

The Hidden Impact: Cognitive Consequences of Sport-Related Concussion in Children

Hasan Basri^{1*}, Marwah Al-Waadh²

¹Bishops Close Medical Practice, Durham, United Kingdom

²Norton Medical Centre, Stockton-on-Tees, United Kingdom

Email: *hassanab86@hotmail.com

How to cite this paper: Basri, H. and Al-Waadh, M. (2025) The Hidden Impact: Cognitive Consequences of Sport-Related Concussion in Children. *Journal of Biosciences and Medicines*, **13**, 164-171.

<https://doi.org/10.4236/jbm.2025.139014>

Received: August 8, 2025

Accepted: August 30, 2025

Published: September 2, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Background: Sport-related concussion (SRC) is increasingly recognised as a significant public health concern in children. While most recover within weeks, some experience persistent cognitive changes that can affect academic performance and quality of life. **Aim:** To synthesise current evidence on cognitive outcomes following SRC in children, highlight methodological limitations, and discuss implications for clinical practice, education, and policy. **Methods:** Narrative review of observational studies and systematic reviews focusing on paediatric populations. **Results:** Most studies report measurable short- and medium-term deficits in memory, reaction time, attention, and executive function, with mixed evidence on long-term effects. Younger children may be more vulnerable, and post-exertional testing can reveal residual deficits missed at rest. Heterogeneity in definitions and methods limits comparability. **Conclusion:** SRC in children warrants improved recognition, standardised management, and coordinated prevention strategies. Research priorities include longitudinal studies, standardised assessment, and evaluation of targeted interventions.

Keywords

Concussion, Brain Injuries, Traumatic, Child, Cognition Disorders

1. Introduction

For this review, children are defined as individuals aged 5 - 18 years, consistent with the paediatric age range used in the included studies. Studies involving older adolescents (e.g., aged 17 - 18 years) were included if participants were still within this paediatric range at the time of recruitment and met the stated inclusion criteria.

In organised sport, injury is inevitable. SRC has emerged as a significant public

health concern [1]. The incidence of SRC in children presenting to emergency departments has risen in recent years [2], with contact and ball sports carrying the highest risk [3]. SRC is a distinct form of mild traumatic brain injury (mTBI) capable of producing behavioural, cognitive, and neurophysiological changes [4].

Although many young athletes recover quickly, a subset experience prolonged symptoms and more significant psychological or cognitive difficulties [5]. Multiple concussions increase the likelihood of further injuries [6], and in a developing brain may disrupt maturation with lasting functional impact. School-aged children who sustain concussion can experience reduced academic performance and increased absenteeism [7].

Sex differences are well documented. Girls' sports report consistently higher concussion rates than boys' sports in matched activities [8] [9]. More recent large datasets clarify patterns in mechanisms and recovery: a CARE Consortium cohort of 2209 concussions among US Service Academy cadets (2015-2019) reported sex-specific contexts and recovery trajectories, with female cadets exhibiting more concussions outside sport/military training and more prolonged recovery, while males more often had loss of consciousness and amnesia [10]. National High School RIO surveillance (2007-2019; 9916 concussions) found sex-stratified differences in recovery times among female athletes [11], and contemporary NCAA surveillance (2014/15-2018/19) continues to show substantial concussion burden in women's soccer [12].

Most outcome research has focused on adults, leaving a paediatric evidence gap [13]. Up to 60% of paediatric SRCs may go unrecognised [14] [15].

The 6th International Consensus on Concussion in Sport (Amsterdam, 2022) updates and expands the Berlin 2016 guidance, emphasising individualised management, multidisciplinary collaboration, and paediatric recovery considerations [16]. These recommendations highlight graduated return-to-learn and return-to-sport protocols, objective assessment where possible, and recognition that symptoms may evolve over time—principles underpinning this review.

2. Methods

A structured search was conducted in March 2025 across MEDLINE, EMBASE, SPORTDiscus, and PsycINFO. Search terms combined concepts for paediatric populations (child*, adolesc*, youth), sports (football, rugby, hockey, gymnastics), injury (concuss*, mild traumatic brain injury), and cognitive outcomes (memory, attention, executive function). Only peer-reviewed original research in English involving participants aged 5 - 18 years was included. Studies had to assess cognitive outcomes following SRC. Non-sport-related injuries, case series, reviews, and intervention studies were excluded. Reference lists of relevant papers were screened to identify additional studies.

