

Psychology of Sport Concussions

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The psychology of sport concussions consists of psychological, psychiatric, and psychosocial factors that contribute to sport concussion risks, consequences, and outcomes. The purpose of this paper is to present a sport concussion-adapted version of the integrated model of psychological response to sport injury and rehabilitation (Wiese-Bjornstal, Smith, Shaffer, & Morrey, 1998) as a framework for understanding the roles of psychological, psychiatric, and psychosocial factors in sport concussions. Elements of this model include preinjury psychological risk factors, postinjury psychological response and rehabilitation processes, and postinjury psychological care components. Mapped onto each element of this model are findings from the research literature through a narrative review process. An important caveat is that the subjective nature of concussion diagnoses presents limitations in these findings. Future research should examine psychological contributors to concussion risk, influences of physical factors on psychological symptoms and responses, and efficacy of psychological treatments utilizing theory-driven approaches.

Keywords: mild traumatic brain injury, athletes, psychiatric, sport psychology, postconcussion syndrome, psychological models

Sport concussions occur in the course of sport-related training and competition, and generally refer to mild traumatic brain injuries (MTBIs) that are the least severe in impact with respect to level of consciousness following injury, duration of symptoms, disruption of brain function, and scope of damage. Compared to patients sustaining concussions via nonsport contexts, such as falls or car accidents, athletes sustaining sport concussions on average show faster recoveries and less disability (Rabinowitz, Li, & Levin, 2014), perhaps due to factors such as better physical and mental health and/or availability of more immediate medical care. With respect to chronic problems, on the other hand, "...athletes may be more vulnerable to the deleterious long-term effects of MTBI because they are often subjected to repetitive trauma and greater levels of physical exertion during recovery" (Rabinowitz et al., 2014, p. 302). Among these chronic problems is postconcussion syndrome (PCS), a term used to refer to a complex cluster of persistent physical, cognitive, and emotional symptoms lasting for weeks, months, or years following a concussion (Al Sayegh, Sandford, & Carson, 2010; Broshek, De Marco, & Freeman, 2015).

Psychological, psychiatric, and psychosocial aspects of sport concussions stem from the acute and chronic

consequences of the injury itself as well as from the unique context of sport-related influences on occurrence and recovery. Psychological aspects include dynamic cycles of thoughts, feelings, and actions related to sport concussions, such as perceptions of poor recovery status leading to frustration and verbal outbursts. Psychiatric aspects include the prevention, diagnosis, and treatment of mental illnesses associated with sport concussions, such as depression and anxiety disorders, which can arise from neurobiological, pathophysiological, and psychogenic causes. Psychosocial aspects refer to intersections of the patient with the external physical or social environment (such as interpersonal communications with health care providers), and influences of the social climate or culture with respect to concussion risks, health care, and return to play (such as the sport norm of playing hurt). Among the least examined and understood aspects of sport concussions in terms of etiology (i.e., origin, cause, or manner of causation), assessment, and care, these psychological, psychiatric, and psychosocial components can be profoundly disabling and have long-term influences on risk, recovery, return to sport, and quality of life among current and former athletes.

The purpose of this paper is to synthesize the emerging body of evidence regarding these psychological, psychiatric, and psychosocial aspects of sport concussions in a way that is relevant for kinesiologists. Scholars who teach and conduct research in the many subdisciplines of kinesiology, as well as professionals in careers associated with kinesiology training—such as sport coaches, sport and exercise psychologists, athletic trainers, physical education and health teachers, and fitness leaders—all intersect with

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sport concussions. Although their roles and contributions to the psychological prevention and care of sport concussions differ, all share the goal of reducing the impact and chronicity of sport concussion symptomatology.

Recognizing that the sport context presents a unique set of challenges and opportunities for preventing and managing concussions, literature specific to sport concussions forms much of the basis for this review. Because a lack of research evidence characterizes many aspects of the psychology of sport concussions, relevant findings on MTBI from other populations are included as needed to bolster understanding and provide bases for future directions in the sport concussion literature. Furthermore, an important caveat to understanding the body of literature on the psychological, psychiatric, and psychosocial aspects of sport concussions is to recognize that the diagnosis of sport concussion and determination of severity is still a largely subjective process. Published research has often relied upon subjective diagnostic approaches to concussion and PCS, such as symptom self-report, self-reported concussion history, and neuropsychological tests (Shahim et al., 2015). The interpretation of subjective assessments is complicated by premorbid (i.e., preexisting before concussion injury) or comorbid (i.e., occurring at the same time as the concussion injury and recovery) conditions such as depression, learning disabilities, whiplash neck injury, and chronic pain. The use of objective diagnostic tools such as blood-based biomarkers, cerebral blood flow, and neuroimaging (e.g., quantitative electroencephalography [QEEG]) to identify organic etiology continues to be an emerging focus within the medical literature, and holds promise for improving assessment and care of sport concussions (McKee & Daneshvar, 2015; Shahim et al., 2015). At present, however, the limited broad-based availability and use of objective diagnostic tools presents a major limitation in establishing organic, brain-based diagnoses of concussion injuries upon which examinations of resulting psychological, psychiatric, and psychosocial disruptions can be based. Therefore, some level of caution is necessary in interpreting findings about the psychology of concussions based on subjective or imprecise diagnoses of the injury, as symptoms based on subjective reports could be attributable to conditions other than concussion injury.

Our approach was to develop a narrative review, thematically organized around a conceptual framework derived from prior models of psychological response to sport injury (Wiese-Bjornstal et al., 1998). To gather data relative to these psychological themes, we conducted extensive literature searches using several databases (e.g., CINAHL, Medline, PsycInfo, PubMed, and SPORTDiscus), and employed many keywords and combinations. Keywords included the word concussion and its associated variations (e.g., mild traumatic brain injury, acquired brain injury, postconcussion syndrome), terms related to psychology and psychiatry (e.g., cognitive functioning, emotions, depression, anxiety, coping), and expressions related to sport populations (e.g., athletes, athletics, intercollegiate sports).

A number of psychological, psychiatric, and psychosocial themes emerged from these searches, which we mapped onto a conceptual model derived from previous work on the psychological aspects of sport injury and adapted specifically to reflect evidence-based findings on sport concussions (Wiese-Bjornstal et al., 1998). For ease of expression in the model schematic and throughout the paper, use of the words psychology or psychological is inclusive of the breadth of psychological, psychiatric, and psychosocial aspects of sport concussions. For the benefit of kinesiologists who may be unfamiliar with the psychological aspects, we identified some evidence-based assessments commonly used to evaluate these dimensions in research and clinical practice, and discuss literature findings with respect to providers and treatments of psychological and psychiatric care. Based on this approach, sections in this paper include an explanation of the conceptual model, evidence from the sport concussion literature related to the model components, the psychological care of sport concussions, and future directions for research on the psychological aspects of sport concussions.

Conceptual Model of Psychological Response to Sport Concussions

The integrated model of psychological response to sport injury and rehabilitation (Wiese-Bjornstal et al., 1998) provided the conceptual framework around which this narrative review is organized (see Figure 1). This model provides an evidence-based operational framework for understanding psychological responses to sport injuries in a way that is useful for kinesiology researchers and sports medicine clinicians working with athletes during recovery and return to sport. The preinjury psychological risk factors at the top of Figure 1 comprise elements of the model of stress and athletic injury that influence vulnerability of athletes to injury (Andersen & Williams, 1988; Williams & Andersen, 1998). Preinjury psychological factors, such as personality (e.g., competitive trait anxiety or achievement motivation), history of stressors (e.g., life event stress or previous injuries), and coping resources (e.g., social support or medication) directly and interactively influence the stress response of the athlete. This stress response is characterized by physiological (e.g., muscle tension) and attentional (e.g., tunnel vision) changes, a result of heightened arousal and activation, which in turn influence sport injury risk. Interventions, such as cognitive restructuring or relaxation imagery, ameliorate the stress response and thus reduce risk of injury (e.g., Kerr & Goss, 1996).

