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**A systematic review of the long and short-term effects of sports related concussions in youth  
and adolescent athletes.**

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Augsburg University: Physician Assistant Program

PA 599: Independent Study – Professional Track

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## **Abstract**

**Background:** Sports-related concussions impact thousands of young athletes. They can lead to short- and long-term effects, such as headaches, behavioral changes, and memory issues. These consequences lead to general concerns about the safety of young athletes participating in sports. Comprehending the effects of concussions in this vulnerable population is crucial for developing more advanced preventive measures and management strategies.

**Methods:** This systematic review followed PRISMA guidelines, searching Google Scholar, PubMed, and the Augsburg University Lindell Library databases. Relevant studies were identified using specific terms. Articles were included based on their relevance to youth or adolescent athletes and sports-related concussions. Studies that did not meet these criteria or were not published from 2018 and beyond were excluded.

**Results:** The review analyzed 15 articles that investigated the effects of concussions on youth and adolescent athletes. Neurological/cognitive function revealed subtle cognitive impairments, altered brain structure, and changes in cognitive domains following concussions. Motor skills studies showed persistent deficits in balance control, visuomotor tasks, and other tasks. Mental health outcomes indicated a positive relationship between concussions and symptoms of depression. Lastly, school-related studies reported a decline in academic performance following concussions.

**Conclusion:** Sports-related concussions have significant short- and long-term effects on youth athletes. The findings demonstrate the need for stricter return-to-play protocols, comprehensive rehabilitation programs, and mental health support during recovery. Prioritizing the health and safety of young athletes is vital for their well-being not only in sports but their livelihoods.

## Introduction

It is estimated that 1.7 million concussions occur each year, with 20% of them being attributed to sports-related activities.<sup>1</sup> A sports-related concussion (SRC) is a type of traumatic brain injury (TBI) that is caused by biomechanical forces<sup>1</sup>. Concussions in youth and adolescent athletes have gained significant awareness and concern in recent years due to their potentially debilitating short-term and long-term effects. These include headaches, dizziness, behavioral changes, memory issues, and sleep difficulty.<sup>2</sup> Important questions have been raised about the safety and overall well-being of young individuals participating in athletic sports due to the increase in these TBIs. Researchers have discovered that athletes with a history of concussions can be three to five times more likely to sustain an ensuing concussion during the school year than their counterparts who have no previous concussion history.<sup>3</sup> While parents are generally knowledgeable about the signs and symptoms of concussions, fewer parents understand what to expect during the recovery process and the long-term return-to-play protocols.<sup>4</sup> Comprehending the impact of concussions on young athletes is essential for developing functional and effective preventive measures, clear-cut diagnoses, and suitable management strategies to prevent detrimental effects on their health and future.

In the United States, roughly 72% of youth athletes play organized or team sports.<sup>2</sup> Due to the increase in participation and general popularity of contact sports among children and adolescents, there has been concern about the potential risks of concussions. Most youth who experience a concussion may see their symptoms resolve within a few weeks.<sup>1</sup> However, some individuals may encounter persistent symptoms for three months or longer, known as post-concussive syndrome.<sup>1</sup> Those who have suffered previous concussions are more susceptible because of the physiological and neuroplasticity changes resulting from the initial concussion,

which compromises the brain's ability to respond to a subsequent concussion.<sup>3</sup> Though concussions can take place in a variety of non-sports related settings such as motor vehicle accidents, this review will primarily focus on concussions due to participation in sports.

A systematic review of the existing literature on this topic is necessary to thoroughly examine the available evidence while garnering an inside inquiry into the nature of concussions in the vulnerable population of young athletes. This paper will seek to answer the question, what are the short- and long-term effects of concussions in youth and adolescent athletes? This will be assessed by examining cognitive, physiological, behavioral, and academic consequences. The findings can be used to assist healthcare professionals, coaches, and parents in making more informed decisions regarding the health and safety of young athletes. If the magnitude of this issue and its consequences are brought to light, individuals can work as a unit to develop comprehensive strategies that will prioritize the long-term health and growth of the younger generation who participate in sports and other athletic activities. A comprehensive search strategy will be utilized to identify relevant studies published in peer-reviewed journals.

## **Methods**

### ***Data sources***

Consistent with PRISMA guidelines, three databases were used to identify relevant studies: Google Scholar, PubMed, and the Augsburg University Lindell Library. The following search terms were used: "Concussions AND effects AND youth athletes," "Concussions AND effects AND high school athletes," and "Concussions AND effects AND adolescent athletes." The word "AND" was utilized to connect "concussions" and the type of athlete.