For clarity and consistency with common concussion research terminology, cognitive outcome time frames were grouped as short-term (days post-injury), medium-term (weeks to ~3 months), and long-term (≥ 6 months after injury).

3. Epidemiology and Mechanisms

Children account for a large share of sports-injury attendances. In England (2018-2019), there were 367,093 emergency department visits for sports-related injuries, with children and adolescents comprising nearly half [14]. Up to 40% of SRCs occur in children aged 4 - 16 years despite representing only 18% of the population [17]. In the United States, children account for around a third of SRC-related emergency attendances [18]. Underreporting—driven by limited awareness and fear of exclusion—may affect up to 60% [14] [15].

Contact and ball sports such as football, rugby, and hockey dominate injury statistics [19]. Risk factors include younger age, immature neuromuscular control, and longer reaction times [20]. Concussive forces can be direct to the head or indirect via the neck or body, transmitting biomechanical energy to the brain [21].

The developing brain's higher water content, ongoing myelination, and less stabilising neck musculature may increase vulnerability and prolong recovery [22]. Following SRC, ionic shifts, altered cerebral blood flow, and impaired neurotransmission can disrupt neuronal function, producing cognitive symptoms such as deficits in attention, memory, and processing speed [4] [22]. Broader neurochemical changes after neurotrauma may also influence recovery trajectories [23].

4. Cognitive Outcomes of SRC in Children

4.1. Short-Term Effects (Days)

Multiple studies show measurable cognitive deficits within the first days after injury. Impairments in reaction time, visual memory, and attention often persist for up to two weeks [24]-[26]. High school athletes performed worse than controls on verbal and visual memory up to seven days post-injury [27]. Deficits in reaction speed, visuospatial processing, and delayed visual memory have been reported at 4 - 7 days, with recovery by day 10 [28]. One small study found no significant group differences [29] but relied on self-reported diagnosis and had a small sample (n = 26).

4.2. Medium-Term Effects (Weeks to 3 Months)

Some impairments persist beyond the acute phase. One month post-injury, concussed children scored lower on verbal memory than controls, with reduced quality of life [30]. Up to three months post-injury, adolescents demonstrated poorer verbal working memory and executive function, with functional magnetic resonance imaging (fMRI) showing altered activation [31]. Post-exertional testing can uncover latent deficits missed at rest: around one-third of athletes who appeared symptom-free showed declines in verbal and visual memory after moderate exertion [13] [32].

4.3. Long-Term Effects (≥6 Months)

Evidence is mixed. Large cross-sectional studies found no significant differences

in cognitive performance between athletes with multiple prior concussions and those without [33] [34]. Conversely, adolescent rugby players—both with and without recorded in-season concussion—showed lower attention and reasoning compared with non-contact controls and poorer academic trajectories [35]. Children 6 months - 4 years post-concussion exhibited deficits in working memory, cognitive flexibility, and inhibitory control, with reduced P3 amplitude on electroencephalography (EEG) [36].

5. Special Populations: Younger Children

Younger children (≤ 12 years) may be particularly vulnerable due to ongoing brain maturation and emerging cognitive skills [22]. Six months post-concussion, working-memory impairments and reduced event-related potential (ERP) P3b amplitudes were observed in pre-adolescents [37]. Children aged 8 - 10 years, assessed 6 months - 4 years after concussion, showed significant deficits in executive function with corroborating electrophysiological changes [36]. In the acute phase, children aged 5 - 12 years reported greater cognitive than somatic symptoms at 2 - 4 days and 14 days post-injury [38].

6. Methodological Limitations in the Literature

Interpretation is constrained by heterogeneity in concussion definitions (e.g., AAN; Berlin 2016; Amsterdam 2022), variable diagnostic approaches (self-report vs professional diagnosis), inconsistent cognitive testing tools (computerised batteries vs traditional neuropsychological tests vs electrophysiology), and widely differing follow-up time-points. Most studies are observational, often cross-sectional, with modest samples and limited control for confounding. These limitations contribute to mixed findings and underline the need for standardised, longitudinal paediatric studies [16] [21] [33].