Once injury occurs, the integrated model of psychological response to sport injury and rehabilitation (Wiese-Bjornstal et al., 1998) illustrates that sport injury itself is now a stressor, and the environment of personal and situational factors influence cognitive appraisals, emotional responses, and behavioral responses. With conceptual origins in transactional models of stress and

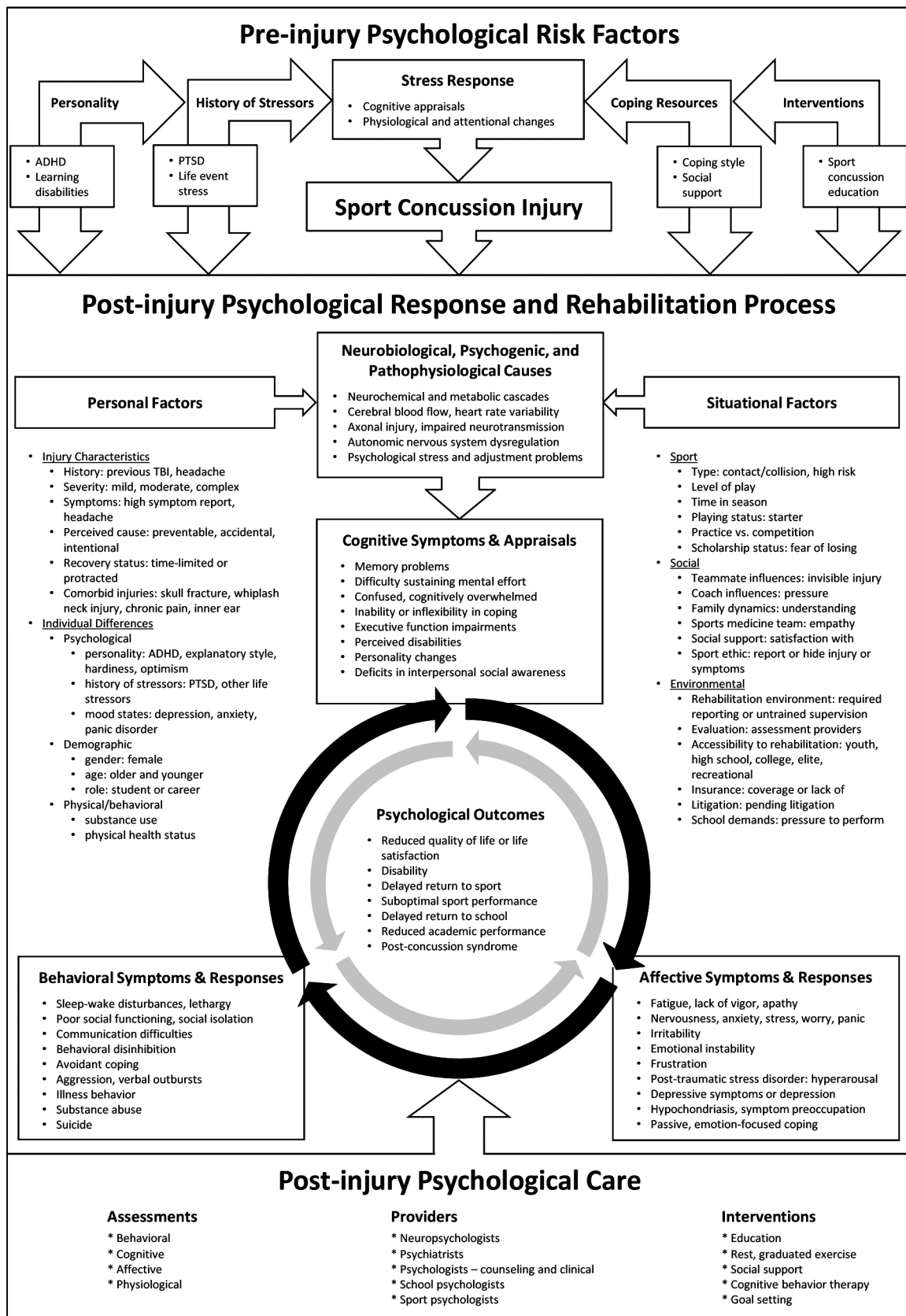


Figure 1 — Integrated model of psychological response to the sport concussion injury and rehabilitation process. Adapted from “An integrated model of response to sport injury: Psychological and sociological dynamics,” by D.M. Wiese-Bjornstal, A.M. Smith, S.M. Shaffer, and M.A. Morrey, 1998, *Journal of Applied Sport Psychology*, 10, p. 49. Copyright 1998 by Taylor & Francis, <http://www.informaworld.com>. Adapted and reprinted by permission of the publisher and the Association for Applied Sport Psychology, <http://www.appliedsportpsych.org>.

coping, the primary path, or cycle, hypothesizes that cognitive appraisals influence emotional responses and emotional responses influence behaviors, although the reverse flow of influence is also possible. These dynamic cycles of cognitive appraisals, emotional responses, and behavioral responses then affect recovery outcomes over the course of rehabilitation and return to sport. Positive recoveries show the absence of any lingering psychological consequences of injury detrimental to athlete health or performance, and athletes may even show indicators of personal growth such as a positive renewed perspective (Podlog & Eklund, 2005) on sport resulting from experiencing the injury process.

For the purposes of the present review, an adapted version of this integrated model (see Figure 1) serves as a conceptual map to examine the psychological aspects of sport concussions. Examples of constructs appearing in some evidence-based findings on sport concussions are bulleted within each element of this model, starting at the top with preinjury psychological risk factors aligned with the stress and injury model components of Williams and Andersen (1998). Space prohibits listing all possible bullet points, or addressing the evidence bases for all bullets listed in the present review, so we chose to discuss examples from each element. All points appearing in Figure 1 have some grounding in empirical findings to date.

Preinjury Psychological Risk Factors

Research into preinjury factors increasing the risk of prolonged concussion symptoms is somewhat limited. Preinjury psychological factors appear to predispose individuals to less than optimal outcomes after sustaining concussions, as identified in the top section of Figure 1. Preinjury factors include the four identified in the model of stress and athletic injury (Andersen & Williams, 1998): personality, history of stressors, coping resources, and interventions. The dynamic and bidirectional relationships between these factors affect the stress response, injury occurrence, and recovery processes surrounding sport concussions.

Personality. Preinjury psychological diagnoses are included under the heading of personality, as in the model of stress and athletic injury. Even though these diagnoses are not personality disorders per se, each of their diagnostic criteria within the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association [APA], 2013) involve constructs related to one's personality (e.g., impulsivity, sensation seeking, negative affectivity, and others). Reflected are individual differences in personal psychological characteristics such as cognitive, emotional, and behavioral tendencies.

Previous research has shown that not only are individuals with attention-deficit/hyperactivity disorder (ADHD) potentially more likely to sustain a concussion (Alosco, Fedor, & Gunstad, 2014), but preexisting ADHD and learning disabilities may also be risk factors for a protracted recovery (Bonfield, Lam, Lin, & Greene, 2013;

Harmon et al., 2013; Ponsford et al., 1999; Stavinoha, Butcher, & Spurgin, 2012). For example, Bonfield and colleagues (2013) found that children (mean age of 12 years) with a preinjury diagnosis of ADHD were more likely to have sustained learning, behavioral, or neurologic consequences following MTBI than same-aged children with no preexisting diagnosis of ADHD. Despite differences in follow-up times (average of 24.9 weeks for the ADHD group but only 7.2 weeks for the control group), 84% of the control group had completely recovered by their follow-up, compared to 56% of the ADHD group. Similar to individuals with preinjury ADHD, research supports prolonged cognitive and behavioral difficulties following concussion in individuals with preexisting learning disabilities (Collins et al., 1999; Ponsford et al., 1999).

Clinical depression preceding a concussion also relates to slower recoveries and PCS (Mooney & Speed, 2001; Mooney, Speed, & Sheppard, 2005; Preece & Geffen, 2007). Depression and MTBI have several overlapping symptoms (e.g., deficits in memory, information processing, attention, executive functions), and both profiles of cognitive deficits may be related to similar neuroanatomical structures (i.e., frontotemporal regions of the brain). However, there is mixed research evidence on the effect of preinjury psychiatric disorders on sport concussions. For example, several researchers have found that preinjury depression was related to prolonged recovery and general cognitive impairment (Bornstein, Miller, & van Schoor, 1989; Mooney & Speed, 2001; Rapoport, McCullagh, Shammie, & Feinstein, 2005; Rapoport, McCullagh, Streiner, & Feinstein, 2003), whereas others have found no effect of depression on specific cognitive abilities (Cicerone & Kalmar, 1997; Preece & Geffen, 2007).