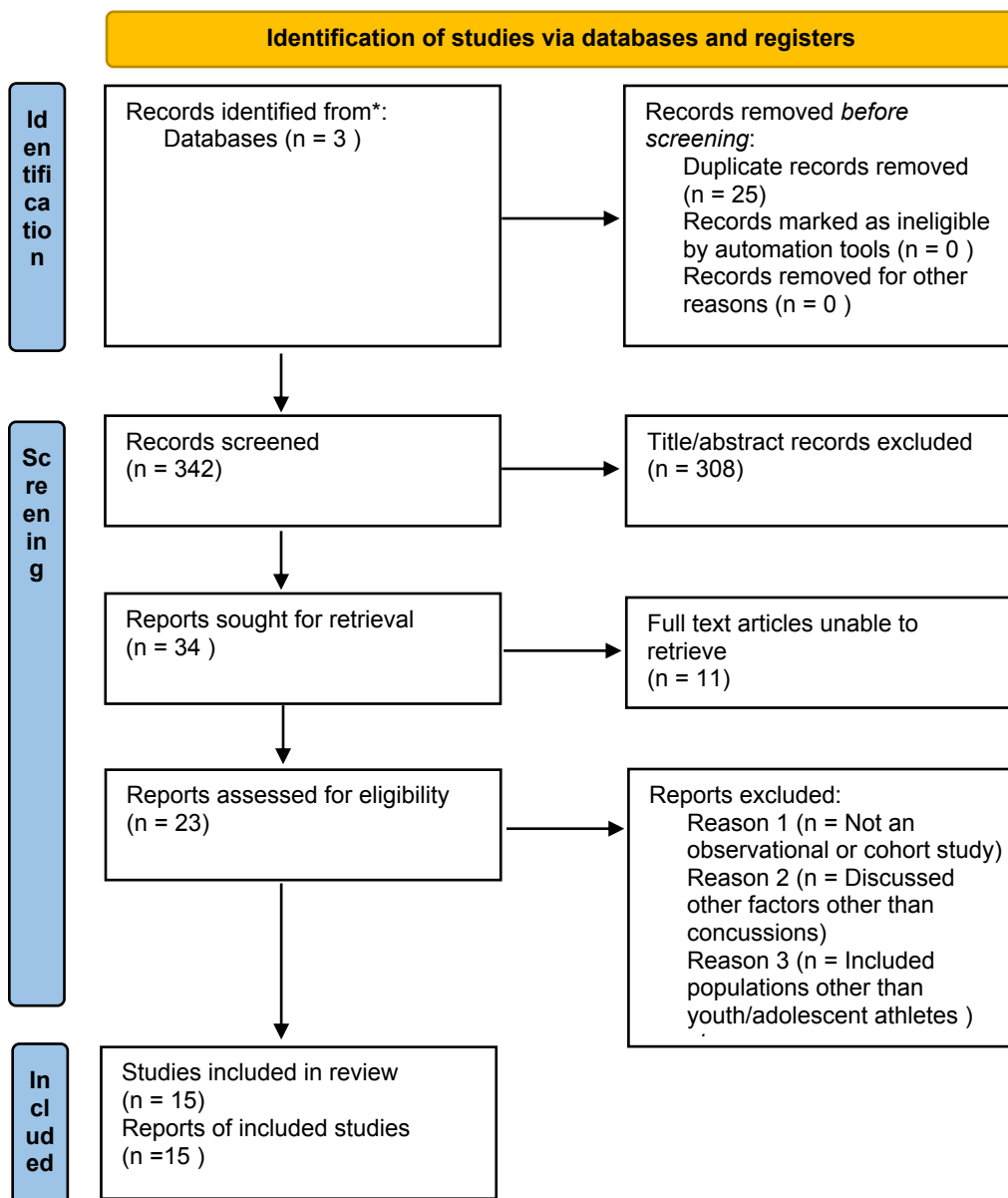
### ***Inclusion and exclusion criteria***

Articles were excluded based on the following criteria: not a peer-reviewed observational or cohort study, not related to the effects of concussions sustained in sports, not youth or adolescent athletes (i.e., <24 y/o). Limitations were placed on the year of publication; only articles published in 2018 and beyond were used.

### **Results**

Figure 1 portrays the PRISMA flow diagram outlining the different stages of the identification and eligibility of articles used in the review. The initial search was conducted on June 29, 2023, and 342 articles were screened by title and abstract after duplicates were removed. 34 articles were sought for retrieval, but 11 could not be accessed. A total of 23 articles were looked at for full-text review. Following the full-text review, 8 were excluded because they were secondary analysis articles, leading to 15 articles being used for the review.

