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Anxiety and Mood Clinical Profile following Sport-related Concussion: From Risk Factors to Treatment

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Abstract

Conceptual models for assessing and treating sport-related concussion (SRC) have evolved from a homogenous approach to include different clinical profiles that reflect the heterogeneous nature of this injury and its effects. There are six identified clinical profiles, or subtypes from SRC, and one such clinical profile is the anxiety/mood profile. Athletes with this profile experience predominant emotional disturbance and anxiety following SRC. The purpose of this targeted review was to present an overview of the empirical evidence to support factors contributing to the anxiety/mood profile, along with methods of evaluation and treatment of this clinical profile following SRC. We discuss the potential underlying mechanisms and risk factors for this clinical profile, describe comprehensive assessments to evaluate concussed athletes with an anxiety/mood clinical profile, and explore behavioral and other interventions for treating these athletes. Although there is limited, but growing empirical evidence for the anxiety/mood clinical profile following SRC, understanding this clinical profile is germane for clinicians who are treating athletes with emotional sequelae after SRC.

Keywords

concussion; anxiety; mood; sport

Sport-related Concussion and Clinical Profiles after Injury

An estimated 1.6 to 3.8 million sport-related concussions (SRCs) occur each year in the United States (Langlois, Rutland-Brown, & Wald, 2006). SRC is a mild brain injury caused by direct or indirect biomechanical forces transmitted to the head that induce a complex cascade of neurometabolic changes and transient neurologic dysfunction (Barkhoudarian, Hovda, & Giza, 2011; Giza & Hovda, 2001a; Giza & Hovda, 2014; McCrory et al., 2013a). An SRC can result in a constellation of physical symptoms (e.g., headache, dizziness), cognitive symptoms (e.g., memory problems, difficulty concentrating), sleep difficulties, and emotional changes (e.g., irritability, anxiety)(Kontos et al., 2012b). Most individuals are expected to have a resolution of these symptoms within 21 days of injury, but between 10 to

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20% of athletes continue to experience these symptoms well-beyond this timeframe (Collins, Lovell, Iverson, Ide, & Maroon, 2006; Karr, Areshenkoff, & Garcia-Barrera, 2014; McCrea et al., 2003). Cognitive and physical symptoms such as headache and mental fatigue are common immediately after the injury, while emotional and sleep symptoms tend to develop later (i.e., 1+ weeks post-injury) in recovery (Kontos et al., 2012b).

Although generalities in the signs and symptoms of concussion have been established, recent research has indicated that concussion is not a homogeneous injury (Collins, Kontos, Reynolds, Murawski, & Fu, 2014a; Ellis, Leddy, & Willer, 2015a; McCrea, Iverson, Echemendia, Makdissi, & Raftery, 2013). Rather, emerging research suggests that following the acute phase of the injury (i.e., 1 to 7 days of injury), athletes exhibit differing subtypes, or clinical profiles of SRC that are associated with particular patterns of symptoms and deficits (Collins et al., 2016; Henry, Elbin, Collins, Marchetti, & Kontos, 2016a; McCrory et al., 2013b). Researchers have proposed six clinical profiles of SRC including: anxiety/mood, post-traumatic migraine, oculomotor, vestibular, cervical, and cognitive fatigue that are briefly described in Table 1 (Collins et al., 2014a; Henry et al., 2016a; Reynolds, Collins, Mucha, & Troutman-Ensecki, 2014). Each of these clinical profiles are determined based on symptom clusters and deficits demonstrated on concussion assessment tools. These clinical profiles require further empirical validation, but are a first step in delineating and conceptualizing the potential varying effects from SRC.

This proposed clinical profile framework enables clinicians to determine the subtype/s of SRC an athlete is experiencing in order to appropriately tailor assessment and treatment rather than applying a “one-size-fits-all” approach to concussion management (Collins et al., 2016). Athletes may demonstrate a cohesive pattern of symptoms and deficits after SRC that clearly fits a single clinical profile, or they may exhibit deficits that overlap multiple clinical profiles. To identify the primary clinical profile that is producing the greatest functional impairment, a comprehensive, multimodal assessment approach to SRC is recommended. An athlete’s clinical presentation following SRC will depend upon a number of contributing factors including personal and family health history, psychosocial characteristics, and the approach to treatment (Collins et al., 2014a).

Anxiety and Mood Clinical Profile

Athletes with persistent, or chronic post-concussion symptoms are often associated with the anxiety/mood clinical profile in which a mental health and/or emotional disturbance becomes the primary concern after injury (Carroll et al., 2004; Corwin et al., 2014; Mittenberg, Canyock, Condit, & Patton, 2001; Ponsford et al., 2012a). The anxiety/mood clinical profile after SRC is characterized by emotional disturbance such as experiencing anxiety, feelings of depression, hypervigilance of somatic complaints, and sleep dysregulation. Research suggests that up to 20% of collegiate athletes display an increase in depressive symptoms following SRC, as compared to only 5% in a control group (Vargas, Rabinowitz, Meyer, & Arnett, 2015). Although it is not unusual for athletes to exhibit transient emotional changes after a concussion, there are several factors identified in the literature that may contribute to a worsened anxiety/mood disturbance and prolonged SRC symptomology (Ponsford et al., 2012a; Thomas, Apps, Hoffmann, McCrea, & Hammeke,

2015b). Some individuals may even experience persistent emotional symptoms that require formal psychological intervention (Covassin et al., 2014; Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009; Kontos, Covassin, Elbin, & Parker, 2012a) due to impairing levels of anxiety, ruminative thinking, hopelessness, and sadness (Collins et al., 2014a). If not properly treated, these mood changes can result in chronic post-concussive symptoms and functional impairment, especially in patients with pre-exiting mood conditions (Corwin et al., 2014; Ponsford et al., 2012a).