History of Stressors. Following concussions, many individuals will misattribute stressors and anxieties of everyday life to their concussions, which results in greater perceptions of stress and emotional difficulty (Fenton, McClelland, Montgomery, MacFlynn, & Rutherford, 1993; King, 1996). Beyond this negative self-sustaining process, preinjury life stress also appears to be a risk factor for MTBI as well as for PCS and social difficulties (Fenton et al., 1993; Karzmark, Hall, & Englander, 1995). Additionally, Bay and Donders (2008) found that preinjury perceived stress was a strong predictor of depressive symptoms following MTBI.

Coping Resources. Certain individual coping styles (Bryant, Marosszeky, Crooks, Baguley, & Gurka, 2000; Harvey & Bryant, 1998; MacMillan, Hart, Mertelli, & Zasler, 2002; Woodrome et al., 2011) have been associated with poor outcomes following a concussion. Specifically, avoidant coping style, a form of emotion-focused coping, has been linked to acute stress disorder (Bryant et al., 2000) and posttraumatic stress disorder (PTSD) (Harvey & Bryant, 1998), whereas problem-focused coping strategies, such as positive reappraisal, have been associated with fewer symptoms and less mood

disturbance following MTBI (Moore & Stambrook, 1992; Woodrome et al., 2011). Limitations in social support systems (Katz & Alexander, 1994; McCauley, Boake, Levin, Contant, & Song, 2001; Webb, 1991) have also been associated with poor postconcussion outcomes. Findings with respect to social support systems are in the expected direction; poor social support systems relate to suboptimal somatic and emotional recoveries (Katz & Alexander, 1994; McCauley et al., 2001), as well as lower ratings of quality of life (Webb, 1991).

Interventions. Education is the critical preinjury intervention that can help reduce the risk of prolonged recovery following a concussion. Although regulations vary across the United States and at different levels of competition, education on concussion symptoms and management is a requirement for most professionals working in sport settings (e.g., coaches, athletes, referees, athletic trainers). Although these programs are widespread and easily accessible, research has yet to examine their impact on an individual's psychological recovery from concussion (McCrary et al., 2013; Salinas & Webb, 2012). Preinjury educational interventions in which the athletes learn about sport concussions and prevention, receive behavioral guidelines, and practice safe sport skills show promise in reducing concussion frequency (Smith et al., 2015; Tator, 2012).

To summarize, numerous psychological factors can affect risk of concussion injury and may complicate the recovery experiences postinjury. These preinjury factors include personality, life stress, coping, and education components that influence risk and recovery. The model of stress and athletic injury (Williams & Andersen, 1998) and its representation at the top of Figure 1 depicts the intersections between these factors, as well as the paths by which they influence stress response processes. The stress response processes could perhaps increase risk of concussion through heightened physiological activation (such as with anxiety) and attentional disruptions (such as tunnel vision that limits awareness of environment). Once concussion injury occurs, most of these preinjury factors and associated heightened stress response parameters continue to exert effects on postinjury psychological responses and recovery processes.

Postinjury Psychological Response and Rehabilitation Process

After sustaining a sport concussion, a complex variety of psychological, psychiatric, and psychosocial responses manifest during acute and chronic rehabilitation and recovery (see Figure 1). A range of symptoms and responses emerge over the acute phase in a pattern unique to each athlete. Chronic symptoms and maladaptive response patterns can also emerge postinjury among a subset of athletes. Identifying whether these psychological symptoms, appraisals, responses, and outcomes originate and maintain via neurobiological, pathophysiological, and/or psychogenic etiologies is a key challenge

facing researchers and health care providers working with sport concussion patients.

Symptoms of concussion refer to the subjective experiences of athletes following injury. Athletes typically self-report or describe their symptoms based on symptom checklists, and many symptoms of sport concussions are psychological in nature because the injury is to the brain and nervous system, the primary sources of cognition and affect. Psychological symptoms and the pattern over which they develop can be unique to each athlete. Cognitive symptoms include processing, memory, and concentration deficits. Affective symptoms include fatigue, irritability, and jumpiness. Behavioral symptoms include changes in sleeping, waking, and social behaviors. Somatic symptoms such as headaches, sensitivity to light and noise, and dizziness are also characteristic of sport concussions. These symptoms can change over time even within the acute period, and all can be psychologically disconcerting. Eisenberg, Meehan, and Mannix (2014) found in a pediatric sample of concussion patients that cognitive symptoms (e.g., taking longer to think) were present throughout the acute phase, but emotional symptoms (e.g., frustration) developed later. The circulating core of the model in Figure 1 captures the dynamic nature of symptoms and responses over acute and chronic periods.

Many devastating psychological aspects of sport concussions extend beyond the one- to two-week recovery period noted for the majority of these sport concussions (Institute of Medicine [IOM] and National Research Council [NRC], 2014; Karr, Areshenkoff, & Garcia-Barrera, 2014). The etiology of chronic cognitive, affective, and neurobehavioral symptoms experienced for weeks, months, or years beyond the usual recovery time for concussions has been the subject of debate (Mounce et al., 2013). Referred to by many different names, including PCS, persistent PCS, and neurobehavioral sequelae of traumatic brain injury (TBI) (Riggio, 2011), researchers have found that many sport concussion and MTBI patients suffer unabated symptoms for years after their head trauma events, with significant negative effects on their work, family, and social lives (e.g., Stycke, Sojka, Björnstig, Bylund, & Stålnacke, 2013).

It is difficult to determine if symptoms are a direct result of neurological trauma and associated neurobiological and pathophysiological changes, arise from pre- or comorbid psychological (e.g., depression) or physical (e.g., neck injury) health issues, or result from a secondary cognitive appraisal process of response to sport injury. Many authors place primary emphasis on psychogenic and social explanations for chronic postconcussion symptoms (e.g., Wood, 2004), yet emerging imaging data show evidence of microstructural changes in the brain that signify a primary or concomitant physical basis for PCS. For example, cognitive and neuropsychiatric deficits resulting from reduced white matter integrity following MTBI are the subject of current investigations (Sharp & Ham, 2011). Evidence such as this shows that functional and structural changes in the brain, such as

axonal damage and impaired neurotransmission, may underlie prolonged symptoms (IOM & NRC, 2014). Silverberg and Iverson (2011) suggested that both "... neurobiological and psychological factors play a causal role in post-concussion symptoms from the outset" (p. 317), which seems the most likely explanation given the complex web of causal factors. Metabolic and physiological responses to concussion such as central and systemic physiologic regulatory dysfunction affect brain function, autonomic functions of the heart, and circadian rhythms, all of which complicate symptom abatement and recovery (Leddy, Kozlowski, Fung, Pendergast & Willer, 2007). If athletes could more accurately identify the causes of their persistent symptoms, it might lead to more effective, targeted medical and psychological treatments. It could also potentially alleviate the self-blame or frustration athletes may feel if there is no identifiable cause for the prolonged symptoms. Personal and situational factors affecting symptoms and responses may help explain these relationships.

Factors. Factors reflect a diverse list of personal and situational factors that influence the cognitive, affective, and behavioral aspects of sport concussions. Using an interactional approach grounded in social psychology, Figure 1 shows that personal and situational factors interact with neurobiological, pathophysiological, and psychogenic mechanisms to affect cognition, affect, and behavior. These factors can be preinjury circumstances (such as TBI history, age, or sport type) related to psychological symptoms and responses, changing circumstances, or experiences emerging during the postinjury rehabilitation and recovery processes that affect symptoms and responses (such as pressure from coaches or insensitive interpersonal interactions with health care providers).

Personal factors. Personal factors affecting psychological responses to sport concussions appear in Figure 1 under the broad headings of injury characteristics and individual differences. Injury characteristics, such as a history of previous TBI and reports of many symptoms can be predictive of cognitive deficits, negative affect, and long-term disability (Ontario Neurotrauma Foundation, 2013). Male and female university athletes reporting a history of three or more sport concussions, for example, reported significantly lower quality of life and more frequent headaches than those with two or less prior sport concussions (Kuehl, Snyder, Erickson, & McLeod, 2010).

Comorbid injuries (i.e., injuries occurring at the same time as the concussion) such as skull fracture, whiplash neck injury, inner ear disturbances, and chronic pain may confound an understanding of the psychological aspects of sport concussion, as it is difficult to determine which symptoms and psychological responses can be attributed to which injury. Chronic pain can be quite prevalent in MTBI patients, with over 70% reporting pain one or more years postinjury (Gosselin et al., 2012; Nampiaparampil, 2008). This is important because pain, in part a psychological construction, affects stress appraisal

and response processes. In a sample of MTBI and PCS patients, Weyer Jamora, Schroder, and Ruff (2013) found that although higher pain severity ratings did not affect neuropsychological cognitive outcomes, they related to greater emotional distress. Specifically, anxiety, depression, paranoia, anger, and aggression related to pain severity ratings. Perceptions of injury causality also have the potential to affect psychological distress associated with injury (Rabinowitz et al., 2014), although few sport concussions studies have specifically addressed this. Hypothetically, athletes who perceive that illegal plays or preventable collisions caused their concussions may be more distressed or angry than those who attribute causality to accidents, unlucky breaks, or just part of the game.

