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Effects of Occupation Based Interventions Related to Play and Leisure for Minimization of Post-Concussion or Mild Traumatic Brain Injury Symptoms in Adolescents: A Critically Appraised Topic

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Effects of Occupation Based Interventions Related to Play and Leisure for Minimization of Post-Concussion or Mild Traumatic Brain Injury Symptoms in Adolescents: A Critically Appraised Topic

Focus Question

What are the effects of occupation-based interventions of aerobic exercise related to play and leisure for the minimization of post-concussion or mild traumatic brain injury (mTBI) symptoms in the population of adolescents ages 10 to 20 years old?

Case Scenario

Occupational therapy has a vital impact on healthcare providing a holistic approach to care with the goal of improving quality of life, increasing participation in meaningful occupations, and speeding up the recovery process for a variety of health conditions. In concussion management, occupational therapy professionals play a critical role on the multidisciplinary team, understanding the important interaction between the athlete, occupation, and the environment (Andreas et al., 2021). Even though the target population for this critically appraised topic (CAT) is adolescents, athletes (those who experienced a sports-related concussion) comprise most of the studies due to the prevalence of sports-related concussions. The role of concussion treatment and management has been an ever-changing process, with new studies and evidence shifting the priorities of rehabilitation from prolonged rest to active recovery and exercise. It is important for practitioners to examine the changes in the evidence to ensure best practices are being implemented. Occupational therapists are specially trained to analyze and understand how the client's occupations are affected after a concussion has occurred, while maximizing the adolescent athlete's return to participation in their meaningful occupations (Andreas et al., 2021). The aim of this domain of care is to maximize the recovery of the adolescent athlete by facilitating re-engagement in the activities of importance to the individual (Andreas et al., 2021).

The health issues related to concussion and mTBI for adolescents are very prevalent and detrimental. In a study sample of 52,949 adolescents in grades 8 through 12, the number of individuals who self-reported having at least 1 concussion increased from 19.5% in 2016 to 24.6% in 2020 (Veliz et al., 2021). Recent studies compiling surveys have estimated 6.5%-18.3% of adolescents between 13-17 years old have been concussed (Haarbauer-Krupa et al., 2021). Concussions are defined as "a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth" (Centers for Disease Control, 2019, para. 1), and adolescents are defined by the American Psychological Association (APA, n.d.) as the time of development that starts at puberty (which is approximately 10 to 12 years old) and ends with both neurobiological and physiological maturity, which has been shown in scientific research to extend until at least the age of 20. The definition of adolescents has not been consistent due to the variation in puberty for men and women and changes in maturation rates over time. The definition by the APA encompasses those who have started the puberty process early, and those who are still developing later, providing a broader group for evidence.



It is important to recognize with adolescents this variation will impact the generalizability of study findings as each person will be in the stage of adolescence for a unique time period. The impact of concussions and mTBI can be detrimental; one study found evidence to suggest prolonged cognitive dysfunction linked to decision-making could average four years post-injury in young adult non-athletes with a concussion history (Caffey & Dalecki, 2021). Additionally, a study of 172 patients (14 patients under the age of 7 and 158 patients in the adolescent age group) found that post-concussion symptoms were present in up to one-third of the patients, and post-concussive symptoms could be diagnosed in 13% of those patients six months post-injury (Riemann et al., 2021).

The literature review for this CAT will analyze the effectiveness of aerobic exercise interventions for adolescents with concussion or mTBI for the purpose of understanding how occupational therapists can better help clients return to the meaningful occupations of leisure and play. This literature review will assist occupational therapists in using evidence-based practice for the recovery process of a prevalent and important condition.

After reviewing the available studies, research has shown that adolescents who have received aerobic exercise treatments for sports related concussion have safely improved their recovery compared to those who just received stretching treatments (Leddy et al., 2019). Also, aerobic exercise has shown a reduced incidence of delayed recovery considered more than 30 days (Leddy et al., 2019).

