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Sports Psychiatry and Medical Views on Mild Traumatic Brain Injury in Competitive Sport: A Current Review and Recommendations

Sportpsychiatrischer und -medizinischer Blick auf traumatische Kopfverletzungen im Leistungssport: Überblick und Empfehlungen

REVIEW

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Summary

› **Head injuries** are common in competitive and recreational sport. Nomenclature, though inconsistent, identifies mild traumatic brain injury (mTBI) based on acute diagnostic criteria, whereas a sport-related concussion (SRC) is event-related and specific to mTBI experienced while participating in athletic activity. The effects of SRC are often neurological, neuropsychological and/or psychiatric with a variety of symptoms.

› **Different organizations** categorize these symptoms differently and this variance demonstrates that no uniform clinical classification system has been agreed upon. Diagnosis of SRC is based on clinical examination. Numerous symptom checklists and assessments are available for clinical diagnosis, but their validity is somewhat limited. There is increasing awareness regarding the psychiatric deficits associated with SRC and the potential for developing post-concussion syndrome (PCS). In addition to complex, causal SRC-associated symptoms, reactive psychological complaints may also occur, as well as social mistreatment on recovery from SRC.

› **Pre-existing mental health conditions** are associated with an increased risk for developing PCS. This often necessitates the implementation of psychiatric or psychotherapeutic care after SRC. As with mTBI and SRC, no standardized classification has been established for PCS. Multi-stage rehabilitation strategies can help injured athletes navigate a successful recovery and prevent premature return to play. Further research on the utility of psychotherapy, psychopharmacotherapy, and exercise therapy of PCS is needed.

KEY WORDS:
Concussion, Mental Health,
Post-Concussion Syndrome, Interdisciplinarity

Zusammenfassung

› **Sportbezogene Kopfverletzungen** sind häufige Ereignisse im Leistungs- und Freizeitsport. Die Nomenklatur ist noch uneinheitlich und es wird vorgeschlagen die mild traumatic brain injury (mTBI) als auf akuten Diagnosekriterien basierend und die sports-related concussion (SRC) als ereignisbezogen und phänomenologisch sowie im Unterschied zur mTBI im Zusammenhang mit sportlicher Aktivität zu verstehen. Die Auswirkungen von SRC sind häufig nicht nur neurologischer oder neuropsychologischer Natur, sondern auch psychiatrisch, mit einer Vielzahl an Symptomen.

› **Verschiedene Organisationen** kategorisieren die Symptome unterschiedlich. Dies zeigt, dass sich bisher kein einheitliches Klassifikationssystem etabliert hat. Die Diagnosestellung der SRC erfolgt anhand klinischer Untersuchung. Es stehen verschiedene Symptomchecklisten und Assessments für die klinische Diagnostik zur Verfügung, deren Validität begrenzt ist. Es besteht zunehmende Wachsamkeit gegenüber psychiatrischen Aspekten wie kognitiven, emotionalen und Verhaltensänderungen im Rahmen der SRC und des Post-Concussion Syndroms (PCS). Neben komplexen, kausalen SRC-assoziierten Symptomen können auch reaktiv psychische Beschwerden auftreten, ebenso wie soziale Benachteiligung im Rahmen der Genesung nach SRC.

› **Zudem gehen psychische Vorerkrankungen** mit einem erhöhten Risiko für PCS einher. Dies macht die Implementierung psychiatrisch-psychotherapeutischer Versorgung der SRC erforderlich. Ebenso wie bei mTBI und SRC besteht noch keine einheitliche Definition für PCS. Mehrstufige Rehabilitationsstrategien für die Rückkehr verletzter Athleten in den Wettkampf oder in die Schule sind sinnvoll zur Vermeidung erneuter SRC durch zu frühe Rückkehr in den Sport. Dabei bedarf es weiterer Forschung zur Evidenz von Psychotherapie und Psychopharmakotherapie der PCS.

