[Primary Care]

CEU

Risk Modifiers for Concussion and Prolonged Recovery

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Context: Currently, no consensus exists for grading the severity of concussions. Identification of risk factors that may affect concussion risk and the likelihood of prolonged recovery can be of value to providers who manage concussion.

Evidence Acquisition: Relevant studies were identified through MEDLINE (1996-2011) using the keywords *concussion, postconcussive syndrome*, and *risk* or *risk factor*. Targeted searches for specific risk factors were conducted with additional keywords, such as *gender* and *migraine*. Manual review of reference lists was also performed to identify pertinent literature.

Results: For risk factors of concussion, history of prior concussion and female sex have the most supporting evidence. Sports with consistently high risk for sustaining a concussion include football, men's ice hockey, and women's soccer. Younger athletes appear to be more susceptible to concussion, but data are limited and inconsistent. Protective equipment does not definitively alter concussion risk, though it protects against other injuries. Symptoms such as long headaches, migraines, amnesia, and multiple symptoms appear to be associated with prolonged recovery. Younger age may also increase the risk of prolonged concussion.

Conclusion: High-quality evidence for risk modifiers in concussion remains sparse. Prior concussion, collision sports, female sex, and women's soccer are the strongest known risk factors. Evidence for most other factors is inconclusive.

Keywords: concussion; postconcussive syndrome; risk factors; risk modifiers

A recent US epidemiologic study showed that concussions constituted 8.9% of high school athletic injuries and 5.8% of collegiate athletic injuries, with an incidence of 0.23 per 1000 and 0.43 per 1000 athlete exposures, respectively.[19] With this high incidence and potential for significant morbidity, it is essential to understand the complexities of concussion diagnosis and management.

Historical grading scales using clinical signs and symptoms, such as loss of consciousness, have failed to consistently predict severity level and length of recovery.[35,43] Therefore, consensus guidelines currently recommend an individual approach to concussion management.[37] Identifying risk factors for concussion risk and prolonged recovery, if they exist, would be of significant value.

RISK OF CONCUSSION

History of Concussion

Multiple prospective studies have identified a history of prior concussion as a risk factor for subsequent concussion.[21-23,45] In high school athletes, a greater-than-twofold increase in concussion rate was seen with history of concussion, even when adjusting for sport contact level, grade, and body mass index.[45] This association was strongest for football.[45] Nonprofessional rugby has similar findings.[23] A dose-response relationship was seen in collegiate football, including a 3-times-higher risk of repeat concussion with a history of 3 or more concussions.[21]

Sports

Comparison of absolute risk among different studies is difficult owing to varied methods for calculating incidence; however, several findings are evident. For individual sports, boxing has the highest incidence compared with martial arts.[28] Collision team sports (football, ice hockey, rugby) have the highest rates of concussion in men at multiple levels of competition.[10,19,23,28,33,45] For women, soccer consistently has the highest risk.[10,19,33] Wrestling, men's soccer, basketball, and lacrosse also put scholastic athletes at risk for concussion.[10,19] In most sports, the rate of concussion is significantly higher in games than practice.[10,19,22,45]

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Positions

Weak evidence suggests that football linebackers, defensive backs, and offensive linemen[19,21,22]; soccer goalkeepers[13,19]; defensive field players[12]; and rugby midfield backs[27] sustain more concussions than other positions.

Age

The relationship of age to overall risk of concussion is unclear. A cross-sectional population survey in 12- to 24-year-olds found that younger age was associated with increased reporting of concussions; however, concussions and internal injuries were grouped.[20] A prospective cohort of football players demonstrated that high school athletes had a higher rate of concussion than collegiate athletes.[22] In contrast, a prospective cohort of athletes in various sports revealed a higher overall rate of concussion for collegiate than high school sports; yet, concussions did account for a greater proportion of total injuries in most high school sports.[19] In general, weak evidence suggests that a younger age is associated with an increased risk of concussion.