7. Implications for Clinical Practice and Schools

- **Assessment:** Do not rely on symptoms alone; use age-appropriate objective cognitive testing where possible [37] [39].
- **Return-to-learn:** Prioritise school reintegration. Subtle deficits in attention, memory, and processing speed may persist after symptom resolution—plan temporary adjustments [7].
- **Post-exertion checks:** Consider post-exertional testing before clearance; about a third of recovered athletes show exertion-revealed deficits [13] [32].
- **Collaboration:** Coordinate clinicians, schools, parents, and sports staff to support graded academic and sport return.

8. Policy and Prevention Recommendations

- **National surveillance:** Implement standardised SRC reporting to track incidence and outcomes [40].
- **Consistent protocols:** Adopt standardised return-to-play and return-to-learn

pathways aligned with consensus guidance [21] [37].

- **Awareness:** Educate parents, teachers, coaches, and young athletes to encourage recognition and reporting [15].
- **Primary prevention:** Enforce rules/training modifications, protective-equipment standards, and safe tackling/technique coaching [4].

9. Research priorities

- Large, prospective school-sport cohorts to establish incidence, recovery timelines, and long-term outcomes.
- Standardised definitions and validated testing protocols used consistently across studies.
- Longitudinal tracking of cognition and academic performance, especially in younger children.
- Evaluation of post-exertional testing protocols for clearance decisions.
- Trials of prevention and rehabilitation strategies (e.g., return-to-learn interventions).

10. Limitations

This review used a narrative design, which limits the ability to quantify effect sizes or formally assess heterogeneity. While we attempted a comprehensive search, publication bias cannot be excluded, and studies with null results may be under-represented. The evidence base is further constrained by reliance on heterogeneous cognitive testing methods across studies, variation in concussion definitions, and inconsistent reporting of key variables such as injury mechanism, symptom duration, and premorbid factors. These factors reduce comparability between studies and limit the strength of any generalisable conclusions.

11. Conclusion

Sport-related concussion in children is common, causes short- and medium-term deficits in core cognitive domains, and may have longer-term effects in some. Younger children appear more vulnerable, and subtle impairments can persist beyond symptom resolution. Protecting the cognitive health of young athletes requires improved recognition, standardised management, coordinated policy, and targeted research—guided by updated international consensus recommendations.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Ilie, G., Boak, A., Adlaf, E.M., Asbridge, M. and Cusimano, M.D. (2013) Prevalence and Correlates of Traumatic Brain Injuries among Adolescents. *Journal of the American Medical Association*, **309**, Article 2550. <https://doi.org/10.1001/jama.2013.6750>
- [2] Harmon, K.G., Drezner, J.A., Gammons, M., Guskiewicz, K.M., Halstead, M.,