This CAT will be conducted through the lens of the model of human occupation (MOHO), to identify areas of importance that occupational therapists will want to address with adolescents who have sustained a concussion and experience ongoing symptoms (O'Brien, 2017). This will include identifying the adolescent's *volition*, which includes their interests, values, and motivation (O'Brien, 2017). There will also be a determination of the adolescent's *performance capacity*, meaning their physical and mental ability to perform occupations they want to engage in, and their *personal causation*, the perception of their ability to perform these occupations (O'Brien, 2017). Additionally, the adolescent's *habitation* will be identified, which includes the habits, routines, and roles that have been impacted since their injury (O'Brien, 2017). *Occupational adaptation* is the general process that influences a person's competence and role identity (O'Brien, 2017). This CAT will provide information to inform occupational therapy interventions used to relieve post-concussion symptoms and help the adolescent return to prior activities they enjoyed doing.

Purpose Statement

There is a need for occupational therapy-based interventions related to play and leisure for adolescents who have experienced a concussion. The current research outlines the importance of aerobic exercises in post-concussion and mTBI care. The purpose of this CAT is to explore the effectiveness of occupational therapy-based interventions using aerobic exercise to minimize post-concussion or mTBI symptoms in adolescents.



Literature Synthesis

Inclusion and Exclusion Criteria for Articles

This critically appraised topic includes studies conducted within the past 5 years (2017) and published in the English language. The participants in the studies were adolescent males and females within the age range of 10-20 years old who have sustained a concussion or mTBI. The search was narrowed down from general interventions for occupational therapists to utilize for concussion management, to the effectiveness of aerobic exercise compared to rest for returning to play and leisure occupations.

The databases utilized for this literature review included PubMed, Elsevier, CINAHL, and Embase, and SportDiscuss. Additionally, the search engine Google Scholar was utilized in an attempt to broaden the search results and access more articles. During the search process, a filter was applied to limit articles published no earlier than 2017. Another filter was used to limit studies to the population of adolescents. The search terms included “occupational therapy”, “interventions”, “treatment”, “adolescence”, “concussion”, “mild TBI”, and “mild traumatic brain injury”. The initial search phrase included “occupational therapy” AND (intervention OR treatment) AND (“mild Traumatic Brain Injury” OR “mild TBI” OR “concussion”) AND adolescents.

Overview of Level II, III, IV and N/A Studies

Of the thirty articles reviewed from PubMed, Elsevier, CINAHL, and Embase, seven research studies were specifically chosen to be critically reviewed. These articles met the inclusion criteria of adolescent age, concussion or mTBI, aerobic exercise, and within 5 years of publication.

Level II Studies

The aim of the study by Leddy et al. (2019) was to evaluate the effectiveness of sub symptom threshold aerobic exercise for boosting the rate of recovery in adolescents (between ages 13 and 18) who sustained a sports related concussion compared to a placebo group who performed stretching exercises. The study design was a randomized control trial lasting 30 days. Male and female adolescents, who had been diagnosed by a physician as having a sports related concussion during the last ten days, were selected from three outpatient concussion management clinics, and with parental consent, were asked to participate in the study. The sample size started with 165 participants who met inclusion criteria but was narrowed down to 113 participants, who were then randomly assigned to an aerobic exercise or stretching exercise group. Afterwards, 10 more participants were removed from the study, resulting in 52 participants in the aerobic exercise group and 51 participants in the stretching group.

Both groups were required to exercise daily for 20 minutes and monitor their heart rate. The aerobic exercise group was instructed to use a bike or treadmill, or to walk or jog, if they lacked access to equipment; and they were not to stretch before or after exercise. The stretching group performed gentle, whole-body stretches that would not elevate their heart rate. The results were significant, with the aerobic exercise group recovering from concussion in a median of 13 (interquartile range, 10-18.5) days, while the stretching group had a median recovery rate of 17



(interquartile range, 13-23) days ($p=0.009$) (Leddy et al., 2019). The data demonstrated that aerobic exercise hastens recovery from concussion in adolescents. Limitations of the study included a small study size and participants not having constant monitoring, meaning there was potential for not following treatment protocol.

Leddy et al. (2021) conducted a randomized control trial that recruited 118 adolescents to determine if aerobic exercise would speed up the time to recover from a concussion compared to the standard stretching rehabilitation. Those study subjects were randomized into two different groups: 61 adolescents in the aerobic exercise group and 57 in the stretching exercise group. All subjects completed an initial visit followed by three subsequent weekly visits. Interventions were initiated between 24 hours and 10 days after the injury. Study results showed adolescents who were randomly assigned to the aerobic exercise group recovered faster during the first month of rehabilitation (median of 14 days) compared to those who were in the stretching group (median of 19 days) showing significant difference between the groups ($p=0.039$) (Leddy et al., 2021). The participants received identical instruction and equal attention from the investigators. Another limitation was the COVID-19 pandemic that stopped recruitment at the sites.