There exists an emergent need for a better understanding of the anxiety/mood clinical profile as there are limited guidelines available to clinicians for conceptualizing or treating emotional factors after SRC. To properly diagnose and treat SRC and prevent persistent mood disturbance, it is imperative that clinicians regularly screen for emotional changes and address factors during SRC recovery that can lead to worsening mood and anxiety (Broshek, De Marco, & Freeman, 2015; Clement, Granquist, & Arvinen-Barrow, 2013; Collins et al., 2014a; Leddy, Sandhu, Sodhi, Baker, & Willer, 2012). The goal of this targeted review is to provide a conceptualization of the underlying mechanisms contributing to the anxiety/mood clinical profile after SRC, methods of evaluating emotional disturbance after injury, and guidance on both preventative and formal interventions for athletes at risk of or currently demonstrating the anxiety/mood clinical profile after SRC based on available empirical evidence.

Mechanisms of Anxiety/Mood Clinical Profile following SRC

Understanding the etiology of emotional changes after an SRC is complex, as there is likely an interplay of contributing physiological and psychosocial factors. Research on the psychological changes after SRC is limited and has primarily focused on individuals with a pre-injury mental health history (Carroll et al., 2004; Cassidy et al., 2004; Ponsford et al., 2012a). There are several other potential mechanisms, however, that may lead to emotional disturbance after SRC. Below is a brief outline of (a) pre-injury risk factors, (b) brain changes from concussion, (c) psychological responses to injury, and (d) concurrent situational risk factors that may engender the anxiety/mood clinical profile subtype after SRC.

Pre-injury Risk Factors—There are several identified pre-injury risk factors that may predispose some athletes to the anxiety/mood clinical profile after SRC. A thorough understanding of these risk factors may yield valuable information on prognosis from SRC and permit clinicians to normalize expected emotional changes after SRC in certain populations. Athletes identified as high risk of the anxiety/mood subtype may be prescribed a more aggressive behavioral treatment approach than athletes with no known risk factors of this SRC subtype.

Mental Health History: One of the most robust predictors of anxiety/mood disturbance and prolonged recovery after SRC is a pre-injury history of a mental health condition (Cassidy et al., 2004; Ponsford et al., 2012b). Several studies have found that a diagnosed mental health condition (e.g., anxiety disorder) and/or history of mental health treatment prior to sustaining a concussion predicts a greater endorsement of overall concussion symptoms

(Balasundaram, Athens, Schneiders, McCrory, & Sullivan, 2016; Edmed & Sullivan, 2012; Iverson et al., 2015) and protracted recovery from concussion (Meares et al., 2008; Morgan et al., 2015; Ponsford et al., 2012b; Silverberg et al., 2015; Wojcik, 2014). Individuals with a prior mental health condition are also more likely to endorse post-injury emotional disturbances relative to those without such a history. Individuals with a mental health history are at risk for greater depressive and anxiety symptoms post-injury (McCauley et al., 2013), worsening of their pre-existing mental health condition (Bombardier et al., 2010), and development of a novel mental health condition (Ellis et al., 2015b; Tsai et al., 2014). Research suggests that at three months post-injury, pre-injury psychiatric disorders are more predictive of ongoing impairment than the concussion itself (Ponsford et al., 2012b). Individuals with no personal history, but a family history of a mental health disorder are predisposed to developing a psychological disorder, and thus careful consideration of family mental health history may be important as well for understanding emotional functioning (Belmaker & Agam, 2008), particularly among young adult athletes who are at the age of onset for some mental illnesses (Center for Disease Control and Prevention, 2011). Conceptualizing the risk of developing the anxiety/mood clinical profile should therefore include a consideration of pre-injury personal and family mental health history.

Biological Sex: In addition to mental health history, biological sex is another risk factor that influences the experience of emotional changes after SRC. Given that mood and anxiety disorders tend to be more prevalent among females than males (Merikangas et al., 2010), it is perhaps unsurprising that females also tend to report more emotional symptoms than males both before and after injury (Iverson et al., 2015; Kontos et al., 2012b). However, the specific pattern of affective symptoms endorsed by males and females may be different, with males more likely to endorse more sadness after SRC (Covassin, Schatz, & Swanik, 2007). Although researchers have attributed these sex differences to biological factors (e.g., hormone production associated with menstrual cycle) and cultural phenomena (e.g., females tend to be more concerned about their future health), there does not seem to be a consensus explanation for sex differences in SRC symptom reporting (Covassin, Elbin, Harris, Parker, & Kontos, 2012; Covassin et al., 2007).

Brain Changes from Concussion—SRC can result in a myriad of organic cognitive, physical (e.g., headache, dizziness), sleep, and emotional changes after the injury. There are several possible factors that complicate the emotional response to recovery from SRC compared to other types of acquired sports injuries (Covassin et al., 2014; Farmer, Singer, Mellits, Hall, & Charney, 1987; Mittenberg, Wittner, & Miller, 1997; Woodrome et al., 2011; Yeates et al., 2009). One potential complicating factor is the overlap between SRC symptoms and those symptoms associated with mood- and anxiety-based mental health disorders (American Psychiatric Association, 2013; Iverson, 2006; Wood, O'Hagan, Williams, McCabe, & Chadwick, 2014; World Health Organization, 1992). The presence of concussion symptoms can affect multiple aspects of an individual's daily functioning, not unlike the functional limitations associated with mood and anxiety disorders. For instance, the presence of cognitive deficits (e.g., impaired concentration, poor executive functioning), which exist as both an aspect of post-concussion syndrome (World Health Organization, 1992) and major depressive disorder (American Psychiatric Association, 2013) criteria, may

result in impaired productivity in the school or work environment. Similarly, the dizziness and imbalance associated with decompensation of the vestibular system after SRC (Alsalaheen et al., 2010b; Guskiewicz, Ross, & Marshall, 2001b; Kontos et al., 2012b; Mucha et al., 2014) is qualitatively similar to diagnostic symptomology for panic attack that can include feelings of dizziness, lightheadedness, and unsteadiness (American Psychiatric Association, 2013). The commonality in symptoms between SRC and mental health disorders may predispose individuals to experience emotional complications after injury relative to other sports injuries.