Personal factors include psychological, demographic, and physical/behavioral variables. Psychological factors include personality and stress factors discussed earlier in the preinjury section. A study examining preinjury relationships between personality traits and self-reported postconcussion symptoms among intercollegiate athletes showed that higher neuroticism scores were associated with more symptoms, whereas higher agreeableness scores were associated with fewer symptoms (Merritt, Rabinowitz, & Arnett, 2015). Although evidence remains conflicted, some research shows that females seem to report more symptoms and greater recovery difficulties than males (e.g., Chamard, Henry, Boulanger, Lassonde, & Théoret, 2014; Covassin, Elbin, Bleecker, Lipchik, & Kontos, 2013; Covassin, Elbin, Crutcher, & Burkhardt, 2013). Kostyun and Hafeez (2015) found that female adolescent athletes had longer recoveries and required more treatments, academic accommodations, vestibular therapies, and medications than did male athletes. By contrast, Bloom, Loughhead, Shapcott, Johnston, and Delaney (2008) found among university athletes that male basketball players had longer recovery periods than female players. Female ice hockey players in the same study, however, had longer recovery periods than male players. Debates about explanations for possible gender differences are ongoing (Laker, 2011).

Age is another factor that influences concussion symptoms and recoveries. There are some indications that early adolescents (e.g., Kostyun & Hafeez, 2015) and adults over 30 (e.g., Mott, McConnon, & Rieger, 2012; Preiss-Farzanegan, Chapman, Wong, Wu, & Bazarian, 2009) are more prone to prolonged recoveries. With respect to adolescent athletes, the lingering presence of cognitive disturbances (Keightley et al., 2014) is particularly troubling due to its negative effects on academic performance during a time of their lives when school achievement is important (Halstead, McAvoy, Devore, Carl, Lee, & Logan, 2013; McCrory, Collie, Anderson, & Davis, 2004).

Situational factors. Situational factors include sport, social, and environmental factors. For example, concussion surveillance literature reports higher rates of concussion among specific sports (e.g., contact, collision, and high-risk sports), levels of sport (e.g., college as compared to high school), and settings in sport (e.g.,

higher rates in games versus practices). McGannon, Cunningham, and Schinke (2013) examined the role of several of these sport factors in concussion injuries. Exploring the media's coverage of the concussion of a high profile National Hockey League (NHL) player, they uncovered themes illustrating how the normative culture of sport relates to concussion narratives. Themes revealed the physically risky and violent nature of professional ice hockey and athletes' acceptance of these risks. The prevailing ethos of toughness and negative effects on perceptions of masculinity if not playing hurt are among the many factors that influence athlete thoughts, feelings, and actions surrounding sport concussions (McGannon et al., 2013).

Social factors that influence the relationship between concussion-related thoughts, feelings, and actions and postconcussion recovery include interactions with teammates, coaches, family members, and sports medicine team members (e.g., Ruddock-Hudson, O'Halloran, & Murphy, 2012). Normative expectations of the team or sport affects concussion reporting, symptoms, and recovery. The sport or team subculture can exert pressure to act in a way that shows toughness and the ability to play through injury or return to sport sooner than expected (Wiese-Bjornstal et al., 1998). Kroshus, Garnett, Hawrilenko, Baugh, and Calzo (2015) examined pressures from several social sources on intercollegiate athletes' decisions to report injury and continue playing following head impacts. Male and female athletes from team and individual sports who reported feeling greater pressure from teammates, parents/guardians, and fans to return to play following head impact were more likely to refrain from reporting their injury. Those athletes who also felt pressure from their coach were the most likely to intend to continue playing in the future, even with symptoms.

Environmental factors might include the psychosocial climate as it relates to athlete decisions to report concussion events and symptoms. Social influences within this environment such as athletic trainers, coaches, and parents can influence this reporting. For example, Register-Mihalik et al. (2013) examined several psychosocial determinants of intentions to report concussions among high school athletes. Positive attitudes toward reporting (e.g., perceiving it as important, valuable, and beneficial), beliefs about whether others expect reporting (e.g., coaches, teammates, and athletic trainers), and perceived personal control over reporting behaviors were positively related to athlete intentions to report. As Register-Mihalik et al. (2013) concluded, "Concussion education initiatives should focus on improving attitudes and beliefs among athletes, coaches and parents to promote better care-seeking behaviours among young athletes" (p. 878).

Cognitive Symptoms and Appraisals. Cognitive symptoms such as impairments of attention, concentration, and memory are evident in the acute and chronic phases of MTBI (Clarke, Genat, & Anderson, 2012). Sport concussions have a negative effect on neurocognitive

functioning in athletes, although this varies over acute and chronic recovery periods (Broglio & Puetz, 2008). Neurocognitive functioning reflects an athlete's cognitive status based on several neurologic domains such as memory, attention, processing, and executive functioning. Evidence supports cognitive symptoms as among the most common psychological symptoms of sport concussions.

Cognitive appraisals of concussion symptoms influence other psychological responses, such as confusion, an inability to cope, and feeling overwhelmed. The model of psychological response to concussion injury and rehabilitation (see core of Figure 1) suggests that cognitive appraisals of symptoms and situations will affect emotional and behavioral responses and recovery outcomes. This has received little explicit attention so it is difficult to draw evidence-based conclusions. Silver (2014), a psychiatrist, describes the cognitive appraisal-concussion response relationship as follows.

A dysfunctional cognitive feedback loop can develop after concussion. A mild TBI occurs, which disrupts cognitive functioning in the short run. In certain individuals, the cognitive slippage and subsequent change in function may elicit fear and anxiety. Anxiety of sufficient magnitude will interfere with cognition in all individuals, and this interference is enhanced when there is a cognitive weak link after a concussion. The increased anxiety heightens the postconcussive cognitive dysfunction, which increases the anxiety, which further interferes with information processing. When depression, sleep disturbance, and/or pain enter the picture, the dysfunctional feedback loop gathers sufficient strength to take on a life of its own. Even when the neurologic effects of the concussion have receded, the patient may continue to exhibit severe cognitive dysfunction (p. 98).

The severe fatigue reported by so many concussion sufferers further compromises cognitive functioning and cognitive appraisals, thus also influencing affective symptoms and responses.

Affective Symptoms and Responses. As used in psychology, the term affect refers to multiple constructs such as core affect (neurophysiological states, such as tension or tiredness), emotions (responses such as anger or fear that are based on cognitive appraisals of specific events), and moods (more global, diffuse, longer-lasting feeling states such as anxious or depressed moods) (Ekkekakis, 2012). Some have argued that affect is actually a form of cognition and that "...the affect-cognition distinction is not respected in the human brain" (Duncan & Barrett, 2007, p. 1184), a concept that may hold important relevance in understanding the psychology of concussion injury. Affective aspects of concussion include irritability, fatigue, anxiety, sadness, mood swings, and emotional lability (i.e., inappropriate emotional reactions such as laughing or crying at the

wrong time) (Centers for Disease Control [CDC], 2015). It is often difficult to distinguish psychologically between affective symptoms (i.e., based on organic etiology) and responses (i.e., based on cognitive appraisals) in concussion.

Findings regarding concussions and depression, for example, show that the severity of brain injury (mild, moderate, severe) does not necessarily predict the severity of depressive symptoms as perhaps would be expected (Sigurdardottir, Andelic, Røe, & Schanke, 2013). Even MTBI can result in severe depressive symptoms. It is unclear whether depressive symptoms stem predominantly from preinjury differences in mental health status, or change because of the concussion injury. Regardless, depressive symptoms can be a significant problem among concussed athletes. Vargas, Rabinowitz, Meyer, and Arnett (2015) reported that 20% of intercollegiate concussed athletes showed increases in depression compared to preinjury measures. Another study of male and female intercollegiate athletes found elevated depression scores at postinjury compared to baseline among concussed and nonconcussed/injured groups (Roiger, Weidauer, & Kern, 2015). Yang, Peek-Asa, Covassin, and Torner (2015) found that preinjury depression significantly predicted postconcussion depression and state anxiety among male and female university athletes.