**Figure 1.** A PRISMA flowchart of the article selection process



Among the 15 articles, 5 focused on exploring the neurological/cognitive effects caused by concussions, while another 4 studies investigated the impact concussions have on motor skills and physical outcomes. Additionally, 3 studies explored the impact of concussions on academics and school-related consequences. Lastly, 3 articles focused on the correlation between

concussions and mental health. The articles encompassed various research designs, including 8 cross-sectional studies, 4 cohort studies, 1 repeated measures design, 1 retrospective observational study, and 1 longitudinal observational study.

### ***Neurological/Cognitive function***

Five articles were thoroughly examined the effects of concussions on neurological/cognitive function. Through the analysis of these articles, several vital findings emerged, which ultimately provided valuable insights into both the long-term and short-term effects of concussions.

Hoffman and colleagues utilized the Ohio State University Traumatic Brain Injury identification method to identify concussions and repeated, subclinical head trauma in young athletes. One hundred and eight subjects were utilized, and results demonstrated that athletes who had a history of repetitive, subclinical impacts had no significant differences in cerebral white matter when measured by tract-based spatial statistics (TBSS) compared to those who have not sustained head injuries.<sup>5</sup> However, results demonstrated that those who have suffered subclinical head trauma exhibit more anxiety symptoms and perform worse on impulse control measures.<sup>5</sup> This suggests that while subclinical head impacts may not lead to changes in white matter microstructure, they can lead to subtle cognitive effects.

Moving on, the next two studies focused on the impact that concussions have on brain structure, specifically cortical thickness. The first study identified an association between brain structure and post-concussive symptoms in 29 young male athletes.<sup>6</sup> Evidence revealed that there was a relationship between participation in contact sports that involve frequent blows to the head



and post-concussive symptoms alongside a reduction in cortical thickness.<sup>6</sup> More specifically, associations between reduced cortical thickness and post-concussive symptoms were shown in the frontal and bilateral temporoparietal cortices.<sup>6</sup> The second study compared cortical thickness measures in children with mild traumatic brain injuries (mTBI), including concussions, compared to those with orthopedic injuries. Freesurfer, which is software used in neuroimaging to analyze brain MRI scans, was used to measure cortical thickness in the 330 subjects.<sup>7</sup> While an age-mediated reduction in cortical thickness was found, there were no consistent differences between the mTBI and OI groups.<sup>7</sup> However, the article did reveal that in the mTBI group, increased symptoms reported by parents were associated with reduced cortical thickness in specific regions of the brain.<sup>7</sup>

Another study conducted by Li and fellow researchers compared neurocognitive scores between three groups using data from immediate post-concussion assessment scores (ImPACT). These included contact collision (CC), limited contact (LC), and non-contact (NC) sports. At first, across-the-board neurocognitive testing was similar for all three groups, except for processing speed, which had improved for LC athletes compared to CC athletes.<sup>8</sup> However, during repeat testing, NC athletes demonstrated higher scores and fewer symptoms compared to CC athletes in a variety of neurocognitive domains.<sup>8</sup> These findings suggest that youth athletes that participated in LC and NC sports may facilitate a faster recovery and have better cognitive outcomes compared to those who participate in CC sports.

The final study focused on the relationship between a history of headaches/headache treatment and neurocognitive function at baseline in young athletes who have suffered SRCs. Results indicated that athletes who had a history of headache treatment demonstrated increased

symptom burden, decreased visual memory scores, and enhanced visual motor speed scores that were measured by IMpact composite scores.<sup>9</sup> Increased visual motor skills may have been due to higher stimulants used in the headache treatment group.<sup>9</sup> This study suggests that headaches and headache treatment in youth athletes may ultimately have a neurocognitive impact, affecting cognitive domains such as visual memory and visual motor speed.

### ***Motor skills***

The effect of concussions on motor skills is a significant concern that warrants comprehensive research. In this review, four studies were analyzed that discussed this topic. These studies covered a wide range of motor assessments that include balance control, visuomotor tasks, gait performance, and eye-tracking variables.

Among the studies that focus on balance control, the first investigation observed differences between a total of 34 concussed and non-concussed youth hockey players using lower limb visuomotor tasks. The results demonstrated that concussed athletes consistently performed the tasks more conservatively. They displayed a significant decrease in the velocity of the Center of Pressure (CoP) in the anterior-posterior and medial-lateral directions compared to the control group.<sup>10</sup> The Center of pressure is often used to assess how an individual's weight shifts and changes during activities. It can provide important insights into a person's stability and coordination.<sup>10</sup> These findings suggest that visuomotor and balance control deficits may persist beyond the standard clinical recovery period.