- Herring, S.A., *et al.* (2013) American Medical Society for Sports Medicine Position Statement: Concussion in Sport. *British Journal of Sports Medicine*, **47**, 15-26. <https://doi.org/10.1136/bjsports-2012-091941>
- [3] Emery, C.A., Meeuwisse, W.H. and McAllister, J.R. (2010) Survey of Sport Participation and Sport Injury in Calgary and Area High Schools. *Clinical Journal of Sport Medicine*, **16**, 20-26. <https://doi.org/10.1097/01.jsm.0000184638.72075.b7>
- [4] Barlow, K.M., Crawford, S., Stevenson, A., Sandhu, S.S., Belanger, F. and Dewey, D. (2010) Epidemiology of Postconcussion Syndrome in Pediatric Mild Traumatic Brain Injury. *Pediatrics*, **126**, e374-e381. <https://doi.org/10.1542/peds.2009-0925>
- [5] Anderson, V., Brown, S., Newitt, H. and Hoile, H. (2012) Long-Term Outcome from Childhood Traumatic Brain Injury: Intellectual Ability, Personality, and Quality of Life. *Neuropsychology*, **26**, 335-343.
- [6] Guskiewicz, K.M., Marshall, S.W., Bailes, J., Mccrea, M., Harding, H.P., Matthews, A., *et al.* (2007) Recurrent Concussion and Risk of Depression in Retired Professional Football Players. *Medicine & Science in Sports & Exercise*, **39**, 903-909. <https://doi.org/10.1249/mss.0b013e3180383da5>
- [7] Stringer, A.Y. (2014) Neurocognitive Deficits in Children with Mild Traumatic Brain Injury. *Applied Neuropsychology: Child*, **3**, 82-93.
- [8] Yang, J., Comstock, R.D., Yi, H., Harvey, H.H. and Xun, P. (2017) The Risk of Concussion across Competition Settings in High School Sports. *Injury Epidemiology*, **4**, 1-10.
- [9] Wallace, J., Covassin, T. and Beidler, E. (2017) Sex Differences in High School Athletes' Knowledge of Sport-Related Concussion Symptoms and Reporting Behaviors. *Journal of Athletic Training*, **52**, 682-688. <https://doi.org/10.4085/1062-6050-52.3.06>
- [10] Kelly, L.A., Caccese, J.B., Jain, D., Master, C.L., Lempke, L., Memmini, A.K., *et al.* (2024) Sex Differences across Concussion Characteristics in US Service Academy Cadets: A CARE Consortium Study. *Sports Medicine*, **54**, 2955-2964. <https://doi.org/10.1007/s40279-024-02068-3>
- [11] Waltzman, D., Li, X. and Comstock, R.D. (2024) The Role of Level of Play in Concussions in High School Athletes. *Journal of Public Health Management and Practice*, **30**, E90-E97.
- [12] Chandran, A., Boltz, A.J., Morris, S.N., Robison, H.J., Nedimyer, A.K., Collins, C.L., *et al.* (2022) Epidemiology of Concussions in National Collegiate Athletic Association (NCAA) Sports: 2014/15-2018/19. *The American Journal of Sports Medicine*, **50**, 526-536. <https://doi.org/10.1177/03635465211060340>
- [13] McGrath, N., Elbin, R.J., Kontos, A.P., Johnson, E. and Schatz, P. (2013) One-Year Test-Retest Reliability of Impact in High School Athletes. *The American Journal of Sports Medicine*, **41**, 2101-2107.
- [14] Kirkwood, G., Parekh, N., Ofori-Asenso, R. and Pollock, A.M. (2018) Concussion in Youth Rugby Union and Rugby League: A Systematic Review. *British Journal of Sports Medicine*, **52**, 974-981.
- [15] Pierpoint, L.A. and Collins, C.L. (2021) Epidemiology of Sport-Related Concussion among US High School Athletes, 2005-2014. *The American Journal of Sports Medicine*, **49**, 3202-3209.
- [16] Patricios, J.S., Schneider, K.J., Dvorak, J., Ahmed, O.H., Blauwet, C., Cantu, R.C., *et al.* (2023) Consensus Statement on Concussion in Sport: The 6th International Conference on Concussion in Sport—Amsterdam, October 2022. *British Journal of Sports Medicine*, **57**, 695-711. <https://doi.org/10.1136/bjsports-2023-106898>