SCHLÜSSELWÖRTER:
Concussion, Psychische Gesundheit,
Post-Concussion Syndrom, Interdisziplinarität

Introduction

Sport-related head injuries and their impact on health have primarily been the domains of sports medicine, neurosurgery, and neurology. In recent years, there has been growing attention to the psychiatric aspects of sport injury, particularly the consequences of mild traumatic brain injury (mTBI), referred to as sport-related concussion (SRC) (14).

Concussion is a subtype of mTBI. Hereafter, mTBI refers to an entity defined by specific diagnostic criteria, whereas SRC is a concussive injury experienced by athletes. Despite important differences between SRC and mTBI that non-athletes experience, these terms are frequently used interchangeably (28, 29). ›

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In addition to typical physical complaints such as dizziness, headache or visual disturbances, SRC can lead to a range of neuropsychiatric symptoms. The focus of psychiatric care in SRC is primarily on the diagnosis and treatment of changes in cognition, emotion, sleep, and behavior. Identifying factors that predict the development of SRC-associated mental health symptoms is becoming increasingly significant. Further attention is being given to possible late sequelae after repeated or severe SRC (28).

The importance of the health risks posed by SRC and the need for preventive measures are reflected by the volume of research and the publication of consensus statements by professional societies and expert groups such as the Concussion in Sports Group (CISG) (14, 29). Additional research aims to clarify associations between SRC and pre-existing mental conditions (16).

Same but Different – Nomenclature of Head Injuries

No uniform definition of SRC or mTBI has been established, and both terms have ambiguities (14). In the International Classification of Diseases (ICD 10), the neuropsychiatric consequences of mTBI are coded as „organic psychosyndrome after traumatic brain injury“ (47).

mTBI has been defined as an „alteration in brain function, or other evidence of brain pathology, caused by an external force“ (33). Defining mTBI severity using characteristics such as the Glasgow Coma Scale (GCS), leads to more uniform criteria and better comparability of data (Table 1), but may not cover all aspects and severities of SRC (45).

Concussion is defined as “a traumatically induced transient disturbance of brain function and involves a complex pathophysiological process” (14). Though controversial and without consensus, sub-concussion has been loosely defined as involving the transfer of mechanical energy to the brain at enough force to injure axonal or neuronal integrity, but not be expressed in clinical symptoms (2). Some laboratory data suggests that repetitive sub-concussive impacts can lead to neuronal impairment, such as axonal injury, increased blood-brain barrier permeability, neuroinflammation, and late life cognitive impairment, all in the absence of cognitive or behavioral changes (2). Other studies have challenged these findings (2, 42).

Materials and Methods

The goal of this manuscript is to provide a broad overview about SRC, mTBI and PCS and their relationship to psychiatric symptoms. To reach this goal a literature research with the key words SRC, mTBI, PCS, and SRC plus risk factors etc. was performed. In addition, educational books and guidelines which provide the basic knowledge about traumatic injuries and co-morbidities have been used. This manuscript is written as a narrative review which does not claim to cover all articles published on this topic, but rather intends to convey a practical and clinical overview.

The Incidence of SRC

An estimated 1.6-3.8 million SRCs occur annually in the USA, a figure that factors unreported or unrecognized cases (23). Despite its prevalence, up to 50% of concussed athletes do not immediately report the presence of concussion-related symptoms (14). There are several important considerations when distinguishing between SRC and mTBI. Athletes who experience SRC are more likely to be helmeted, have baseline testing, receive immediate medical attention, and experience a milder impact involving a collision with a peer or ground. Conversely, mTBI is more likely to be un-helmeted, baseline neurocognitive testing is uncommon, medical attention may be delayed, and impacts are more likely to be the result of a vehicle impact, assault, or fall from height (4, 29, 40).

Rates of SRC vary depending on sport, gender, level of play, and age (3). Of 2.5 million high school students who had sustained at least one sports/recreation-related concussion in the previous year, one million reported more than one (7). The idea that concussion incidences have increased is likely due to increased awareness and more uniform definitions. Rates of SRC are typically higher in competition than in training, with some sports such as ice hockey, soccer, basketball, and American football, having 4- to 10-fold lower rates of SRC in training (19).