The overlap in symptoms of SRC and mental health disorders are at least partially contributed to physiological changes that occur in the emotional centers of the brain after concussion (Elson & Ward, 1994; Kontos et al., 2012a; Yeates et al., 2009). Neurometabolic disturbance secondary to concussion exhibits a similar pattern of brain alterations as individuals diagnosed with clinical depression on advanced neuroimaging (Barkhoudarian et al., 2011; Chen, Johnston, Petrides, & Ptito, 2008; Giza & Hovda, 2001a; Giza & Hovda, 2014). There is evidence of alterations in limbic-frontal circuitry after concussion that resembles the functional alterations seen in major depression (Chen et al., 2008). Other neurochemical changes consistent between mood disorders and concussion are the presence of serotonin disturbance (Smyth et al., 2014) and decreased dopamine in the prefrontal cortex and brainstem (Chen et al., 2008; Sheline, Wang, Gado, Csernansky, & Vannier, 1996; Venzala, Garcia-Garcia, Elizalde, & Tordera, 2013). Organic brain changes may provide an explanation for mood and anxiety symptoms post-injury in the absence of pre-injury mental health conditions.

Psychological Responses to Injury—In addition to pre-injury mental health vulnerabilities and physiological brain changes, an athlete's response to sustaining an SRC may have implications for the development of the anxiety/mood clinical profile. The method in which athletes cope and regulate their distress after the injury, as well as the guidelines provided for treating SRC can affect an athlete's outcome. Mismanagement of SRC can potentially result in iatrogenic behavioral problems and worsened symptoms.

Coping Style: Understanding the association between coping style and SRC symptoms is important, particularly as athletes during the acute phase of recovery frequently experience abrupt increases in symptoms in response to returning to everyday physical and mental activities, such as exercise and school work. While these "symptom spikes" do not appear to be detrimental to recovery (Silverberg et al., 2016), it is reasonable to assume that many athletes, especially those with poor coping strategies, may develop a fear of increasing their symptoms and maladaptive behaviors that impede their recovery. To this end, studies have examined the effectiveness of coping styles among concussed individuals. The use of maladaptive behavioral coping strategies after SRC can result in prolonged post-concussive symptoms and emotional sequelae (Kontos, Elbin, Newcomer Appaneal, Covassin, & Collins, 2013a; Woodrome et al., 2011). Individuals who utilize avoidant/passive coping strategies report elevated levels of depression and anxiety, lowered quality of life, cognitive problems, and physical symptoms after concussion (Carroll, Cassidy, & Côté, 2006; Jensen, Turner, & Romano, 2001; Maestas et al., 2014; Roesch & Weiner, 2001; Woodrome et al.,

2011). Research suggests that an active, problem-focused coping style is beneficial for reducing post-concussion symptom burden (Woodrome et al., 2011).

In the context of SRC, an example of a maladaptive passive coping style would be an athlete who resists returning to school post-injury out of fear of experiencing unpleasant SRC symptoms. This passive coping may be appropriate in the initial stages of the injury when the brain is in neurometabolic crisis (Giza & Hovda, 2001b, 2014; Kontos et al., 2012b), but continuation of this avoidant coping style can be functionally disruptive to daily life (e.g., declining grades, falling behind in school). The development of this maladaptive coping style can be theoretically explained based on behavioral operant conditioning principles. In this example, avoiding school prevents the athlete from experiencing unpleasant SRC symptoms, thus negatively reinforcing non-attendance to school. Despite an alleviation of symptoms, encouraging this type of avoidance behavior such as prescribing strict rest, may actually have adverse effects on outcomes from concussion and worsen emotional symptoms. For instance, these athletes may take longer to recover from concussion and develop a mood disturbance (Thomas, Apps, Hoffmann, McCrea, & Hammeke, 2015a).

Emotional Regulation: Capacity for emotion regulation also appears to influence the expression and development of post-injury affective symptoms. Individuals with higher levels of resiliency demonstrate less depression and anxiety, and endorse a better quality of life after sustaining a concussion (Losoi et al., 2015; McCauley et al., 2013; Merritt, Lange, & French, 2015). Those with a history of poor responses to negative life events in the past may be at an increased risk of difficulty with emotional regulation after SRC, particularly given that concussion predisposes individuals to organic changes in limbic neurochemistry (Giza & Hovda, 2001b, 2014). Understanding how an athlete has responded to prior injuries, whether an SRC or another injury that limits their daily functioning, may provide insight into their ability to tolerate the distress of adverse events.

Clinical Management of SRC: SRC symptoms and functional impairments may result in secondary problems that create emotional distress and protracted symptomatology. For instance, in the case of prolonged symptoms due to inappropriate intervention or prescription of strict rest (e.g., missed school, no exercise, limitations on social activities), individuals may develop emotional disturbances in response to these limitations (Gibson, Nigrovic, O'Brien, & Meehan III, 2013; Leddy et al., 2012; Schneider et al., 2013; Thomas et al., 2015a). Avoidance of certain environments may result in a loss of outlets for coping with stress and limited engagement in meaningful activities. Athletes in particular, may experience a sense of loss due to a lack of team involvement, reduced physical activity, and absence of a structured, routine schedule (MacPherson, Kerr, & Stirling, 2016; Tracey, 2003; Wiese-Bjornstal, Smith, Shaffer, & Morrey, 1998). Adolescents may also be especially vulnerable to secondary emotional distress when their social interactions are limited, as social activity is considered an important part of identity development in this stage of life (Erikson, 1993; Jones, Vaterlaus, Jackson, & Morrill, 2014). In determining treatment options for a concussed individual, it is therefore recommended that careful consideration of both physiological and behavioral repercussions are considered when treatment planning to

prevent from the development of secondary emotional disturbance (Broshek et al., 2015; Clement et al., 2013; Collins et al., 2014a; Leddy et al., 2012).