With respect to other affective reactions to concussion such as mood state changes, Mainwaring, Hutchison, Bisschop, Comper, and Richards (2010) found among intercollegiate athletes that concussed athletes showed elevated negative mood and depression postinjury compared to their preinjury status. In a secondary analysis of symptom progression among acute concussion patients 11–22 years of age, irritability and frustration were among the specific affective symptoms that emerged later and lasted longer than depression (Eisenberg, Meehan, & Mannix, 2014). Hutchison, Mainwaring, Comper, Richards, and Bisschop (2009) found that levels and patterns of mood changes among concussed athletes differed from those of athletes with musculoskeletal injuries. Elevated fatigue and decreased vigor characterized concussed university athletes, whereas elevated anger characterized those with musculoskeletal injuries. Excessive fatigue is a common complaint postconcussion, and relates not only to affect such as apathy, but to cognitions and behaviors as well. For example, cognitive difficulties and slow or impaired performance on cognitive tasks depletes energy. Struggling with depression or anxiety can be fatiguing, or conversely, unrelenting fatigue can contribute to the development of depressive symptoms. Expending greater energy on daily cognitive tasks, along with poor sleep behaviors also common to concussion, creates a cycle of sustained fatigue that is difficult to break (Gosselin et al., 2009).

Affective and somatic symptoms of PCS overlap with those of PTSD (Lagarde et al., 2014), particularly with respect to the hyperarousal dimension that is characterized by the nervous system being on high alert. Hyperarousal symptoms include exaggerated startle responses,

hypervigilance, irritability, difficulty concentrating, and sleep problems, all well documented as part of the constellation of PCS symptoms. Lagarde et al. (2014) found that MTBI predicted PTSD among a sample of patients aged 15 years through older adults, and suggested that persistent subjective symptoms of MTBI diagnostically tie to the hyperarousal dimension of PTSD rather than to a unique diagnosis of PCS.

Qualitative examinations of concussed athlete stories reveal the depth of long-term struggles with many diverse emotional symptoms, responses, and outcomes. Caron, Bloom, Johnston, and Sabiston (2013) interviewed former NHL players who had suffered multiple concussions and consequently retired in order to understand the meanings and lived experiences of players in a comprehensive way. These athlete stories extensively illustrate how severely concussion symptoms and outcomes "...affected their professional careers, personal relationships, and quality of life" (Caron et al., 2013, p. 168). Emotional turmoil, anxiety, paranoia, depression, and suicidal thoughts were among the many consequences of their sport concussion and life after sport experiences.

Behavioral Symptoms and Responses. Coping behaviors, which are strategies used to minimize or tolerate stressful events such as sport injuries, have received some attention in the concussion literature. Broad categories of coping behaviors include active coping strategies, which involve awareness of the stressor and active behavioral attempts to address the stressor, and passive coping strategies, which involve ignoring the issue or denying the problem. Wolters, Stapert, Brands, and Van Heugten (2010) examined coping styles and quality of life in acquired brain injury patients with disabling cognitive, emotional, or behavior symptoms more than six months postinjury. These patients participated in an outpatient cognitive rehabilitation program. Contrary to expectations, the use of active problem-focused coping styles was less frequent and the use of passive emotion-focused coping styles more frequent after five months of rehabilitation than at the start of rehabilitation. Wolters et al. (2010) referred to this pattern of coping styles as maladaptive. An adaptive pattern characterized by greater use of active coping and lesser use of passive coping styles predicted better quality of life among these patients and thus the authors advocated teaching active coping strategies during rehabilitation.

Among adults more than six months following an acquired brain injury, Wolters, Stapert, Brands, and Van Heugten (2011) found that passive coping behaviors, including isolating oneself, seeking minimal social support, not asking for help, and not sharing worries with others, were associated with higher levels of subjective complaints (such as fear, depression, sleep problems, and cognitive difficulties). In a study comparing high school and collegiate athletes on coping with orthopedic and concussion injuries, Kontos, Elbin, Newcomer Appaneal, Covassin, and Collins (2013) concluded that at one week postinjury, "...concussed athletes may not

engage in coping to the same extent as athletes with other injuries” (p. 368). Hou et al. (2012) found that behavioral (e.g., coping behaviors) and cognitive responses (e.g., negative perceptions of injury) were stronger predictors of the development of PCS in a general MTBI population than were emotional (e.g., mood) and social (e.g., social support) factors.

Psychological Outcomes. Health-related quality of life, life satisfaction, disability, and prolonged PCS symptoms are examples of psychological outcomes reported in the MTBI literature. Kuehl et al. (2010) found that lower quality of life (such as low vitality, poor social functioning, and high fatigue) was associated with a history of sport concussions among university athletes. In a nonsport TBI population, Stycke et al. (2013) reported that over 50% of women and more than 30% of men self-reported evidence of PCS, significant disability, and lower life satisfaction than reference populations three years after concussion injury. In a retrospective, mixed methods study of an MTBI population, Åhman, Saveman, Stycke, Björnstig, and Stålnacke (2013) found “...disabling post-concussion symptoms and consequences in many areas of life 11 years after the injury event” (p. 758). Yang, Tu, Hua, and Huang (2007) reported that higher PCS symptom scores (such as for headache, dizziness, fatigue, irritability, insomnia, difficulty with concentration or memory, emotional lability, and stress intolerance) adversely affected clinical outcomes (including self-reported disability, recovery, and social and family relationship quality) among an adult MTBI sample. Of an intercollegiate sport population, 8% reported moderate to severe disability related to missing sport, school, and social activities that was attributable to concussion history and headaches (Register-Mihalik, Guskiewicz, Valovich McLeod, & Mann, 2009).

Although return to play is an important outcome following a sport concussion, understanding other outcomes such as disability and quality of life that affect return to school, work, and social activities is equally important to the psychological care of an athlete postinjury. Valovich McLeod and Register-Mihalik (2011) advocated for the inclusion of a variety of patient-oriented outcomes measures as part of clinical assessments after sport concussion. Among their recommendations are that clinicians consider using measures of health-related quality of life, perceived disability, social functioning, postconcussion symptom scales, and mood states as part of a comprehensive management plan.

Postinjury Psychological Care

The lower portion of Figure 1 reflects a new addition to the integrated model of psychological response to sport injury and rehabilitation as a way of specifically highlighting assessment, provider, and intervention aspects of psychological care related to sport concussions. Psychological assessments refer to methods of testing or evaluating cognition, affect, and behavior, and can include techniques such as standardized tests, screening

instruments, interviews, observations, and informal assessments. Interventions and providers refer to various sport professionals, mental health professionals, and interpersonal connections that deliver various forms of concussion interventions both pre- and postinjury, such as psychological therapies, educational materials, and mental skills training techniques.

Assessments. Although the majority of individuals who suffer a concussion are symptom free approximately 10 days after their injury, a substantial portion (reported from 5–15%) experience prolonged recovery periods (Iverson, 2005; Makdissi, Cantu, Johnston, McCrory, & Meeuwisse, 2013; McCrory et al., 2013). A protracted recovery can have significant effects on athletes’ psychological states. This section overviews the assessment of behavioral, cognitive, affective, and physiological consequences of concussion and explains how these consequences relate to psychological recovery from sport concussion injury. As with preinjury psychological factors, there are interactive effects of neurobehavioral, cognitive, and affective sequelae following sport concussion (King et al., 2012; Riggio, 2011).

Behavioral. Sleep disturbance appears to be the primary behavioral consequence of concussion that significantly impacts an individual’s psychological recovery. Although there is not one consistent pattern of disturbance, sleep problems appear to be common following concussions and include insomnia, hypersomnia, narcolepsy, delayed sleep phase syndrome, obstructive sleep apnea, delayed onset, early awakening, and poor sleep efficiency (Baumann, 2012; Castriotta et al., 2007; Mathias & Alvaro, 2012; Wiseman-Hakes, Colantonio, & Gargaro, 2009). As with people who have not suffered a concussion, these sleep disturbances can negatively affect emotional, cognitive, and social functioning (Chaput, Giguere, Chauny, Denis, & Lavigne, 2009; Ouellet, Beaulieu-Bonneau, & Morin, 2006; Wiseman-Hakes et al., 2013). Assessment options for sleep disturbance following a concussion include keeping a sleep diary (Ouellet, Beaulieu-Bonneau, & Morin, 2012), the self-report Sleep and Concussion Questionnaire (Beaulieu-Bonneau, Ouellet, & Wiseman-Hakes, 2013), and the Short Clinical Interview for Sleep after Head Injury (Ouellet et al., 2012).