The study by Chizuk et al. (2022) was a planned secondary analysis of the results for adolescents, ages 13 to 18, who had been randomly assigned to the aerobic exercise group during the Leddy et al. (2021) randomized control trial. This follow-up analysis was to determine if participants who adhered to an aerobic exercise plan recovered more quickly from a sport-related concussion than those who were not. Exercise adherence was defined as completing two-thirds of the prescribed volume of aerobic exercise. Originally there were 62 adolescents assigned to the aerobic exercise intervention, but from this group 1 participant withdrew, 1 was lost to follow-up, and 9 participants had no heart rate data, so they were not included. Therefore, only 51 participants were analyzed.

There was a 61% adherence rate, with 31 out of 51 adolescents completing at least the minimum aerobic exercise prescribed for each week. Without experiencing any adverse effects, many of the participants who followed the prescribed amount of exercise engaged in more exercise than required. Those who adhered to the aerobic exercise regimen had a significantly faster rate of recovery than those who did not; the median recovery time for those who were adherent was 12 (interquartile range, 9-22) days compared to 21.5 (interquartile range, 13-29.8) days ($p=0.016$) (Chizuk et al., 2022). These findings demonstrated the efficacy of aerobic exercise on the rate of recovery in adolescents after sustaining a concussion. The limitations of this study included a small sample size and lack of generalizability to adolescents who do not engage in regular physical activity.

Kurowski et al. (2017) looked at the outcomes of an exploratory randomized clinical trial of aerobic training for management of prolonged symptoms after a concussion/mTBI in adolescents. Thirty participants between the ages of 12 and 17 years old who had sustained an mTBI and had between four and sixteen weeks of persistent symptoms were eligible for the study. Exclusion criteria included children and/or families who did not speak and/or read English, evidence of a more severe brain injury (Glasgow Coma Scale score below 13), or evidence of more severe injury on clinically performed neuroimaging. Participation in other therapy programs was also an exclusion criterion. Week 1 consisted of a pre-intervention and randomization run-in period which allowed for monitoring of change or improvement of



symptoms that may occur as natural recovery. The 30 participants were reevaluated for eligibility and randomized into either the sub-symptom exacerbation aerobic training group or the full body stretching intervention. Not all participants finished the study; however, 12 were able to complete the study in the aerobic group and 14 completed the program in the stretching group. The aerobic training group completed a cycling test for a baseline, and then an individualized aerobic exercise training program was prescribed for participants to complete five to six days per week. After re-evaluation during weekly visits, the program was modified accordingly. The control group was instructed to complete a full body stretching program to be complete five to six days per week. All participants were asked to complete these exercises for at least six weeks of their respective training program. The Post-Concussion Symptom Inventory (PCSI) was used to assess self and parent rated symptoms with self-rating utilized as the primary outcome. There was less adherence to the program in the aerobic exercise group compared to the stretching group, but there was greater improvement from the sub-symptom exacerbation even though both groups saw improvement from the baseline (Kurowski et al., 2017). Mixed models analysis was utilized to assess the data and the analysis of variance demonstrated a significant (group \times time interaction) difference with self-reported PCSI ratings. This indicated a greater rate of improvement within the aerobic training group than the stretching group ($F=4.11, p=0.044$) (Kurowski et al., 2017). These findings revealed that sub-symptom exacerbation aerobic training was potentially beneficial for adolescents with persistent symptoms after an mTBI.