Concurrent Situational Risk Factors—Psychosocial stress resulting from situational/environmental challenges has the potential to disrupt the recovery process from SRC. Challenges that are secondary to the injury (e.g., financial strain, alterations in interpersonal dynamics) or even entirely independent of the injury (e.g., death in the family, break up with a significant other) can occur at inopportune times and produce emotional distress that interferes with recovery. Perceived stress after concussion has been positively associated with concurrent levels of anxiety and depressive symptoms (Hou et al., 2012; McCauley, Boake, Levin, Contant, & Song, 2001; Van Veldhoven et al., 2011). Although not directly related to treatment for SRC, these stressors must be addressed to mitigate higher stress levels and prevent from an exacerbation of emotional symptoms that may prolong recovery time.

Interpersonal and family dynamics are associated with outcomes after concussion. Higher levels of parental pre-injury anxiety and child-reported stress at six months after concussion are predictive of a greater burden of post-concussive symptoms at 18 months post-injury (Olsson et al., 2013). Moreover, there is research showing increased symptom reporting by parents for their concussed child, as compared to the child's self-report (Elbin et al., 2016). The mechanism by which family dynamics may influence recovery from SRC is unclear, though one possible pathway may be through reporting style (i.e., tendency to over/underreport) as athletes may be pushed toward one direction as a result of situational factors. Just as psychosocial stress can have a detrimental effect on an individual's emotional functioning, the availability of social support serves as a protective factor from emotional symptoms. For instance, Covassin and colleagues (2014), found that concussed individuals who endorsed high levels of social support reported low levels of post-injury state anxiety. Although the role of concurrent psychosocial stress in predicting outcomes following SRC is often overlooked, clinical experience and emerging evidence suggests that it is a factor that needs additional consideration.

Comprehensive Assessment for Anxiety/Mood Clinical Profile after SRC

International guidelines (McCrory et al., 2013a; McCrory et al., 2009) recommend a multimodal approach to the evaluation of SRC given the heterogeneity of deficits and symptoms that can occur after the injury (Collins et al., 2014a; Ellis et al., 2015a; McCrea et al., 2013). A thorough initial evaluation after the injury can provide valuable information for prognosticating recovery (Anzalone et al., 2016; Kontos et al., 2013b; Lau, Lovell, Collins, & Pardini, 2009; Lau, Kontos, Collins, Mucha, & Lovell, 2011). Although the specific clinical tools utilized as part of the evaluation depend upon the time since injury when evaluated, a comprehensive assessment should always incorporate a clinical interview, neurological/neuromotor screening (e.g., vestibular and oculomotor screening), and neuropsychological evaluation (National Institute of Neurological Disorders and Stroke, 2017). Methods of assessment should comprise both subjective and objective measures as athletes tend to underreport their SRC symptoms (Delaney, Lacroix, Leclerc, & Johnston, 2002; Sandel, Lovell, Kegel, Collins, & Kontos, 2012; Schatz & Sandel, 2012). The initial

evaluation of the injury may be more comprehensive, particularly in terms of collecting information on pre-injury risk factors and the mechanism of injury, but a multimodal approach should be utilized at each follow-up visit to assist clinicians in verification of the clinical profile/subtype of SRC overtime, tracking of recovery progress, and guiding treatment.

The evaluation of the anxiety/mood clinical profile after SRC requires formal assessment of emotional changes as well as careful consideration of the potential contribution of emotional factors to other multimodal assessment outcomes (e.g., neurocognitive testing). Some athletes may not be fully aware of or accept that somatic complaints may have an underlying psychological source, and therefore, a delineation of the physical signs of injury from emotional sequelae requires intimate knowledge of the signs and symptoms of concussion as well as the typical pattern of concussion deficits on diagnostic instruments utilized. However, even among astute clinicians this is not always a straightforward task as athletes often have overlapping clinical profiles after SRC and may require both physical rehabilitation and behavioral intervention for a full recovery (Collins et al., 2014a; Henry et al., 2016a; Reynolds et al., 2014). Two general indicators of emotional disturbance after injury include (a) inconsistencies in athletes' pattern of symptom reporting versus objective deficits (e.g., complaints of memory problems, but intact memory on standardized examination), and (b) worsening of symptoms/deficits over time, as these patterns are not consistent with the typical recovery trajectory after SRC (Henry, Elbin, Collins, Marchetti, & Kontos, 2016b; Iverson, Brooks, Collins, & Lovell, 2006; Lezak, 2004; Ponsford et al., 2012a). Through describing a multimodal assessment of concussion, we provide guidance on teasing apart emotional symptoms from physical signs of injury.

Clinical Interview—A thorough clinical interview is the first step in the assessment process and consists of gathering information regarding the individual, details of his or her injury, risk factors for SRC, and functional limitations. As noted by Reynolds and colleagues (2014), the goals of the clinical interview include "understanding the mechanism of injury, acute and current (potentially chronic) symptoms, [and] to obtain a detailed biopsychosocial history" (pg. S73). With regard to screening for emotional disturbance after an SRC, a thorough understanding of personal and family mental health history, risk factors for emotional disturbance after SRC, and current emotional symptoms is recommended. Individuals with no prior history of mental health conditions who lack familiarity of signs of psychological disturbance may benefit from being asked about specific symptoms (e.g., "do your thoughts race when trying to sleep?" or, "are headaches brought on by stress?"), rather than the presence of specific psychological disorders (e.g., "do you feel anxious or depressed?"). It may even be necessary to ask these questions in a more subtle nature in which there is less face validity to questioning, particularly for athletes suspected of having the anxiety/mood clinical profile, but are denying emotional changes. Consistent with general psychological evaluation, clinicians should be aware of affect and non-verbal cues in addition to verbal self-report.

An important facet of the clinical interview for discriminating the anxiety/mood clinical profile from other SRC clinical profiles is to develop a detailed conceptualization of symptoms and functional limitations (Collins, Kontos, Reynolds, Murawski, & Fu, 2014b).