Cognitive. As reflected in many acute concussion screening tools, common cognitive consequences of concussion include deficits in attention, concentration, memory, executive functioning, and speed of information processing. Commonly used and validated concussion screening tools have tests specifically designed to test some, or all, of these cognitive domains. These include the Immediate Post-Concussion Assessment and Cognitive Testing system (ImPACT; Lovell, Collins, Podell, Powell, & Maroon, 2000), Standardized Assessment of Concussion-Second Edition (SAC-2; McCrea, Kelly, & Randolph, 2000), the Sport Concussion Assessment Tool-Third Edition (SCAT-3; McCrory et al., 2013),

Automated Neuropsychological Assessment Metrics (ANAM; Cernich, Reeves, Sun, & Bleiberg, 2007), and CogSport (Collie et al., 2003).

The cognitive deficits above often resolve in the same time course as other symptoms (7–10 days), but may persist beyond this period (Bleiberg & Warden, 2005; Broglio, Macciocchi, & Ferrara, 2007; Fazio, Lovell, Pardini, & Collins, 2007). For example, Broglio and colleagues (2007) found that 38% of concussed collegiate athletes showed deficits on at least one ImPACT variable when they were asymptomatic. These prolonged cognitive decrements, especially in the absence of other symptoms, can be particularly worrisome for patients (who are often eager to return to their regular sport or physical activity patterns). However, what is currently not definitive is if persistent cognitive difficulties are the result of the injury itself (e.g., diffuse axonal injury; McKee & Daneshvar, 2015), or a result of interrelationships between other stressors associated with the injury and recovery process (Beaupré, DeGuise, & McKerral, 2012; Bigler, 2008; Mittenberg & Strauman, 2000; Wood, 2004).

Affective. Emotional sequelae following concussion can persist beyond resolution of somatic and cognitive symptoms (Levin et al., 1987; Ponsford et al., 1999). The most prevalent clinical diagnoses following MTBI are major depressive disorder and anxiety disorders, including PTSD. Other emotional consequences of concussion that have empirical support include emotional lability, apathy, and irritability (Whelan-Goodinson, Ponsford, Johnston, & Grant, 2009). These outcomes are not necessarily a reflection of preinjury disturbances, and recognizing symptoms promptly is important in helping patients recover from concussions more quickly, as these cognitive factors could inhibit recovery in other areas as well (Chamelian & Feinstein, 2006; Mainwaring, Hutchison, Camper, & Richards, 2012; McCauley et al., 2001; Rapoport et al., 2003).

Unfortunately, the significant symptom overlap between concussions and many mental health disorders makes accurate assessment and diagnosis difficult (McCullagh, Rees, & Velikonja, 2013). Additionally, little research to date has focused specifically on emotional correlates of sport concussion, so the assessment tools discussed are not all validated in concussion populations but have been effective in other assessment contexts. These tools include the Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1996), the Primary Care PTSD Screen (PC-PTSD; Prins et al., 2003), and the PTSD Checklist (PCL; Weathers, Huska, & Keane, 1991). Several self-report measures, including the nine-item Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001), Profile of Mood States, Beck Depression Inventory-II, and the seven-item Generalized Anxiety Disorder (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) are also possible tools.

Major depressive disorder and depressive symptoms are the most commonly reported mental health problems following MTBI, with at least 6% of those suffering

from a concussion receiving a clinical diagnosis (Deb, Lyons, Koutzoukis, Ali, & McCarthy, 1999; Jorge & Robinson, 2003). However, there does not appear to be a consistent pattern for when these symptoms become apparent (Gomez-Hernandez, Max, Kosier, Paradiso, & Robinson, 1997); this inconsistent pattern may be a result of the combined biological and psychosocial mechanisms at play (Bay & Donders, 2008). At a three-month follow-up assessment, Levin and colleagues (2001) reported significantly worse memory, attention, and problem-solving abilities in a mild-to-moderate TBI group with depression when compared to a matched, but depression-free TBI group. Depression also negatively affected this group's functional outcome following TBI, based on reports of ability to resume previous activities and satisfaction with social support.

Evaluating anxiety following sport concussion has not been the primary focus of research to date. When included as part of a larger study, no significant differences were found between concussed athletes and healthy controls in terms of anxiety levels (Mainwaring et al., 2012). However, in other injury contexts, Mooney and Speed (2001) report that nearly one-quarter of clinical patients with MTBI developed anxiety following their injury. Additionally, those suffering from PTSD following their injury were more likely to have postconcussion symptoms (Bryant & Harvey, 1999) and sustained cognitive deficits (Levin et al., 2001). Because concussed individuals are more likely to have elevated levels of preinjury anxiety (Bailey, Samples, Broshek, Freeman, & Barth, 2010) and be more affected by daily stressors (Ford, Swirsky-Sacchetti, & Chute, 2002), evaluating anxiety following concussion appears to be warranted.

Physiological. Concussions cause a cascade of physiological changes in the brain (Ellemberg, Henry, Macciocchi, Guskiewicz, & Broglio, 2009; Leddy et al., 2007). Of the neuroimaging techniques that have been used, event-related potentials (ERPs), diffusion tensor imaging (DTI), functional magnetic resonance imaging (fMRI), magnetic resonance spectroscopy (MRS), and possibly single-photon emission computed tomography (SPECT) seem to hold the most promise for objective assessment of concussions (Ellemberg et al., 2009).

ERPs are a relatively cost-effective, sensitive, and noninvasive way to measure neural processing dysfunction, even when the test taker is symptom-free and does not show cognitive deficits on standard measures. For example, Gosselin, Theriault, Leclerc, Montplaisir, and Lassonde (2006) demonstrated significant alterations to the P300 signal of the ERP for concussed athletes (both symptomatic and asymptomatic) compared to controls, despite similar performance on neuropsychological tests. Specifically, the amplitude of the P300 component, an indicator of how much attention a stimulus is given, was reduced for concussed athletes, while the latency of the signal, an indicator of the speed of processing the stimulus, was lengthened. These findings show that athletes took longer to process a stimulus and failed to attend to the stimulus appropriately, despite similar performance

on the task. Gosselin et al. (2006) also demonstrated that the amplitude of the P300 component was negatively correlated with self-reported concussion symptom severity. Other researchers have reported that these deficits can persist for up to three years after a concussion in athletes who have sustained multiple concussions (Broglio, Pontifex, O'Connor, & Hillman, 2009). These subtle physiological deficits could put concussed athletes at risk for greater stress and frustration with challenging tasks in their everyday lives, as well as increase the risk of subsequent injury.

Much like ERPs, structural and functioning neuroimaging techniques have the ability to provide information that is not accessible through standard neuropsychological testing or symptom ratings. Unfortunately, most concussions cannot be identified using common structural neuroimaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI). DTI, a structural imaging technique that provides information on white matter pathways, however, does show promise for detecting diffuse axonal injury that may result from a concussion (Toga & Mazziotta, 2002). Functional imaging, such as fMRI, may also be an effective way to detect physiological deficits in the aftermath of a concussion, although it is cost-prohibitive for routine use. Although few studies have been conducted using fMRI following sport-related concussions, results consistently show that atypical neural activation shortly after a concussion is positively related to recovery time (Chen et al., 2004; Chen, Johnston, Collie, McCrory, & Pfitz, 2007; Chen, Johnston, Petrides, & Pfitz, 2008; Lovell et al., 2007). Similarly, SPECT and MRS, types of metabolic imaging that provide information on regional cerebral blood flow and tissue composition, respectively, appear to have potential in the assessment of concussions (Ellemberg et al., 2009).

Interventions and Providers. Psychological interventions and the roles adopted by various psychological professionals are important in both the prevention and treatment of concussions (Moser, 2007). Specifically, there is some evidence for the effectiveness of psychological

interventions in the prevention of concussions, in increasing the reporting of concussions, and in treating the symptoms of concussions and PCS. Table 1 presents an overview of interventions receiving research attention within the sport concussion literature.

Preinjury interventions. Interventions implemented prior to the occurrence of a concussion primarily aim to decrease the incidence of concussions through education and stress management and increase the reporting of concussions through efforts targeted at coaches, athletes, and parents.