These studies demonstrated that sub-symptom threshold aerobic exercise was a safe and effective treatment for post-concussion recovery in athletic adolescents. All the studies were randomized control trials with significant results ($p<0.05$), showing support for the data collected. Despite some lack of adherence to treatment, there was overall improvement from post-concussion symptoms. For the trial with adolescents having persistent symptoms after four weeks, both the aerobic exercise and stretching exercise groups improved, though the effect was greater for the aerobic exercise group. The other selected studies looked at the rate of recovery from symptoms based upon exercise treatment and found adolescents in the aerobic exercise group had post-concussion symptoms resolve more quickly than adolescents in the stretching exercise group. Adherence to the treatment plan or a higher level of aerobic exercise decreased the duration of symptoms overall. Researchers commented that a higher proportion of individuals with non-sports related injuries in the stretching group were adherent to the treatment planned as compared to the control group. This suggested that athletes may have a faster response to aerobic interventions compared to non-athletes (Kurowski et al., 2017). This factor should be considered when treating the general adolescent population. One problem with the data collected was that participants were not constantly monitored throughout the trial, and the use of self-report logs means self-report bias was evident. Another problem was the lack of generalizability due to small sample sizes. Although more research needs to be conducted with larger sample sizes, the data collected provided initial evidence to support the use of exercise interventions in an occupational therapy treatment plan when working with adolescents who experience sports-related concussions.



Level IV Study

Boisgontier et al. (2020) completed a cross sectional study conducted within a larger study looking at childhood concussions. The participants were recruited through advertisements and referrals, had to be 11-18 years old, experienced a concussion within the last month, and could not be previously enrolled in a rehabilitation program. The Health and Behavior Inventory was completed by both parents and adolescents, and the Physical Activity Questionnaire for Adolescents was only completed by the adolescents. The participants received an honorarium for participation. The measures were conducted during the first, third and sixth month after injury. Ten adolescents sustained a sports-related concussion and were analyzed using the Sports Concussion Assessment Tool (SCAT). These measures showed participation in daily life physical activity was associated with minimizing concussion symptoms. Limitations of this study included a small sample size, lack of comparison group and minimal background information.

Level N/A Studies

Moen et al. (2022) interviewed participants aged 11-19 years old from a cohort study about their experiences of engaging in occupations after a concussion. Eight participants (5 male, 3 female) were included in the study by convenience sampling, and the semi-structured interviews were conducted three to twenty-four months post-concussion. The data was analyzed by interpretive description methodology that enabled exploration of a phenomenon to inform clinical understanding. Two graduate researchers who were trained in qualitative research and supervised by an experienced research team completed the interviews and data analysis. The study was approved by the Behavioral Research Ethics Board of the University of British Columbia (Moen et al., 2022). Three themes were identified from the research: diverse experiences of concussion, knowledge is key to management, and concussions affect engagement in occupations (Moen et al., 2022). Participants expressed how lack of past knowledge and inconsistent recommendations from medical professionals negatively affected their recovery. These findings outlined the importance of consistency and collaboration among healthcare professionals for improving outcomes. The findings of this study suggested the importance of individualized care with client-centered goals for occupational engagement. As discussed in this study, occupational therapy interventions are vital in concussion management, supporting the need for clarified best evidence in concussion treatment.

Choudhury et al. (2020) researched the adolescent patient's perspectives on their concussion recovery and presence of long-term consequences. Two semi-structured focus groups and two narrative interviews were conducted with a group of seven adolescents for the sample. Strategies for recruitment included posters in hockey arenas, soccer clubs, martial arts training facilities, Brain Injury Rehabilitation Clinic, Alberta Children's Hospital, and Twitter posts. All participants recruited were athletes aged 13-19 years old. Data was collected and analyzed through a combination of grounded theory thematic analysis framework and constructivist narrative analysis technique. The Patient and Community Engagement Research (PaCER) program (*set, collect, reflect*) was utilized for patient engagement driven by patients working together to facilitate a collective understanding of concussion recovery (Choudhury et al., 2020). This study outlined the experience of adolescents in their recovery from concussion, and how



important concussion knowledge and training are for athletes, coaches, teachers, and practitioners.

Both qualitative studies utilized interviews to understand and expand on the perspectives and experiences of adolescents who have suffered concussions. The outcomes of one study suggested a lack of common understanding of best clinical practice by practitioners which resulted in confusion for the clients (Moen et al., 2022). Both studies focused on the client's point of view rather than the practitioner. The goal of occupational therapy is to provide evidence-based care that is client-centered. These studies provide important perspectives for practitioners to keep in mind when implementing interventions for post-concussion symptom management. One key factor about the qualitative studies is that they did not address aerobic interventions, but rather the entire experience of the recovery process. A limitation of the qualitative studies is the small sample sizes. Although this is common in qualitative research, it focuses on the quality of individual perspectives rather than gathering a large amount of data.