In another study, the researchers sought to identify visuomotor deficits that were beyond the typical recovery identified by standard return-to-play protocols. By integrating dynamic balance control with complex visuomotor processes, they discovered that athletes who were

previously concussed tended to walk through gaps that were on average 0.4 smaller than their non-concussed counterparts (1.0x their shoulder width compared to 1.4x their shoulder width).<sup>11</sup> These results showed that athletes who had sustained previous concussions tended to act with less caution because they squeezed themselves through smaller gaps. The instability during the approach to the gap was related to decision-making capabilities, proposing that there are both balance and decision-making impairments in previously concussed athletes.

The remaining two studies explored gait performance and complex cognitive tasks in concussed adolescents. In the first study, researchers had prospectively evaluated single/dual-tasks timed-up-and-go (TUG) and tandem gait performance among 23 adolescents with concussions and 27 non-concussed controls.<sup>12</sup> The findings demonstrated that across two different time points, the concussion group had slower completion times in both the single and dual-task TUG tests compared to the controls.<sup>12</sup> The concussed group also demonstrated slower tandem gait time<sup>12</sup>. These results indicate that complex cognitive tasks such as TUG tests and tandem gait times can assist in detecting persistent post-concussion deficits.

Moreover, the next study aimed to discover if there were any remaining balance deficits in concussed athletes at the time of return-to-sport clearance (RTS). The results demonstrated that there was no statistical difference in dynamic balance between 16 concussed athletes and 15 healthy non-concussed controls during the analysis of various walking tasks.<sup>13</sup> This suggests that the athletes had recovered from the concussions at the time of RTS. However, further exploration must be done due to the large variability in the dynamic balance measures in both the concussed and control groups.

### ***Mental Health outcomes***

The effect of concussions on the mental health of young athletes is an extremely important topic, causing several studies to have investigated this relationship. In this systematic review, three studies that explored the association between concussions in young athletes and mental health outcomes were analyzed.

All three studies examined the relationship between concussions and a variety of mental health factors, including symptoms of depression, suicidal thoughts, and suicidal actions. The first study utilized data from a population-based sample of US high school-aged athletes and discovered that self-reported concussions were related to several harmful health behaviors and outcomes, including suicidal thoughts/actions and symptoms of depression.<sup>14</sup> The researchers suggested that there was a positive correlation between the two, where an increase in the number of concussions is associated with higher odds of experiencing negative mental health outcomes.<sup>14</sup> These findings demonstrate the importance of considering not only the physical factors in SRCs but also the mental health aspect.

The second and third studies drew data from the Youth Risk Behavior Survey (YRBS) to investigate the association between mental health outcomes and concussions. The second study analyzed data from both the 2017 and 2019 YRBSs, revealing that student-athletes with a history of SRCs were far more likely to report symptoms of depression and suicidal tendencies compared to those who did not have a history of concussions.<sup>15</sup> This relationship persisted even after various demographic and psychosocial variables were accounted for. In the third study, which focused solely on data from the 2017 YRBS students who suffered one or more concussions were more likely to experience hopelessness or persistent feelings of sadness.<sup>16</sup> As it

was discovered, the prevalence of these mental health outcomes was significantly higher than their counterparts who do not have a history of concussions.<sup>16,17</sup>

### ***Academic and School related Consequences***

The effect of concussions on the academic performance of youth and adolescent athletes has been a growing concern in recent years. Three studies were analyzed to shed light on this complex situation.

The first two studies both investigated the impact of SRCs on academic performance among high school athletes. The first study, a longitudinal investigation, focused on examining the longitudinal effects of SRCs on grade point averages (GPAs) among high school athletes. Results revealed that there was a significant decline in GPAs following SRCs, especially in students who had experienced multiple SRCs.<sup>17</sup> The decrease in GPA emphasizes the potential academic consequences of SRCs and underscores the importance of observing and assisting student-athletes during their recovery to reduce adverse effects on their academic performance.