Results of research on educational interventions for concussion prevention and concussion reporting have yielded mixed results. Heads Up (CDC, 2015) is one of the most commonly-used educational campaigns. Developed by the CDC National Center for Injury Prevention and Control, Heads Up provides educational resources aimed to increase public awareness of the consequences of concussions (Sarmiento, Hoffman, Dmitrovsky, & Lee, 2014). The CDC has developed educational materials for health care professionals, high school coaches, youth sport coaches, school professionals, and parents (CDC, 2015). With respect to health care professionals, the Heads Up materials showed no significant impact on general concussion knowledge; however, health care professionals who received the materials were significantly less likely to recommend return to play the day after a concussion as compared to those health care professionals who did not receive the materials (Chrisman, Schiff, & Rivara, 2011).

High school coaches involved in a Heads Up educational intervention indicated that there were improvements in knowledge, attitudes, and behaviors surrounding concussions (Sarmiento, Mitchko, Klein, & Wong, 2010). About one-third of coaches indicated they learned something from the Heads Up materials and one-half reported improved attitudes toward concussions (specifically that they were more likely to recognize the seriousness of a concussion). One-half of coaches reported that they educated others about concussions after using the materials, and more than one-third said that they made

Table 1 Summary of Evidence-Based Psychological Interventions for the Treatment of Sport-Related Concussions

Intervention	Symptoms Addressed	Providers	Evidence
Rest	Acute concussion symptoms		Leddy et al., 2012; Schneider et al., 2013; Strauss, 2013
Social support	Coping resources	Coaches, athletic trainers, friends, family, teammates, physicians	Horton et al., 2002
Cognitive behavioral therapy	Anxiety, depression, sleep disruptions, postconcussion syndrome	Clinical psychologists, counseling psychologists	Burke et al., 2015; Conder & Conder, 2015; Silverberg et al., 2013
Education	Stress, concussion management skills	Parents and athletes	Ponsford et al., 2001
Goal-setting	Mood state, goal attainment	Sport psychologists	McPherson et al., 2009

changes in how they prevented or managed concussions because of the educational program (Sarmiento et al., 2010). Youth coaches' data from a different study showed similar results (Covassin, Elbin, & Sarmiento, 2012). Specifically, 50% of coaches who received the Heads Up materials reported learning something from the materials, 77% reported improvements in their ability to identify athletes with concussions, and 63% reported the materials increased their perceptions of the severity of concussions in athletes they coached (Covassin, Elbin, & Sarmiento, 2012).

Evaluations of educational materials aimed at athletes have shown mixed results. ThinkFirst Canada, Smart Hockey is an educational video aimed at increasing knowledge about concussions and reducing penalties among youth ice hockey players. This program can change both knowledge and behaviors. Cook, Cusimano, Tator, and Chipman (2003) found that teams who viewed the educational video showed an increase in knowledge about mechanisms of concussions while the teams that did not view the video showed no changes. Additionally, although there were no differences in overall penalty minutes in either group (i.e., control or intervention), those teams that viewed the educational video showed a significant reduction in high-risk penalties including cross-checking and checking from behind, whereas the control group remained unchanged (Cook et al., 2003). Glang, Koester, Beaver, Clay, & McClaughlin (2010) assessed the effectiveness of an online training program called ACTive: Athletic Concussion Training using Interactive Video Education. Through a randomized control trial with athletes 10–18 years of age, he found significant differences between control and treatment groups, with treatment groups rating higher in knowledge about concussion prevention and management, in attitudes about the importance of concussion management, and in intentions and self-efficacy for preventing and managing concussions in sport (Glang et al., 2010). Kroshus, Baugh, Hawrilenko, and Daveshtar (2015) found somewhat different results when they assessed the influence of three different publicly available concussion educational materials. In late adolescent hockey players, they found no significant influence of the educational materials on knowledge of concussions, reporting behavior, or thoughts about concussions at one day or one month after viewing. However, a study of collegiate athletes showed positive results. Miyashita, Timpson, Frye, and Gloeckner (2013) found that an educational intervention increased athletes' knowledge of concussions and improved their reporting behaviors.

All states have implemented interventions to decrease incidence of concussion, increase concussion reporting, prevent same-day return to play, and ensure that athletes do not return until cleared by a qualified health care provider (Smith et al., 2015). For example, the state of Washington enacted the Zackery Lystedt Law in 2009, which mandated that coaches receive education on concussions, parents and players sign information sheets on concussions, and athletes be removed from practice or

competition and assessed by a health care professional if a concussion is suspected (Echemendia, 2013). Results of the impact of this law have not been particularly positive; specifically, most athletes reported that they continued to participate in sport while experiencing concussion symptoms and 40% of athletes reported their coaches were unaware of their symptoms despite signing agreements to report concussion symptoms (Rivara et al., 2014).

Generally, education-based interventions show mixed results in the prevention of concussions. Interventions aimed at coaches and athletes both seem to increase participants' knowledge about concussion; however, this knowledge of concussion does not necessarily result in subsequent concussion prevention or reporting behaviors (Cook et al., 2003; Covassin, Elbin, & Sarmiento, 2012; Kroshus, Baugh, et al., 2015; Sarmiento et al., 2010). Similarly, state-mandated laws such as that in Washington do not seem to change behaviors of coaches or athletes with respect to concussions (Rivara et al., 2014).

Postinjury interventions. Psychological interventions for concussion management are used to manage psychological distress or psychopathology, aid in return to sport, and prevent or treat persistent PCS. Ideally, concussion treatment should begin prior to the season with baseline assessments (Esfandiari, Broshek, & Freeman, 2011) and from there should involve case-by-case assessments and treatments via an integrated approach including the involvement of psychologists, psychiatrists, and sport psychologists, as well as physical health care providers and coaches (Esfandiari et al., 2011; McCrea & Powell, 2012). Some of the specific psychological interventions used in the care of concussed athletes are described next.

According to recent reviews of studies related to concussion and PCS, the most common treatment for the acute symptoms of concussion is physical and cognitive rest (Leddy, Sandhu, Sodhi, Baker, & Willer, 2012; Schneider et al., 2013; Strauss, 2013). This rest should include abstaining from physical activity such as training, running, or weightlifting. Other aspects of rest include good sleep hygiene (getting adequate sleep, getting up at the same time every morning, avoiding naps and caffeine) and temporary avoidance of school, work, reading, and memory tasks (Strauss, 2013).

Despite the many benefits of rest in the treatment of concussion, a number of negative outcomes of rest are uniquely concerning for athletes as compared to other populations. For example, this rest can lead to concern regarding physical deconditioning, and other symptoms such as fatigue and depression among athletes (Esfandiari et al., 2011). It can also lead to reduced social engagement with teammates, falling behind on coursework for student-athletes, and illness behavior, all of which can contribute to psychological distress if the rest period is prolonged. From the standpoint of neuropsychiatry, Silver (2014) stated, "...the practice of cocooning, where the injured person is told to completely rest for weeks, can be counterproductive, not only deconditioning the person, but giving him or her a heightened sense of vulnerabil-

ity” (p. 96). Gradual resumption of noncontact aerobic exercise holds psychological and physical benefits for sport concussion patients and speaks to the importance of counterbalancing the benefits of rest and physical activity (IOM & NRC, 2014).

Following rest and symptom abatement, a gradual return to work, school, or sport activity is the usual course of action. Subsequent psychological interventions are recommended if athletes experience continued symptoms (Strauss, 2013). Several such psychological interventions have shown to be effective in reducing psychological symptoms and preventing PCS in athletes, including social support, cognitive behavioral therapy, educational interventions, goal setting, mindfulness, and other sport psychology interventions.

Social support has repeatedly been found to be important for injured athletes in general (Bianco, 2001; Chertok & Martin, 2013; Covassin et al., 2014). For example, Covassin et al. (2014) examined the differences in social support and anxiety between athletes with orthopedic and concussion injuries. They matched 63 Division I college athletes with concussions with 63 Division I college athletes with orthopedic injuries based on sex, sport, and time loss due to injury. Athletes in both groups identified family, friends, teammates, athletic trainers, coaches, and physicians as sources of social support throughout their injury. Both concussed athletes and athletes with orthopedic injuries reported comparable degrees of trait and state anxiety. Athletes with orthopedic injuries reported greater satisfaction with their social support than did concussed athletes, and satisfaction with social support was a stronger predictor of lower state anxiety for concussed athletes than for athletes with orthopedic injuries.