Women may have higher rates of SRC in similar sports compared to men, though data is conflicting (14, 28). This is likely attributed to physiological and biomechanical factors as well as sociocultural differences in reporting symptoms (30). In gender-comparable sports such as basketball, ice hockey, and American football, an approximate 1.4-fold higher incidence of SRC was found in female high school athletes compared with male athletes (32). Sports in which female athletes participate in greater numbers (e.g., cheerleading, gymnastics, field hockey) also have high rates of SRC (26). Although male athletes suffer a greater number of SRC overall, female athletes have a higher incidence (26, 50). Women‘s soccer is the sport with the second highest incidence of SRC after American football among youth sports in the United States (26). Although underreported, some para-sports are associated with a high risk for SRC (wheelchair basketball, football for the visually impaired, para-alpine skiing, and wheelchair racing) (20, 46). In addition to gender differences, ADHD/learning disorder, older age, and prior SRC are associated with a higher risk of one or more SRC (14).

Neurobiology and Physiology of SRC

Both mTBI and SRC can be characterized by a neurochemical disruption and diffuse axonal injury caused by a force transmitted to the white matter of the brain (15). The injury is the result of diffuse and multifocal damage to the integrity of the axons within the white matter of the brain. This accounts for an impaired interaction between a variety of brain-regions resulting in a range of symptoms. mTBI also leads to a gross disruption of brain neurochemistry, the correction of which requires energy that is not available due to the mTBI. This “neurochemical cascade” and energy disparity is believed to be responsible for many of the symptoms associated with mTBI and SRC (12). While macroscopic injury can coexist, symptoms of mTBI are not due to focal brain dysfunction, but rather a disturbance of functional networks leading to impaired cognition, altered affective, altered vestibulo-ocular function, impaired sleep, and potentially other domains (14).

Signs and Symptoms

The symptoms of SRC can lead to varying degrees of urgency and need for care. Warning signs (Table 2) can indicate more severe TBI and necessitate emergency medical intervention. Symptoms of SRC typically develop within minutes to 24 hours (39). Multiple attempts have been made to categorize the clusters of physical, cognitive, sleep, and emotional symptoms (Table 3) (28). Different organizations such as the CISG and American Medical Society for Sports Medicine (AMSSM) categorize these symptoms differently, demonstrating that no uniform clinical classification system exists and that SRC can manifest in a variable clinical presentation (14, 29).

Langdon et al (2020) identified five subtypes of SRC symptoms in a meta-analysis: migraine cluster, cognitive-emotional cluster, sleep-emotional cluster, neurological cluster, and an undefined

feelings cluster (22). The complexity of these symptoms is reflected in exercise intolerance often present after SRC, thought to be caused by autonomic nervous system dysfunction (9). Analgesic medication or sleep aids, in addition to acute stress reactions or trauma response, can cause cognitive impairment that may mimic SRC (18). Additionally, pre-existing mental health disorders can significantly confound symptom reporting after SRC (28).

While about 90% of athletes are symptom-free within two (adults) or four weeks (children) after SRC, a minority experience longer-lasting symptoms and a reduced quality of life, often referred to as Post-Concussion Syndrome (PCS) (29). There are rare cases where symptoms last longer than three months with numerous risk factors including age, gender, and medical/psychiatric history (28). In cases of symptoms lasting over one year, adults present with cognitive deficits significantly more often than children, and women more often than men (31). In this context, there is often low resilience or mental comorbidities which can make it difficult to clearly differentiate symptoms from pre-existing conditions (25. In addition, reactively developed mental health issues such as anxiety or a trauma response can be significant (14).

The severity and number of symptoms reported and multiple SRC predict the development and duration of PCS (14). Pre-existing migraine, subacute headache, female gender, adolescence, depressive and anxious symptoms, and a family history of mental health disorder are predictors of a prolonged course (28, 29). Conversely, resilience is considered a factor for less severe symptom expression (44).