Study two aimed to assess the extent of SRCs on academic function and neurocognitive abilities during the academic year using GPA and ImPACT scores. Astonishingly, the results demonstrated that there were no significant differences in GPAs and ImPACT scores between individuals who experienced concussions and those who haven't.<sup>18</sup> These results do not align with the first study, which suggests that there is some academic decline after concussions; however, it was emphasized that there is variability due to individual recovery patterns.<sup>18</sup> And although there was an unexpected correlation between concussions and academics, researchers discovered that athletes may experience lasting neuropsychological effects due to their head injuries.<sup>18</sup> While

contributing to the effects of SRCs on academic performance, study 2 also demonstrated the need for an increase in comprehensive assessments of cognitive functions following a concussion.<sup>18</sup>

Another study conducted by Holmes and colleagues investigated the effect of concussions on students' well-being in academic settings, focusing on the prevalence of concussion-related symptoms, duration of cognitive engagement without experiencing symptoms, and perceptions of difficulty in academic tasks. It was revealed that across all age groups, there were a plethora of concussion symptoms that were prevalent in academic settings. This included difficulty concentrating, headache, sensitivity to light, and feeling slow.<sup>19</sup> The study also highlights the differences in the perceptions of difficulty with academic tasks between high school and college students. The younger athletes showed less resilience in cognitive functions during recovery compared to the older athletes.<sup>19</sup> These findings show that there is an age-dependent response to concussions; this implies that there needs improvement in age-specific guidelines and accommodations to support these students in their academic recovery.

## **Discussion**

### ***Neurological/Cognitive function***

The five studies discussed provide essential insights into the impact of concussions on the neurological and cognitive function of youth and adolescent athletes. These results suggest that concussions and repetitive head impacts may lead to subtle cognitive impairments, increased symptoms, altered brain structure, and changes in cognitive domains such as impulse control and visual memory.<sup>5-9</sup> These findings demonstrate the importance of early detection and management of concussions in young athletes.

***Motor skills***

Moving on to motor skills, the four studies offered valuable information on the effects of concussions on youth and adolescent athletes. The findings indicate that concussed young athletes exhibit persistent deficits in balance control, performed visuomotor tasks more conservatively, and decreased gait performance.<sup>10-13</sup> The evidence highlights the importance of using comprehensive motor skill assessments to identify and monitor the effects of SRC. Because these deficits can extend beyond the standard recovery period<sup>10-13</sup>; it is essential to integrate more comprehensive motor performance assessments into standard concussion protocols. The management and indication of post-concussion deficits in young athletes can vastly improve, ultimately enhancing safety and recovery outcomes.

***Mental Health outcomes***

As for mental health, the three studies consistently demonstrated that there is a correlation between concussions and numerous mental health consequences in young athletes. It was consistently found that concussions were associated with symptoms of depression, hopelessness, and suicidal thoughts/actions.<sup>14-16</sup> Also, student-athletes who had a history of multiple concussions were more likely to report symptoms of depression.<sup>15-16</sup> The findings emphasize the need to address mental health concerns in young athletes who sustain concussions. It is vital for there to be an increase in awareness, monitoring, and support of the mental well-being of young athletes.

***Academic and School related Consequences***

Shifting the focus to academic performance, all three studies contribute valuable insights into the relationship between SRCs and academic performance in youth and adolescent athletes. It was revealed that there was a significant decline in GPAs following concussions, especially in individuals with multiple concussions.<sup>17</sup> Additionally, it was discovered that concussion symptoms prevalent in academic settings affect cognitive function differently based on age, suggesting the necessity for age-specific guidelines and accommodations.<sup>19</sup> Comprehending the potential negative academic impacts of concussions and implementing strategies to support athletes' return to learning is vital for their success in the classroom. Prioritizing the academic well-being of these young athletes should be a top priority for long-term monitoring of head injuries.

### ***Limitations***

Despite the important information discovered in the studies discussed, it is important to acknowledge their limitations. These studies relied on cross-sectional designs, self-reported data, and small sample sizes which can impede the ability to establish cause and effect, generalize findings, and accurately measure concussion-related outcomes. To address these limitations, future research should aim to use larger sample sizes, longitudinal study designs, and objective measures. By addressing these limitations, the evidence of the effects of concussions on young athletes can be enhanced, leading to more effective concussion management protocols and improvement in athlete safety.

### **Conclusion**

Considering the prevalence of concussions, with approximately 1.7 million reported annually,<sup>1</sup> and their potential short- and long-term effects on young athletes, this systematic



review pursued to gain comprehensive insights into this important issue. Due to the potentially debilitating consequences of SRCs, understanding the significance of this issue is important in ensuring the safety of young athletes. Through a careful examination of the literature, this paper has highlighted several crucial domains that are affected by concussions. These included neurological/cognitive function, motor skills, mental health, and academics.

Moving forward, future research and regulations should continue to focus on the effects of concussions and developing effective preventive measures to reduce the risk of injuries among young athletes. These include stricter return-to-play protocols, comprehensive rehabilitation, addressing mental health alongside physical recovery, and providing academic accommodations. It is essential to create a safer and more supportive environment for these athletes by prioritizing their health and growth.

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