Horton, Bloom, and Johnston (2002) examined the psychological impact of sport concussions and the role of participation in social support groups in improving psychological responses. In their randomized control intervention, Horton et al. (2002) examined both male and female elite athletes on mood state and a postconcussion rating scale. Participants in the experimental group participated in three support group sessions each lasting 45 min. These sessions included education on topics including psychological responses to injury, concussion, and fear of reinjury and return to sport, and included a session of discussion of the topics directed by athletes in the social support group. Results showed that social support groups improved rehabilitation outcomes for athletes with concussions.

Cognitive behavioral therapy (CBT) focuses on relationships between thoughts, feelings, and behaviors, and has been used as a treatment to prevent chronic PCS, as well as to treat postconcussion symptoms such as anxiety, depression, and sleep disruptions such as insomnia (Ouellet & Morin, 2007) and parasomnia (Conder & Conder, 2015; Silverberg et al., 2013). CBT treatment involves identifying maladaptive thinking, such as overgeneralizations and catastrophizing, and challenging this thinking with more rational and realistic alternatives to

the distorted patterns of thought (Conder & Conder, 2015) as a means of improving coping. Silverberg et al. (2013) examined the efficacy of CBT in treating individuals identified as at risk for chronic PCS. Twenty-eight patients were randomized to either a CBT intervention group or an education control group. The CBT intervention was effective, having a moderate effect on postconcussion symptoms. Additionally, fewer participants in the treatment group had a diagnosis of PCS at follow-up as compared to the control group (54% as compared to 91%). Participants in the treatment groups reported lower perceived disability and fewer depressive symptoms and reported being satisfied with the intervention (Silverberg et al., 2013). Ponsford et al. (2012) suggested the use of CBT for managing the fatigue of TBI patients by helping them “...regulate their lifestyle to live within cognitive and physical limitations” (p. 231).

Researchers have also found support for educational interventions postconcussion. With children 6–15 years of age who incurred concussions during sports and bike riding, Ponsford et al. (2001) found support for the effectiveness of educational materials. They designed an educational booklet for children that outlined the typical course of symptoms for concussions and the best strategies for coping with them effectively. Comparing children who had received the booklet with those who had not, Ponsford et al. (2001) showed that, “The provision of information about expected symptoms, their likely time course, and how best to cope with them resulted in significantly reduced reporting of symptoms and behavioral changes months after injury” (p. 1300). At three months postinjury, children and parents in the treatment group utilizing the booklet endorsed lower stress about concussions, greater ease in the management of concussions, and fewer attributions of concussion symptoms to preexisting problems than did the control groups who had not received the booklet.

Only one pilot study examined the efficacy of goal-setting interventions with individuals who experienced concussions. Although this study had a small sample size, the interventions showed positive results. Specifically, participants in the goal-setting interventions indicated improved mood state, goal attainment, and use of goal-setting skills postintervention, indicating goal-setting interventions may be effective in improving postconcussion outcomes (McPherson, Kayes, & Weatherall, 2009).

There is preliminary evidence supporting the utility of mindfulness-based stress reduction (MBSR) in recovery from concussions. MBSR is a treatment approach originally developed to treat chronic pain (Azulay, Smart, Mott, & Cicerone, 2013). MBSR involves awareness of thoughts, feelings, and bodily sensations (Azulay et al., 2013). Azulay et al. (2013) examined the effectiveness of a 10-week MBSR intervention in a sample (18–62 years) of MTBI patients recruited from a brain rehabilitation center. They found significant improvements in self-efficacy and quality of life at postintervention. Based on this initial work, they suggested that MBSR shows promise as an effective intervention in MTBI populations.

Future Directions on Psychology of Sport Concussions

Although this review has identified many important findings relative to the psychology of sport concussions, future directions for research are evident for all aspects of the model in Figure 1. Among the preinjury contributors to concussion risk, for example, it would seem viable to examine whether the predictions of the model of stress and athletic injury (Williams & Andersen, 1998) would hold true for sport concussions in ways similar to those shown for musculoskeletal and orthopedic injuries. For example, one of the most consistent findings from musculoskeletal-injured populations is that a high perception of negative life event stressors is a risk factor for sport injury, particularly in situations where athletes are simultaneously low in perceptions of coping resources. The physiological and attentional consequences associated with the stress response would seem likely to render athletes more vulnerable to sport concussions, such as via attentional failures to recognize and brace for impending collisions.

Once concussion injury happens, there is little in the research literature to longitudinally document the dynamic cycles of psychological response to the injury. Prospective, repeated-measures designs such as those used in longitudinal studies of athletes with knee injuries could provide ideas for sport concussion research. Although limited in number and contradictory in findings, more research to date has focused on the psychiatric symptoms and influences of PCS than on secondary cognitive appraisal and psychological response processes or psychosocial influences on recovery. Knowledge about the psychology of sport concussions would benefit from studies in the latter areas, focusing, for example, on how the lack of objective diagnostic evidence of concussion, struggles with enduring symptoms, and the invisibility (i.e., lack of outward evidence to others) of the injury handicap recovery processes. As gender differences seem to be the topic of some debate in the literature, future studies of the consequences of early-career sport concussions to later life psychological events (such as depression or cognitive impairments) among former female athletes would complement the many studies of older male athletes appearing in the literature. The first generation of Title IX females who came of age during the dramatic increases in girls' and women's sports in the 1970s are now of the age similar to that being looked at in former National Football League (NFL) players. As with these early NFL players, recognition and care for concussion injuries was similarly primitive for female athletes, many of whom played in what are now known to be sports with relatively higher concussion rates for females (e.g., basketball).

Studies investigating the psychological care of athletes with concussions are in relative infancy. One area worth looking at closely is rest. For athletes it is particularly important to examine the duration and benefits

of rest compared with the psychological drawbacks of social isolation and lengthy physical activity restrictions. Surprisingly, little research examines optimal rest and return-to activity timelines, according to Burke, Fralick, Nejatkakhsh, Tartaglia, and Tator (2015). Although rest is indicated in the management of acute concussion symptoms, studies utilizing modified treadmill testing and controlled aerobic exercise show benefits in alleviating chronic symptoms (Leddy et al., 2012). Psychological therapies are also emerging as important aspects of psychological care postconcussion. For example, clinical trials are continuing to examine the efficacy of cognitive behavioral therapies with concussion patients, with some promising results to date (Burke et al., 2015). Burke et al. (2015) advocated for research examining sport concussion populations, employing objective assessments of concussion injury, and utilizing larger sample sizes. Conder and Conder (2014) present another example of an emergent frontier of psychological care: the use of biofeedback in restoring optimal heart rate variability to improve emotional regulation and neurocognitive performance postconcussion. According to Conder and Conder (2014), optimal heart rate variability can be disrupted by concussions, and "...interactive communication between the cardiac and the neurocognitive systems" (p. 1) affects recovery from concussions. Preliminary studies have supported the use of biofeedback training as a means of restoring optimal heart rate variability in the management of sport concussions (Conder & Conder, 2014).

An important future direction across all aspects of the psychology of sport concussions is to utilize psychological theory as the basis for investigations. Psychological theories have the potential to help describe, explain, and predict human thoughts, feelings, and actions within sport concussion contexts. Yet many studies reporting on the psychological aspects of sport concussions are still exploratory and atheoretical, perhaps because psychological purposes are seen as secondary to addressing specific clinical purposes. Nonetheless, clinical purposes could benefit from comprehensive understanding of how psychology affects sport concussion occurrence and recovery; it is impossible to separate mind and body in the sport concussion context, as is evident from this review. Therefore, the clinical care of sport concussion patients must include a consideration of psychological contributors to health. Investigations based on psychological, psychiatric, or psychosocial theories would provide stronger frameworks for seeing the interconnectedness between mind and body in sport concussions, and explain the powerful roles of social influences on risk and recovery.

Conclusions

The psychological, psychiatric, and psychosocial aspects of sport concussions affect athlete risks, responses, and recoveries. An integrated model of psychological

response to the sport concussion injury and rehabilitation process provides a conceptual framework for consolidating literature on these aspects. This model provides a foundation that assists kinesiologists with incorporating evidence-based psychological considerations into their research and professional practice work. Clinical outcomes benefit when prevention efforts and return-to-health strategies improve through thoughtful attention to cognitions, affects, behaviors, and social influences among sport concussion patients. Kinesiologists working in a wide variety of settings are essential partners in advancing the body of knowledge about sport concussions and improving athlete recoveries following sport concussions.

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