Using a behavioral contingency framework, establishing the antecedents and consequences of symptoms/behavior yields valuable information in determining the etiology of complaints, particularly if a behavioral/psychological component is present. For instance, when interviewing an athlete who endorses an intermittent headache, this framework would include questions for determining what prompted the headache (e.g., “What activity were you doing before it occurred? Where were you when it occurred? What time of day did it happen?”), the athlete’s response/behavior for addressing the headache (e.g., “Once the headache started, what did you do next?), and the consequences of the headache (e.g., “Did you miss school because of the headache?”). This framework for interviewing can yield valuable information for evaluating the presence of a psychological or emotional component to symptomology.

To provide an example of how to tease apart psychological sequelae from organic physical deficits of concussion, the symptoms and deficits of two athletes with predominant visual disturbances and headache complaints are described. In these examples, questioning regarding the antecedent, response to, and consequence of headaches are conducted. The first athlete reports “headaches and blurred vision are prompted by reading” and “cause pressure around the eyes,” resulting in the athlete having to take breaks every 20 minutes when reading, and thus result in inefficiency in completion of schoolwork. This athlete exhibits a typical pattern of primary oculomotor dysfunction in which near-vision acuity is affected and produces frontal-based headaches and eyestrain (Collins et al., 2014b). In contrast, consider the second athlete who reports “headaches are diffuse in nature, and occur only when reading text in Spanish class, but subside with math class,” resulting in the athlete avoiding all Spanish classes to go to the nurse, but completing math coursework without difficulty. In the second example, it is important to recognize that the athlete’s report of headache and problems with visual activity (i.e., reading) is inconsistent with known patterns of concussion; an athlete with an oculomotor deficit would typically complain that any near-vision activity (e.g., reading, solving math problems on paper) would result in eyestrain, headache, and/or visual discomfort, rather than the ocular symptoms being situation-specific. The astute clinician would notice this discrepancy between Spanish and math coursework, and then both delve into possible psychosocial reasons Spanish class results in provocation of SRC symptoms, as well as compare symptom report with objective assessments (e.g., measurement of near-point of convergence) to verify clinical hypotheses.

The clinical interview can also serve as an opportunity for management of acute stress. Previous studies indicate that by using techniques such as psychoeducation and motivational interviewing, clinicians were able to help patients reduce their symptoms following concussion even through a telephone conference (Bell et al., 2008). Our clinical experience suggests that in the realm of SRC evaluation and treatment, often times individuals are hesitant to resume activity due to fear of injury or symptom exacerbation. However, by building a therapeutic alliance and using motivational interviewing techniques, the clinician may be able to help the patient recognize the value of behavioral change and adopt an adaptive, active coping strategy.

Neurological/Neuromotor Screening—The neurometabolic disturbance that occurs after SRC can result in abnormal findings on neurological exams. The National Institute of

Neurological Disorders and Stroke (2017) recommends several brief screenings of neurological function after SRC, with specific emphasis on evaluating balance, gait, and vestibular-ocular function as these have been demonstrated to be affected after concussion (Alsalaheen et al., 2010a; Anzalone et al., 2016; Cavanaugh et al., 2005; Guskiewicz, Ross, & Marshall, 2001a; Hoffer, Gottshall, Moore, Balough, & Wester, 2004; Mucha et al., 2014). The vestibular system is a complex sensory network that provides information to the brain regarding balance and stabilization of vision with movement (Mucha et al., 2014). Vestibular impairment is associated with symptoms of dizziness, imbalance, blurry vision, and discomfort in complex environments (Alsalaheen et al., 2013; Mucha et al., 2014), and abnormal vestibular-oculomotor screening is predictive of a prolonged recovery time from SRC (Anzalone et al., 2016).

Many vestibular symptoms secondary to SRC overlap with symptoms common in affective disorders (e.g., lightheadedness/dizziness related to panic attack, and discomfort in complex environments related to social anxiety) (American Psychiatric Association, 2013). It is not uncommon for individuals with vestibular impairments to have co-existing emotional changes. Research suggests close relationships between the vestibular system and anxiety/mood changes (Balaban, Jacob, & Furman, 2011; Jacob & Furman, 2001). In fact, the sensation of dizziness has been seen as both a symptom and a cause of anxiety (Balaban & Porter, 1998; Ruckenstein & Staab, 2009; Stein, 1989). Anxiety is often triggered by a vestibular event, though may be maintained by psychosomatic factors (Edelman, Mahoney, & Cremer, 2012). For instance, an athlete with a vestibular disturbance may experience dizziness and anxiety when running sprints at practice, and then begin avoiding any physical activity or movement of their head for fear of re-experiencing the dizziness. If anxiety is not properly identified and addressed, it may interfere with the efficacy of treatment (Kontos, Deitrick, & Reynolds, 2015).

When conducting vestibular-oculomotor screening, clinicians should be aware of signs of anxiety given the overlap in the symptoms of anxiety and vestibular dysfunction. Indicators of anxiety during vestibular-oculomotor screening include avoidance behavior (e.g., nervous to engage in head movement, poor persistence on vestibular exam), non-verbal cues of anxiety (e.g., heavy breathing/sighing), and non-organic dysfunction on exam (e.g., exaggeration of symptoms, physical signs that are inconsistent with known neurological patterns). Information gleaned from vestibular-oculomotor screening should also be considered in the context of functional complaints, again looking for inconsistencies in symptom report and objective examination. For instance, an athlete may endorse dizziness when screening for vestibular dysfunction (e.g., vestibular-ocular reflex [VOR], visual motion sensitivity [VMS]), but then report that they are capable of tolerating dynamic exercise (e.g., rotation of the head and body) in daily life without difficulty. This does not follow known neurological relationships; heavy, dynamic exercise requires greater demand from the vestibular system than would a simple screening of head movement. In this instance, after a more detailed evaluation, the athlete may be considered to demonstrate a primary anxiety/mood clinical profile with features of the vestibular subtype. Treatment for this athlete may also be more effective if it targeted both the anxiety/mood subtype as well as the vestibular sensitivities endorsed by the athlete.