Sex

Female sex confers an increased risk of concussion.[14,19,33] While overall rates of concussion at the high school and collegiate levels are higher in male athletes, when sports are examined where the men's and women's games are similar (including soccer and basketball), female athletes have a higher risk of concussion.[19,33] A prospective study in high school students differed in that boys' soccer had a higher concussion rate than girls'; however, the confidence intervals were large and overlapping.[45] A recent critical literature review of sport concussion by sex analyzed prospective surveillance studies in sports with similar rules and equipment (soccer, basketball, ice hockey). Nine of 10 studies had higher injury rates for women, including those examining ice hockey, where the men's but not women's game allows body checking; 4 studies reached statistical significance.[14]

Migraines

The overlap of symptoms between migraine and concussion suggests a relationship, but there are little quality data to support this.[30,40] A Canadian cross-sectional survey found that migraine was associated with an increased risk of sport-related concussion.[20] Multiple unanswered questions remain regarding their association.[30]

Genetics

Little evidence exists for the role of family history and genetics as risk factors for concussion. Apolipoprotein E is involved in nervous tissue healing, and polymorphisms of the *APOE* gene have been implicated in Alzheimer disease,[44] chronic traumatic encephalopathy,[26] and worse outcome after traumatic brain injury.[18,48] Retrospective studies of college athletes suggest a possible association between minor alleles of the *APOE* promoter and risk of concussion with mixed results for minor alleles for the *APOE* gene.[49,50] A prospective study showed that the minor *APOE* E4 allele was not significantly related to concussion.[29]

Equipment

Football helmets reduce the acceleration of the head from collisions and decrease severe head injuries,[7,38] but the rate and severity of concussion are not affected by different helmets.[11] Similarly, ice hockey helmets decrease severe head injuries but not concussion rate.[11] Headgear in rugby shows mixed results without conclusive evidence for a protective effect on concussion.[11] Two recent prospective studies showed a positive effect on regular headgear use and a decreased rate of concussion; however, the studies were not designed to detect a protective effect, and low usage of headgear may have biased results.[23,27] A small retrospective study suggests that headgear in soccer may decrease concussion risk, but significant weaknesses, including only 19% wearing headgear, hamper conclusions.[11] Mouthguards in multiple sports and face shields in ice hockey decrease dental and orofacial injuries but have no effect on concussion risk.[2,11,36,47]

RISK OF PROLONGED CONCUSSION

A majority of concussed athletes have symptom resolution within a week.[21] A subset, however, suffers prolonged symptoms lasting weeks to months.[4,16] Current research on potential risk factors for prolonged recovery is promising but heterogeneous.[43,51] There is disagreement in defining prolonged concussion, ranging from recovery greater than 7 days to symptoms at 3 months.

Signs and Symptoms

Loss of consciousness had been a traditional marker of severity for concussions based on its association to outcome in moderate to severe traumatic brain injury.[25] Some evidence suggests a relationship,[1] but overall data do not support a strong relationship.[21,35,37,43] The low prevalence of loss of consciousness in sports concussions makes it less useful as a predictive factor,[19,22,45] and it is no longer a major marker of severity.

Other signs and symptoms have been explored as markers of severity. Posttraumatic amnesia, both retrograde and anterograde, has been associated with more and longer duration of concussion symptoms.[43] In professional football, risk factors for return to play greater than 7 days included retrograde amnesia, general cognitive problems, fatigue, and a greater number of symptoms at initial presentation.[42] A recent prospective cohort of Australian football players showed that the following factors were related to a longer time to return to play (as a continuous variable): prolonged headache (greater than 60 hours), fatigue, "fogginess," or greater than 3 symptoms

at initial presentation.[35] A prospective descriptive study found several factors significantly related to prolonged return to play (greater than 7 days), including headache lasting longer than 3 hours, trouble concentrating longer than 3 hours, retrograde amnesia, loss of consciousness, and a trend for anterograde amnesia.[1] Confusion, memory problems, and greater number of symptoms are also associated with slower resolution of symptoms.[15,34] Greater deficits in visual memory and processing speed on computerized neuropsychologic testing scores have been associated with longer recovery (greater than 10 days).[31] Sensitivity is improved by combining neurocognitive test scores with symptom scores.[32]