Diagnostics

The diagnosis of SRC is based on clinical examination and should be made immediately after the inciting event (14). Ideally this is done by medical staff directly on the sidelines. In addition to a symptom assessment including cognition and balance, physical examination including evaluation of the cervical spine and musculoskeletal system is indicated (14).

Numerous symptom checklists (SCLs) and assessments are available for screening and diagnosis, but their validity can be limited (14). A distinction must be made between simple SCLs and multi-stage procedural assessments. Whereas simple SCLs are suitable for identifying deficits and monitoring progress, the multilevel assessments can provide standardized injury management from the acute event with on-field clarification to the return-to-sport (RTS) protocol (Table 4) (14).

The Sports Concussion Assessment Tool - 5th Edition (SCAT-5) and the Child Sport Concussion Assessment Tool 5th Edition (Child-CAT-5) are considered the gold standard to guide SRC diagnosis (6, 43). The SCAT-5 is used by the International Olympic Committee (IOC), the World Football Association (FIFA), and other major sports federations. It is part of the World Rugby Head Injury Assessment (HIA01) and the National Football League (NFL) concussion protocol (35, 49). For both federations, an additional clinical assessment is used initially, and the SCAT-5 is used second line. Vestibular symptoms such as dizziness or gait problems can be evaluated with the Vestibular/Ocular Motor Screening (VOMS), a brief, standardized way to assess vestibular-ocular function in athletes 10 years and older (34).

Depending on the severity, persistence, and nature of the symptoms, further assessment can be done by neurologists, psychiatrists, and psychologists. This is particularly true in cases of PCS where the assessment of pre-existing mental health disorder is crucial (17).

Table 1

Severity of traumatic brain injuries (TBI). AOC = alteration of consciousness, GCS = Glasgow Coma Scale, LOC = loss of consciousness.

TBI	GCS	LOC	AOC	AMNESIA
minimal	15	-	-	-
mild	13-15	<30 min.	A moment to 24 hrs.	<1 day
moderate	9-12	30 min. to 24 hrs.	>24 hrs.	>1 day and <7 days
severe	3-8	>24 hrs.	>24 hrs.	>7 days

Table 2

Warning signs of sports-related concussion.

WARNING SIGNS			
LOC/ AOC	Facial injury after head trauma	Disorientation	Blank or vacant look
Lying motionless	Seizure, convulsion	Increasing confusion or irritability	Slow in getting up
Worsening headache	Focal neurologic signs	Increasingly restless, agitated or combative	Gross motor instability
Repeated emesis	Tonic posturing	Unusual behavioural change	Balance probelms

Though not always indicated, the most sensitive method for assessing deficits in SRC-patients with cognitive symptoms is neuropsychological testing (NP) (14). NP can be helpful in cases of PCS. The availability of baseline testing can be extremely helpful in assessing return to play/learn readiness (14).

Increasing focus is being given to potential biomarkers such as tau protein, S100β, serum neurofilament light chain, and glial fibrillary acidic protein in the diagnosis of SRC (37). New findings suggest small non-coding RNAs (sncRNAs) in the salvia as a possible biomarker in mTBI (8). However, no reliable and accessible biomarkers have been detected to date (28).

Various consortiums exist with the goal of using neuroimaging to further our understand of SRC. The Enhanced NeuroImaging Genetics through Meta-Analysis (ENIGMA) has been forefront by providing a global platform for data sharing and collaborative analysis. This group and others aim to use neuroimaging and genetics to answer important questions such as mechanisms for the underlying brain function experienced in SRC, what confounding factors influence SCR and PCS, and how emerging technologies can be used for diagnosis, treatment, and prevention of this complicated injury.

Management of the SRC

Following the diagnosis of SRC, the patient should mentally and physically rest for 24 to 48 hours. Premature RTS after sustaining SRC can increase the risk for prolonged recovery and future SRC or other injuries (36).