Neuropsychological Evaluation—Neuropsychological evaluation is the assessment of brain-behavior relationships and provides information regarding an individual's cognitive and emotional functioning. Neurocognitive testing provides information on processes such as learning, memory, and attention that can be affected after SRC (Covassin, Elbin, & Nakayama, 2010). Emotional functioning can be evaluated both through clinical interview, and through formal, standardized assessment measures of mood and personality.

Neurocognitive Testing: Neurocognitive testing is an important component of comprehensive evaluation of SRC (Collins et al., 2014a). Clinicians may utilize computerized and/or traditional (i.e., paper-and-pencil) neurocognitive testing, both of which provide utility in assessment of SRC (Echemendia et al., 2013). While neurocognitive testing is primarily used to identify cognitive impairment (e.g., memory, processing speed, reaction time), poor performance may also indicate emotional involvement. For instance, patients endorsing symptoms of depression performed worse on neurocognitive testing, particularly with regard to reaction time and visual memory (Kontos et al., 2012a). There are other emotional and secondary factors that can impede optimal cognitive performance and it is recommended that performance and symptom validity measures be utilized to capture the validity of neuropsychological testing (Armistead-Jehle, Cooper, & Vanderploeg, 2016; Parks, Gfeller, Emmert, & Lammert, 2016). To delineate whether emotional factors are influencing cognitive deficits, a careful review of neurocognitive domains and functional cognition may provide further information into thought processes. For instance, athletes with the predominant anxiety/mood clinical profile may report that they performed poorly on testing or endorse memory problems, but demonstrate intact cognitive scores that are within normal limits when compared to their peer group and developmental history.

Formal Psychological/Emotional Assessment: In addition to questions of affective symptoms on post-concussion inventories and throughout the concussion evaluation, utilizing questionnaires specifically validated for evaluating mental health disorders are important when there is a question of an anxiety/mood component to an athlete's presentation after SRC. Traditional self-report inventories of affective functioning, such as the Beck Depression Inventory-II (BDI-II; (Beck, Steer, & Brown, 1996) or Beck Anxiety Inventory (BAI; (Beck & Steer, 1988), provide more detailed information regarding the presence of depression and/or anxiety and determine the severity of the reported symptoms. These assessments are helpful in elucidating whether emotional disturbances after SRC meet clinical criteria for mental health disorders, and if a discussion regarding formal treatment of anxiety/mood is warranted. It is important to note that when interpreting these self-report inventories, an elevated level of symptoms does not always equate to the athlete having a psychological disorder. Again, there is overlap in physical symptoms of concussion with those in mental health disorders (e.g., endorsement of numbness/tingling on the BAI may indicate a cervicogenic abnormality after SRC rather than a symptom of anxiety, or endorsement of dizziness may suggest vestibular dysfunction) and therefore, it is important to conduct a thorough clinical interview to help elucidate the etiology of reported symptoms on these questionnaires. If an athlete endorses persistent post-traumatic stress, in such cases when a violent injury occurred, then a formal evaluation of post-traumatic stress and related

psychological symptoms may be warranted with a trauma assessment such as the Trauma Symptom Inventory – 2 (TSI-2) (Briere, 1996).

Athletes reporting persistent or chronic psychological and/or psychiatric symptoms may require a more thorough evaluation of their mental health. Broadband measures of personality and emotional functioning, such as the Personality Assessment Inventory (PAI) (Morey, 1999) or Minnesota Multiphasic Personality Inventory – 2 (MMPI-2) (Butcher, Graham, Ben-Porath, Tellegen, & Dahlstrom, 2003), may help to inform differential diagnosis and severity of psychological disturbance. These measures may be particularly helpful in evaluating athletes with a pre-injury history of a mental health condition such as bipolar disorder or obsessive compulsive disorder that involve patterns of symptoms not typically captured on brief affective or post-concussion self-report inventories. Broadband measures may also be helpful when evaluating an adolescent athlete who sustained an SRC, but there is also question of onset of a psychiatric disturbance given their age range and clinical presentation. Although these broadband psychological assessment measures are comprehensive, they may be impractical when an athlete requires acute, serial assessment for SRC, as these measures are time consuming and not designed to be repeated in a short time interval. Given that emotional symptoms of concussion typically remit in the acute phase of the injury, these more extensive measures of psychological functioning are likely the most valuable when evaluating chronic SRC symptoms (Collins et al., 2006; Karr et al., 2014; McCrea et al., 2003).

Treatment for Athletes with Anxiety/Mood Clinical Profile

The first step in developing a comprehensive treatment plan for SRC is to determine what clinical profile subtype/s (i.e., vestibular, ocular, post-traumatic migraine, anxiety/mood, cognitive fatigue, cervical) present and if the subtypes overlap. For individuals presenting with mood changes, it is particularly important to assess for vestibular system involvement and to treat this aspect first or concurrently with the mood component (Collins et al., 2014a; Reynolds et al., 2014). While many individuals will experience acute emotional symptoms as overall recovery progresses, there are some individuals in whom targeted behavioral interventions become necessary. Aspects of preventative and active treatment for the anxiety/mood subtype of SRC include psychoeducation, behavioral regulation strategies, addressing sleep disturbance, physical activity, desensitization to environmental stimuli, and psychotherapy.

Psychoeducation—A common behavioral intervention for SRC is providing psychoeducation on the expected signs and symptoms after injury. The efficacy of providing psychoeducation post-injury has been replicated in several randomized controlled clinical trials, with stronger effect demonstrated when the intervention occurs in the acute post-injury phase (Comper, Bisschop, Carnide, & Tricco, 2005). While a variety of formats for providing psychoeducation exist (i.e., individual feedback, group sessions, handouts), most interventions include the clinician setting a positive expectation for recovery, an explanation of the pathophysiology of the injury, common symptoms one may experience, and effective strategies for symptom reduction (Cooper et al., 2015). A concern regarding the discussion of symptoms is that some patients may interpret a negative expectation of symptoms, or a

nocebo effect (Zuckerbraun, Atabaki, Collins, Thomas, & Gioia, 2014); however, research has shown that discussing symptoms within an overall positive framework of recovery is beneficial (Ponsford et al., 2001).