History of Prior Concussion

A statistically significant association between multiple prior concussions and longer recovery (greater than 7 days) was demonstrated in a prospective cohort of collegiate football players.[21] However, there was no difference in protracted recovery (greater than 14 days[32] or as a continuous variable[35]) in a comparison of those with and without prior concussion in 2 prospective cohorts.[32,35]

Attention Deficit/Hyperactivity Disorder and Learning Disability

Many concussion studies exclude those with attention deficit/hyperactivity disorder and learning disability. Studies that include these subjects have not found an association between either and time to return to play.[1,32]

Mood Disorders

Anxiety and depression have been shown to occur after traumatic brain injury, but they have not been specifically studied as premorbid conditions that may affect the risk of concussion and/or prolonged symptoms.[30] Premorbid mood disorders may affect baseline cognitive functioning and confound postconcussion symptoms.[24]

Migraine and Migraine-like Symptoms

A small cohort study did not show that premorbid headaches or migraines predict protracted recovery after concussion.[32] Posttraumatic migraine symptoms in concussed athletes have been associated with greater deficits on neurocognitive testing and overall higher symptom scores compared with those with nonmigraine symptoms.[39] A case-control study in high school football players showed a statistically significant association between migraine symptoms and longer time to recovery.[31]

Age

Several studies suggest a relationship between younger age and slower recovery from concussion.[37,43] The developing brain has prolonged and widespread cerebral swelling and increased sensitivity to glutamate in response to head injury.[6] Concussed high school athletes take longer to recover neurocognitive deficits compared with collegiate[9,17,46] and professional athletes.[41] A prospective descriptive study of concussion management did not show an association with age less than 18 years and prolonged return to play (greater than 7 days).[1]

Sex

Women showed more cognitive function deficits and more symptoms than men after concussion.[5,9] Given that multiple early symptoms are associated with a longer return to play,[15,34,35] female sex may represent an underlying risk factor. Among young elite soccer players, a higher percentage of female athletes reported late sequelae from concussion.[3]

CONCLUSION

Prior concussion[21,23,45] and female sex[14,19,33,45] have modest evidence for increased risk of concussion. Football, men's ice hockey, rugby, and women's soccer have consistently shown high risk for concussive injury.[10,19,23,28,33,45] Younger athletes may experience higher rates of concussion.[19,20,22] Protective equipment, such as helmets, headgear, and mouthguards, has not been shown to definitively alter concussion risk; they may protect against other head and facial injuries.[11] Multiple symptoms, postconcussion memory dysfunction, longer duration of headache, and migraine symptoms are suggestive of an increased risk for prolonged concussion symptoms.[1,8,15,31,34,35,39,42,43] Younger age may predispose to longer recovery from concussion.[17,41,43,46] Evidence for most other factors is limited or inconclusive. Overall, more research is needed to clarify the role of risk modifiers in concussion.

Clinical Recommendations

SORT: Strength of Recommendation Taxonomy
A: consistent, good-quality patient-oriented evidence
B: inconsistent or limited-quality patient-oriented evidence
C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation[a]	SORT Evidence Rating
Risk factors for concussion:	
Prior concussion[21,23,45]	A
Collision sports for men[10,19,23,28,33,45]	A
Soccer for women[10,19,33,45]	B
Female sex[14,19,33,45]	B
Age[19,20,22]	B
Migraine[20]	C
Risk factors for prolonged recovery:	
Multiple symptoms at presentation[15,34,35,42]	B
Memory dysfunction[1,8,15,34,42,43]	B
Migraine symptoms[31,39]	B
Longer duration of headache[1,35]	B
Age[1,17,37,41,43,46]	C

[a]Insufficient evidence exists to make clinical recommendations on genetics and sport positions for concussion risk and on sex, prior concussion, mood disorders, attention deficit/hyperactivity disorder and learning disability, and premorbid migraine on prolonged recovery.

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