clinical information. Moreover, at the end of the process, the determination of RTP ultimately is a medical decision. Just as a physician might consider the results of blood work or other markers in making a determination about the presence or absence of a medical disease in a patient, the results of NP testing similarly contribute knowledge about cognitive changes that may or may not be related to a concussive event (or possibly some other psychological condition). This is not to diminish the importance of the psychologist in the process, quite the contrary; if it were simply a matter of monitoring an athlete taking tests at a computer, then the involvement of a psychologist would not be required. Rather, the role of the psychologist as a scientist-practitioner goes well beyond the application and interpretation of neuropsychological tests, which ideally will show...
a postconcussion decline in test performance followed by a pattern of recovery to normal, but which frequently does not. The psychologist not only determines what the NP test results are, but also what they mean in the context. An athlete’s postinjury scores might be low because he or she is depressed, anxious, or has slept poorly since being injured, and thus, perhaps psychological treatment should be undertaken or a recommendation for psychotropic medication should be given, and so on. In short, there is much more to concussion management than administering a 30–40 min brief battery of NP tests.

**Conclusion**

The essential components of a concussion surveillance program include clinical and common sense cornerstones such as early identification and diagnosis, ongoing monitoring of the concussed athlete by a dedicated therapist/trainer, timely medical follow up, and neuropsychological intervention. Although most athletes who suffer concussions can be expected to experience full symptom resolution within 7–10 days, a minority will continue to have prolonged symptoms past that point. When this occurs, the U of T current approach is to engage the athlete in a directed but limited exercise protocol intended to advance recovery; this approach is combined with additional neuropsychological intervention, education, and support. In short, we espouse an integrated interdisciplinary approach to concussion management for university athletes with the ultimate goal of decreasing risk of reinjury in both the short and long term. Within this integrated approach, the role of the neuropsychologist includes clinical evaluation, supervision/execution of baseline and postinjury neuropsychological testing, education, and possibly supportive counseling and psychological intervention.

**References**