Summary

Overall, the studies provided a comprehensive understanding of the effects that aerobic exercise provides in treatment of adolescents with mTBI/concussion. There were gaps in the literature related to the specific use of interventions in occupational therapy; however, many of the studies analyzed interventions that are well within the scope of practice for occupational therapy. When narrowing down the evidence base, the most prevalent and promising research was related to studies on aerobic exercising versus rest or stretching. In relation to the case study, most studies analyzed the impacts on adolescents in sports-related concussions, and the findings were congruent in the effects and improvement of recovery for this population. When generalizing to the adolescent population, it must be recognized that not all adolescents sustain a concussion or mTBI due to sports, yet this is most cases and will be relevant in occupational therapy implications. In all the quantitative studies examining aerobic exercise compared to other interventions or no interventions at all, there was a positive effect either on post-concussion symptom mitigation or time for recovery. Additionally, the perspectives of adolescent patients in the qualitative studies expanded on the experiences of recovering from mTBI and emphasized the importance of consistent information and recommendations from health professionals. In conjunction with the evidence presented in the level II and level IV research studies, agreement on what is the best evidence-based approach will not only benefit the practitioners, but most importantly the clients who are being treated.

Clinical Bottom Line

After reviewing the literature in search of the effects of occupation-based interventions of aerobic exercise related to play and leisure for the minimization of post-concussion or mild traumatic brain injury symptoms in the population of adolescents aged 10 to 20 years old, the findings suggest positive outcomes. Of the research done, aerobic exercise has decreased the recovery time and minimized the post-concussion symptoms for adolescents who have experienced a sports-related injury. With less recovery time, healthcare costs can be reduced for treatment of post-concussion rehabilitation.



Since adolescents who suffered a sports-related concussion were the most studied, the relation of occupational importance can be seen when rehabilitation is related to their interests. The model of human occupation helps to outline the various factors related to why a person will or will not engage in an occupation. In relation to aerobic exercise for adolescent athletes, all aspects of volition as well as performance capacity, habituation, and environment will be involved in the recovery process (O'Brien, 2017). The habits, routines, and roles of an adolescent may be impacted by a concussion; therefore, allowing them to return to their meaningful activities and roles will positively impact occupational adaptation. Motivation for adolescents to adhere to a rehabilitation program that is centered around their preferred occupations of play and leisure has shown improved recovery and minimization of symptoms. When aerobic exercise is utilized early in intervention, greater improvements are seen in minimization of symptoms. Additionally, the culture of adolescent athletes is an important factor to consider when implementing interventions. Occupational therapists are specially trained to have a client-centered approach that aligns with the goals, interests, and abilities of the adolescent. Understanding what motivates this population will influence the effectiveness of the intervention.

Aerobic exercises can be occupation-based, especially when rehabilitation is for sports related injury. The activities used for rehabilitation could be occupations involved in the adolescents' play and leisure activities. These occupations can also be considered when deciding what aerobic activities to use. There were many aerobic exercises utilized, including jogging, biking, or walking. It is important to note that activities can be done without equipment so they can be accessible to any adolescent who has experienced a concussion. When injury occurs during leisure and extracurricular activities, generalization to the larger population warrants further study. Play and leisure are core occupations for this population, so interventions targeting these activities for treatment are supported by this research. Occupational therapists can utilize this information for implementing aerobic exercise as an effective intervention for adolescents who have endured a concussion/mTBI.