In their consensus statement the CISG promotes the 11 'R's to provide a logical flow of clinical concussion management (14). These include: Recognize (sideline assessment); Remove; Re-evaluate (extended SRC assessment); Rest; Rehabilitation; Refer (specialists); Recover; Return to sport; Reconsider; Residual effects and sequelae; Risk reduction.

Treatment of persistent symptoms should take a multidisciplinary and collaborative approach. Somatic symptoms may benefit from the involvement of physiotherapy. Medications can be used to target specific symptoms but should be ›

Table 3

Core symptoms of sports-related concussion.

PHYSICAL SYMPTOMS		COGNITIVE SYMPTOMS
Headache	Light sensitivity	Confusion
Dizziness	Blurred vision	Repeats questions
Nausea	Double vision	Difficulty concentrating
Vomiting	Unsteadiness	Difficulty remebering
Gait problems	Fatigue	Mentally foggy
Noise sensitivity	Numbness	Slowed down
SLEEP		**EMOTIONAL SYMPTOMS**
Difficulty falling asleep		Irritability
Sleeping more		Sadness
Sleeping less		Feeling more emotional
Drowsiness		Nervousness / anxiousness

Table 4

Comparison of SCAT-5 and *) Child-SCAT-5 with ACE and PCSI-P. ACE= Acute Concussion Evaluation, CSA =cervical spine assessment, GCS=Glasgow Coma Scale, PCSI-P=Post-Concussion Symptom Inventory - Parent Assessment Form, RTS=return to sport.

FIELDS		SCAT-5*	ACE	PCSI-P
On field	Red flags	+	+	
	Core symptoms	+	+	
	GCS	+		
	CSA	+		
Off field	Symptom evaluation	+	+	+
	Neuro screen	+		
	Follow-up	+	+	+
	RTS	+		

deferred until other interventions have proven unsuccessful. Antidepressants may be indicated to target mood symptoms, sleep disturbance, and/or headaches or pain syndromes, and various medications can be helpful for cognitive impairment (17). Cognitive Behavioral Therapy can be used in conjunction with medication for persistent emotional symptoms (29). Accommodations for school and work can be indicated, especially in young athletes.

Return to Play and Return to Learn

There are multi-stage rehabilitation strategies to help injured athletes return to play and academics. Evidence demonstrates that mild exercise after an initial rest period can speed recovery and prevent the development of PCS (24). In cases of SRC-associated autonomic dysfunction, training must be adapted. For a RTS, and athletes is expected to adhere to an initial period of rest, after which light and gradually increasing aerobic activity can be resumed so long as it does not exacerbate symptoms (39). This can be followed by moderate sport-specific training in the next stage. If still symptom-free, non-contact training drills can be added. Eventually, training at normal intensity, including full contact, can be performed. After these stages are complete a return to competition can be made. Graduation from one step to the next occurs after at least 24 hours without symptom exacerbation (29). If discomfort occurs with an increase in activity or intensity, the previous step is returned to for at least one day. RTS should always be done under medical supervision.

For a Return to Learn (RTL), a similar period of rest precedes the addition of simple activities at home. This can then be supplemented with in-home school activities (eg homework). The third step is to return to school with a reduced workload before full reintegration into the classroom (29). Children and adolescents should not begin a RTS protocol until the return to school has been successful.

While the goal is most often to return to a baseline level of activity, rare cases may necessitate an unplanned career end. There are no evidence-based guidelines that determine whether an athlete should be disqualified from sport because of SRC. Each individual case should be carefully considered, and individualized counseling should be provided regarding possible career termination (14).

Consequences of SRC

SRC has the potential to precipitate or exacerbate mental health issues. In competitive sports, numerous studies show an association between SRC and psychiatric symptoms, with depression being the best studied (28). Certain athletes with three or more SRC during the active period may have lower life satisfaction and quality of life after career end, compared with those with two or fewer SRC (11). In women, sexual dysfunction may occur after SRC, and in men, testosterone deficiency after SRC has been explored (1, 13). There are no reliable epidemiological studies to date that demonstrate a causal link between SRC and CTE, a subject of ongoing research and debate (29, 41).