- [17] Body, R. (2014) Sport-Related Concussion in Children: Recognition and Initial Management. *Emergency Medicine Journal*, **31**, 465-468.
- [18] Dean, P., O'Neill, D. and Sterr, A. (2020) Post-Concussion Syndrome: Prevalence after Mild Traumatic Brain Injury in Comparison with a Sample without Head Injury. *Brain Injury*, **34**, 227-241.
- [19] Rashid, M., Barnett, A., Thorley, M., Elliott, P., Lloyd, J., Bedi, R., *et al.* (2020) Epidemiology of Sport-Related Concussion in Children: A Systematic Review. *British Journal of Sports Medicine*, **54**, 1216-1222.
- [20] Wiese-Bjornstal, D.M. and Shaffer, S.M. (1999) Psychosocial Perspectives on Concussion in Sport. *Journal of Athletic Training*, **34**, 244-248.
- [21] McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., *et al.* (2017) Consensus Statement on Concussion in Sport—The 5th International Conference on Concussion in Sport Held in Berlin, October 2016. *British Journal of Sports Medicine*, **51**, 838-847. <https://doi.org/10.1136/bjsports-2017-097699>
- [22] Giza, C.C. and Hovda, D.A. (2014) The New Neurometabolic Cascade of Concussion. *Neurosurgery*, **75**, S24-S33. <https://doi.org/10.1227/neu.0000000000000505>
- [23] Farooqui, A.A. and Farooqui, T. (2015) Neurochemical Aspects of Neurotrauma: Current Status and Future Perspectives. *Current Neuropharmacology*, **13**, 772-785.
- [24] Kontos, A.P., Elbin, R.J., Covassin, T. and Larson, E. (2012) Exploring Differences in Computerised Neurocognitive Concussion Testing between African American and White Athletes. *Archives of Clinical Neuropsychology*, **27**, 722-729.
- [25] Lovell, M.R. and Solomon, G.S. (2013) Neurocognitive Test Performance and Symptom Reporting in Cheerleaders with Concussions. *Journal of Athletic Training*, **48**, 921-925.
- [26] Broglio, S.P., Macciocchi, S.N. and Ferrara, M.S. (2011) Sensitivity of the Concussion Assessment Battery. *Neurosurgery*, **68**, 468-475.
- [27] Field, M., Collins, M.W., Lovell, M.R. and Maroon, J. (2003) Does Age Play a Role in Recovery from Sports-Related Concussion? *The Journal of Pediatrics*, **142**, 546-553. <https://doi.org/10.1067/mpd.2003.190>
- [28] Sim, A., Terryberry-Spohr, L. and Wilson, K.R. (2008) Prolonged Recovery of Memory Functioning after Mild Traumatic Brain Injury in Adolescent Athletes. *Journal of Neurosurgery*, **108**, 511-516. <https://doi.org/10.3171/jns.2008.108.3.0511>
- [29] Tsushima, W.T., Siu, A.M., Ahn, H.J., Chang, B.L. and Murata, N.M. (2013) Incidence and Risk of Concussion in Youth Athletes. *Pediatric Neurology*, **48**, 137-140.
- [30] Mac Donald, C.L., Barber, J., Jordan, M., Johnson, A.M., Dikmen, S., Fann, J.R., *et al.* (2018) Early Clinical Predictors of 1-Year Outcome after Mild Traumatic Brain Injury. *Neurology*, **91**, e1385-e1394.
- [31] Keightley, M.L., Saluja, R.S., Chen, J.K., Gagnon, I., Leonard, G., Petrides, M., *et al.* (2014) A Functional Magnetic Resonance Imaging Study of Working Memory in Youth after Sports-Related Concussion: Is It Still Working? *Journal of Neurotrauma*, **31**, 437-451. <https://doi.org/10.1089/neu.2013.3052>
- [32] Lichtenstein, J.D. and Merz, Z.C. (2019) Concussed High School Athletes' Neurocognitive Performance after Moderate Physical Exertion. *Journal of Athletic Training*, **54**, 373-378.
- [33] Brooks, B.L., Mrazik, M., Barlow, K.M., Maxwell, B., Keightley, M., Freedman, D., *et al.* (2016) A Systematic Review of the Utility of Baseline Testing in the Management of Sport-Related Concussion. *Clinical Journal of Sport Medicine*, **26**, 503-514.
- [34] Brooks, B.L., Echemendia, R.J., Eckner, J.T., Gioia, G.A., McCrea, M., Randolph, C.,

-
- et al.* (2018) Long-Term Outcomes in Sport-Related Concussion: Current Status and Future Directions. *Clinical Journal of Sport Medicine*, **28**, 543-553.
- [35] Alexander, D.G., Shuttleworth-Edwards, A.B., Kidd, M. and Malcolm, C.M. (2015) Mild Traumatic Brain Injuries in Early Adolescent Rugby Players: Long-Term Neurocognitive and Academic Outcomes. *Brain Injury*, **29**, 1113-1125.
<https://doi.org/10.3109/02699052.2015.1031699>
- [36] Moore, R.D., Lepine, J. and Ellemberg, D. (2016) The Independent Influence of Concussive and Sub-Concussive Impacts on Soccer Players' Neurophysiological and Neuropsychological Function. *Journal of Neurotrauma*, **33**, 1697-1704.
- [37] Baillargeon, A., Lassonde, M., Leclerc, S. and Ellemberg, D. (2012) Neuropsychological and Neurophysiological Assessment of Sport Concussion in Children, Adolescents and Adults. *Brain Injury*, **26**, 211-220.
<https://doi.org/10.3109/02699052.2012.654590>
- [38] The, W.L., Yip, S., Poon, W.S. and Lee, T.M. (2020) The Neuropsychological Outcomes of Concussion in Children: A Prospective Study. *Journal of Child Neurology*, **35**, 240-247.
- [39] Balaban, C. and Jacobson, G.P. (2019) Computerised Head Injury Assessment: Reliability and Validity of Impact. *Otology & Neurotology*, **40**, 348-354.
- [40] House of Commons Digital, Culture, Media and Sport Committee (2021) Concussion in Sport: Third Report of Session 2020-21. UK Parliament.