References

- American Psychology Association. (n.d.). Adolescence. In *APA dictionary of psychology*. Retrieved March 3, 2023, from <https://dictionary.apa.org/adolescence>
- Andreas, N., Molitor, W. L., & Dubisar, L. (2021). Managing concussion: Occupational therapy's role in evaluating and treating athletes. *OT Practice Magazine*, 26(7), 10-13. <https://www.aota.org/publications/ot-practice/ot-practice-issues/2021/managing-concussion>
- Boisgontier, M.P., Cheval, B., & Schmidt J. (2020). Daily life physical activity and concussion symptoms and concussion symptoms in adolescents. *Canadian Journal of Occupational Therapy*, 87(5), 364-371. <https://doi.org/10.1177/0008417420953228>
- Caffey, A. L., & Dalecki, M. (2021). Evidence of residual cognitive deficits in young adults with a concussion history from adolescence. *Brain Research*, 1768, 147570. <https://doi.org/10.1016/j.brainres.2021.147570>
- Centers for Disease Control. (2019). What is a concussion? *U.S. Department of Health & Human Services*. https://www.cdc.gov/headsup/basics/concussion_what.html
- Chizuk, H. M., Willer, B. S., Cunningham, A., Bezherano, I., Storey, E., Master, C., Mannix, R., Wiebe, D. J., Grady, M. F., Meehan, W. P., Leddy, J. J., & Haider, M. N. (2022). Adolescents with sport-related concussion who adhere to aerobic exercise prescriptions recover faster. *Medicine & Science in Sports & Exercise*, 54(9), 1410-1416. <https://doi.org/10.1249/MSS.0000000000002952>
- Choudhury, R., Kolstad, A., Prajapati, V., Samuel, G., & Yeates, K. O. (2020). Loss and recovery after concussion: Adolescent patients give voice to their concussion experience. *Health Expectations: An International Journal of Public Participation in Health Care and Health Policy*, 23(6), 1533–1542. <https://doi.org/10.1111/hex.13138>
- Haarbauer-Krupa, J., Lebrun-Harris, L. A., Black, L. I., Veliz, P., Daugherty, J., Desrocher, R., Schulenberg, J., Pilkey, D., & Breiding, M. (2021). Comparing prevalence estimates of concussion/head injury in U.S. children and adolescents in national surveys. *Annals of Epidemiology*, 54, 11-20. <https://doi.org/10.1016/j.annepidem.2020.11.006>
- Kurowski, B., Hugentobler, J., Quatman-Yates, C., Taylor, J., Gubanich, P., Altaye, M. & Wade, S. (2017). Aerobic exercise for adolescents with prolonged symptoms after mild traumatic brain injury: An exploratory randomized clinical trial. *Journal of Head Trauma Rehabilitation*, 32(2), 79-89. <https://doi.org/10.1097/HTR.0000000000000238>
- Leddy, J. J., Haider, M. N., Ellis, M. J., Mannix, R., Darling, S. R., Freitas, M. S., Suffoletto, H. N., Leiter, J., Cordingley, D. M., & Willer, B. (2019). Early subthreshold aerobic exercise for sport-related concussion. *JAMA Pediatrics*, 173(4), 319-325. <https://doi.org/10.1001/jamapediatrics.2018.4397>



- Leddy J. J., Master, C. L., Mannix, R., Wiebe, D. J., Grady, M. F., Meehan, W. P., Storey, E. P., Vernau, B. T., Brown, N. J., Hunt, D., Mohammed, F., Mallon, A., Rownd, K., Arbogast, K. B., Cunningham, A., Haider, M. N., Mayer, A. R. & Willer, B. S. (2021). Early targeted heart rate aerobic exercise versus placebo stretching for sport-related concussion in adolescents: A randomised controlled trial. *The Lancet Child & Adolescent Health in Elsevier*, 5(11), 792-799. [https://doi.org/10.1016/S2352-4642\(21\)00267-4](https://doi.org/10.1016/S2352-4642(21)00267-4).
- Moen, E., McLean, A., Boyd, L. A., Schmidt, J., & Zwicker, J. G. (2022). Experiences of children and youth with concussion: A qualitative study. *American Journal of Occupational Therapy*, 76, 7604205040. <https://doi.org/10.5014/ajot.2022.047597>
- O'Brien, J.C. (2017). Model of human occupation. In J. Hinojosa, P. Kramer, & C. Royeen (Eds.), *Perspectives on human occupation: theories underlying practice* (2nd ed., pp. 93-136). F. A. Davis Company
- Riemann, L., Voormolen, D. C., Rauen, K., Zweckberger, K., Unterberg, A., Younsi, A., & the Collaborative European NeuroTrauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) Investigators and Participants. (2021). Persistent postconcussive symptoms in children and adolescents with mild traumatic brain injury receiving initial head computed tomography, *Journal of Neurosurgery: Pediatrics*, 27(5), 538-547. <https://doi.org/10.3171/2020.9.PEDS20421>
- Veliz, P., McCabe, S. E., Eckner, J. T., & Schulenberg, J. E. (2021). Trends in the prevalence of concussion reported by US adolescents, 2016-2020. *JAMA Network*, 325(17), 1789-1791. <https://doi.org/10.1001/jama.2021.1538>