Behavioral Regulation—SRC management protocols have traditionally included a strict rest period, typically during the acute post-injury stage. However, recent research suggests that implementing a behavioral regulation plan may be more useful in mitigating symptoms. Behavioral regulation refers to the practice of maintaining healthy lifestyle factors including a regular sleep schedule, adequate nutrition and hydration, daily movement (i.e., non-contact physical activity), and management of stress (Womble & Collins, 2016). A recent randomized controlled trial (RCT) revealed that adolescents presenting to the emergency room with concussion symptoms demonstrated greater post-injury symptoms when assigned to a strict rest group versus a group with detailed instructions regarding behavioral regulation. The differences in reported symptoms and recovery trajectories between groups were associated with disruption of daily routine, which led to reduced social interactions, lack of exercise, missed school, and increased stress associated with falling behind academically (Thomas et al., 2015a). Following a behavior regulation plan may reduce the overall stress associated with having an SRC as well as physiological symptoms such as post-traumatic migraine and sleep (Rains, Poceta, & Penzien, 2008) that may potentially reduce length of recovery time.

Sleep—Sleep disturbance following concussion is common, with insomnia being the most common sleep disorder reported (Kostyun, Milewski, & Hafeez, 2015; Lu, Krellman, & Dijkers, 2016). The effect of disrupted sleep on cognitive function (O'Brien, 2009) and psychiatric disorders such as anxiety and depression has been well documented in the general population (Alvaro, Roberts, Harris, & Bruni, 2017). While there is no current intervention to treat both insomnia and common comorbid psychiatric disorders (i.e., anxiety and depression), there is emerging evidence that a short course of cognitive behavioral therapy for insomnia (CBT-i) reduces symptoms of insomnia with ancillary reduction of anxiety and/or depression (Lu et al., 2016; Martínez et al., 2014; Tang et al., 2011).

CBT-i is a manualized treatment that includes a psychoeducational component (with overviews of normal sleep, circadian rhythms, impact of substances, and sleep restriction), stimulus control instructions to address conditioned arousal, strategies to reduce sleep-interfering thoughts and concerns (including stress management and cognitive restructuring) and a final component that addresses relapse prevention (Lu et al., 2016; Ritterband et al., 2017). Unfortunately, there is a lack of trained clinicians offering CBT-i, but there is hope of a new web-based adaptation (Sleep Healthy Using the Internet [SHUTi]) that incorporates the primary tenets of CBT-i and is easily delivered as a less expensive, scalable option (Ritterband et al., 2017).

As individuals with disordered sleep have been shown to demonstrate marked changes in emotional functioning (O'Leary, Small, Panaite, Bylsma, & Rottenberg, 2016), it is imperative for individuals sustaining an SRC to utilize appropriate sleep hygiene techniques (e.g. avoiding naps, reducing use of electronics before bedtime, and limiting caffeine and

nicotine close to bedtime). Employment of proper sleep hygiene may help facilitate overall recovery from SRC, as well as mitigate emotional changes post-injury.

Physical Activity—Exercise has been demonstrated to improve mental health outcomes for individuals experiencing a range of psychiatric conditions, including anxiety, depression, and overall stress management (Pedersen & Saltin, 2015). Systematic reviews suggest physical activity is particularly helpful in reducing anxiety symptoms (Conn, 2010; Jayakody, Gunadasa, & Hosker, 2013; Pedersen & Saltin, 2015; Stubbs et al., 2017). The positive effect of physical activity on anxiety symptoms is multifactorial. While physical activity may simply serve as a distraction from symptoms, research suggests that physiological changes caused by exercise (i.e., perspiration, increased heart rate) may help individuals with anxiety associate these phenomena with normal activity rather than panic (Pedersen & Saltin, 2015).

Although physical activity is an essential component of a comprehensive treatment plan for SRC rehabilitation, it is important to understand that limitations to physical activity may be warranted in patients with vestibular symptoms or post-traumatic migraine. It is therefore necessary to identify clinical subtypes and to appropriately treat overlapping subtypes prior to or concurrent with initiation of an exertion plan (Collins et al., 2014a; Reynolds et al., 2014). A 2010 meta-analysis of 3,289 participants across 19 studies revealed that while overall interventions employing physical activity were effective in reducing anxiety, those employing supervised physical activity were significantly more effective than non-supervised physical activity (Conn, 2010). Employing formal exertion therapy as part of an SRC treatment plan allows for targeted physical intervention within a structured and safe environment while under supervision. Supervised exertion may be beneficial for reducing fear of further injury, social support in working through uncomfortable symptoms, and the development of a workout plan with achievable goals.

Desensitization to Environmental Stimuli—For individuals with increased anxiety following SRC, particularly within the context of overlapping vestibular system involvement, it is not uncommon to begin avoiding symptom-provoking environments. Complex, crowded environments such as grocery stores, school cafeterias, and churches may increase overall symptoms, thereby exacerbating anxiety, and creating a feeling of overstimulation (Collins et al., 2014a; Goldberg, 2012). Once avoidance behaviors are conditioned, it is important to employ a targeted behavioral intervention to desensitize individuals to environments that provoke symptoms.

Systematic desensitization is a type of behavioral therapy based on the principle of classical conditioning that includes an imagined exposure to a feared stimulus paired with a relaxation exercise (Wolpe & Lang, 1964). Traditionally used in the treatment of phobias, systematic desensitization is easily adapted into a more loosely framed exposure-recovery model to be used in SRC rehabilitation. For example, if an individual experiences increased anxiety in a busy visual environment, the treatment plan may include short, repeated exposures to that environment, with a longer recovery period in a quieter, less complex environment. Over time, the individual acclimates to longer exposures with reduced recovery times, until the recovery times are no longer needed. While systematic

desensitization works with certain SRC patients in theory and in our clinical experience, there is no empirical evidence supporting its use. Research on the effectiveness of systematic desensitization and other behavioral therapies for SRC patients is warranted.