There is considerable controversy surrounding the impact of multiple "sub-concussive" impacts. There are studies that suggest that accumulation of sub-concussive injuries can lead to late life complications such as increased risk for dementia, mood disorder, or sensorimotor disturbance. Other studies have challenged or failed to replicate these findings. An obstacle for this area of study is that there is no consensus definition of what qualifies as a sub-concussive injury other than it is milder than a concussion. Furthermore, monitoring for and tracking this type of injury is extremely difficult.

Impact of Social Maltreatment on Recovery from SRC

We understand that both internal and external pressures play a role in an athlete's decision to report concussion symptoms and engage in rehabilitation. Bullying, hazing, and peer harassment are unfortunate but ubiquitous phenomenon in sport. Bullying aims to alienate or exclude a member from the team environment (10). It has been shown to impact performance and participation across all ages, genders, and levels of play. Athletes who have been the victim to bullying are at a significantly higher risk for developing physical issues and psychiatric disorders (27).

SRC is viewed as an "invisible injury" due to athletes appearing "normal" after injury (38). Evidence has shown that conditions with invisible symptoms may lead to an increased burden on the individual suffering from them including negative peer interactions, bullying, low self-esteem, and social isolation (21). The issue of bullying as a risk factor for both experiencing SRC and affecting recovery lacks extensive research. It is reasonable to postulate that in some cases bullying or harassment may serve as a barrier during recovery from SRC by impacting an athlete's willingness to report symptoms, the rehabilitation process, or even precipitate early retirement from sport.

Acknowledgement and understanding of this as a possible risk factor is critical to consider as we continue to address SRC identification and management strategies. Parents, coaches, and

medical staff can be proactive about mitigating this risk. Providing developmentally appropriate education about concussion and possible sequelae can increase the understanding of what an injured peer is experiencing. Adult supervision in locker-room settings is crucial. Fostering a health athletic environment that encourages disclosure of issues and works to dismantle the stigma of mental illness is an imperative. Further studies are needed to investigate the frequency of this interaction, and exactly how bullying and maltreatment in sport can affect recovery and return to activity after SRC to develop a safer recovery space for athletes.

Prevention

SRC will remain a risk as long as people engage in physical activity (14, 29). Rule changes may be an approach for preventing SRC, but there is limited evidence for long-term effects (29). Advances in protective equipment such as helmets may decrease injury severity. However, equipment changes alone cannot eliminate SRC and in some cases may confer a false sense of protection which may increase high risk play and lead to more injury (5).

Efforts are needed to educate athletes, parents, coaches, officials, school administrators, and health care providers regarding the recognition, management, risk factors, and prevention of SRC (14). This includes educating sideline providers to properly perform concussion assessments and supervise RTS/RTL, especially in para-sports (48).

A major focus of prevention is to work toward adherence to existing consensus recommendations or concussion protocols. Particularly in para-sports, there is still a lack of specific programs for head injury prevention that take into account the specificities of each disability (46).

Baseline testing and evaluation has an important role in injury prevention, recognition, and rehabilitation. It can identify athletes at increased risk for SRC by surveying past concussion events which allows counseling of coaches for risk reduction measures (29).

Conclusions

Just as the distinction between non-sport mTBI and SRC can be complicated, there are blurred boundaries between neurological and psychiatric symptoms of these injuries. Careful assessment of ongoing symptoms should always be performed and distinguishing persistent from pre-existing symptoms is critical in setting expectations for recovery.

Future research needs to focus on protective and predictive factors for SRC, as well as evidenced based treatments for SRC including pharmacotherapy, psychotherapy, and exercise therapy. Existing SRC assessment tools need to be validated, especially with regards to risk factors for PCS. Comprehensive prevention programs including specific education for athletes, coaches, parents, and physicians should be developed and implemented. The integration of sports psychiatric diagnostics and treatment as well as training into the care-models can be a next step to improve the care of athletes.

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None.

Conflict of Interest

The authors have no conflict of interest.

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