Psychotherapy—There are a number of evidence-based psychotherapy models and pharmacological therapies that may be effective in decreasing anxiety or mood dysregulation following SRC. Acute stress initially after injury may not warrant formal psychotherapy or medication (Collins et al., 2006; Karr et al., 2014; McCrea et al., 2003) unless there is a pre-injury history of a mental health disorder. If an individual demonstrates persistent mood dysregulation and/or there are situational stressors impeding recovery, then psychotherapy and/or medication management may be necessary. Some of the most common treatments employed after head injury include cognitive behavioral therapy (CBT), mindfulness practice, alteration of coping strategies, and pharmacological intervention.

Cognitive Behavioral Therapy: CBT is the psychological treatment of choice for anxiety and depression in the general population (Butler, Chapman, Forman, & Beck, 2006). CBT is a skills-based, manualized treatment that aims to alter maladaptive beliefs and coping behaviors to achieve positive health outcomes. Treatment typically includes graded exposure, activity scheduling, relaxation exercises, social skills, and cognitive restructuring (Beck, 2011). Research suggests that CBT effectively reduces symptoms of anxiety and depression in a concussed population, particularly when using an adapted protocol for individuals with cognitive impairments and when implemented early in the recovery period (Mittenberg et al., 2001; Ponsford et al., 2016).

Mindfulness: The practice of mindfulness is rooted in Buddhist meditation and is described as the act of paying attention to the present moment and developing an awareness of one's thoughts, feelings, and bodily sensations (Azulay, Smart, Mott, & Cicerone, 2013; Kemper & Hill, 2017). Mindfulness-based stress reduction (MBSR) is a group-based intervention developed in the 1970s for individuals with chronic pain that has been widely implemented in a number of medical and psychiatric populations (Kabat-Zinn et al., 1992). A 2013 pilot study utilizing an adapted MBSR 10-week protocol for individuals with concussion resulted in clinically significant improvements in participants' perceived self-efficacy, particularly for the management of emotional and cognitive symptoms, as well as increased problem solving ability (Azulay et al., 2013). Given these findings, employing a mindfulness practice to reduce anxiety following SRC may be particularly valuable, as mitigation of the stress response may improve overall cognitive functioning and self-perception.

Coping Strategies: As discussed previously, it is likely that psychological factors such as the implementation of maladaptive coping strategies play a role in ongoing anxiety or mood changes following SRC. Woodrome and colleagues (2011) found that children's self-reported coping strategies were related to their overall symptom ratings following concussion. Specifically, they reported that children employing problem-focused engagement strategies (i.e. cognitive structuring) reported fewer overall symptoms following concussion. In contrast, employing emotion-focused strategies was associated with higher overall symptom report regardless if the child employed emotion-focused engagement (i.e.

expressing emotions, seeking social support) or emotion-focused disengagement (i.e. self-criticism, social withdrawal) strategies (Woodrome et al., 2011). These findings suggest that identifying children who employ maladaptive coping strategies early in the recovery process and helping them develop strategies that encourage active, problem-focused engagement may help to prevent post-injury anxiety and chronic symptoms. These findings are consistent with previous research demonstrating that CBT is effective in preventing chronic symptoms following concussion in an adult population (Mittenberg et al., 2001).

Pharmacologic Intervention: Finally, there may be some cases in which behavioral treatments are unsuccessful and pharmacologic intervention is warranted. In the case of chronic anxiety/mood changes, regardless of ongoing SRC symptomatology secondary to overlapping clinical profiles, it is recommended that the individual undergo a comprehensive psychiatric evaluation to determine if medication is indicated. Medication adjustments for individuals already on psychotropic medications prior to injury may also be necessary if emotional symptoms are persistent and not well controlled after injury.

Conclusion

Concussion is a heterogeneous injury that requires individualized assessment and treatment. While there are six identified clinical profiles, many individuals experience changes in mood following SRC. The presence of the anxiety/mood subtype and overall prolonged emotional sequelae following SRC can be attributed to both pre-injury risk factors (such as pre-injury mental health history, family mental health history, and biological sex), and post-injury factors (such as neurochemical changes in the brain, psychological response to injury, psychosocial stress, and interpersonal and family dynamics), as well as the quality of clinical management. A comprehensive assessment is necessary to disentangle psychological factors from overlapping subtypes (e.g., vestibular) and should include a detailed clinical interview, neurocognitive testing, vestibular/ocular motor exam, and, in some cases, more formal psychological assessment. Treatment should focus on identification of overlapping profiles with active management of any overlay (e.g., vestibular) and targeted treatment of anxiety/mood disturbance, specifically through psychoeducation, behavioral regulation (particularly in terms of sleep and exercise), desensitization to environmental stimuli, or psychotherapy (including CBT, mindfulness, and coping strategies). While not all athletes experiencing mood changes following SRC will require formal treatment, it is common for athletes to face stressors associated with return to sport. Clinicians should be cognizant of the role of stress and should utilize stress-reduction protocols in clinical management of the injury.

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Table 1

Emerging Clinical Profiles for SRC and Associated Symptoms (Collins et al., 2014; Henry et al., 2016; Reynolds et al., 2014).

Clinical Profiles of SRC	Symptoms/Deficits
Anxiety/Mood	Ruminative thinking, hypervigilance, anxiety, panic, depressed mood, apathy, sleep disruption, symptom endorsement on psychological inventories
Post-traumatic Migraine	Unilateral headache with nausea and photosensitivity and/or phonosensitivity, memory deficits on cognitive testing
Oculomotor	Frontal headache, pressure behind eyes, trouble with visually-demanding tasks, deficits on cognitive testing, abnormal eye movement/function
Vestibular	Dizziness, overwhelmed in complex environments, motion sensitive, mental fogginess, increased symptoms when perform vestibulo-ocular reflex and/or optokinetic testing, balance problems
Cognitive Fatigue	Low energy, fatigue, symptoms towards end of day, non-specific headache, global cognitive deficits
Cervical	Headache and neck pain, numbness/tingling in extremities, cervical abnormalities