CONCUSSIONS: MANAGEMENT, PREVENTION, AND LONG-TERM EFFECTS

Joy Campbell

BIOL405W

1 December 2023

Dr. Osgood

Abstract:

This paper provides a comprehensive exploration of concussions, a form of traumatic brain injury, focusing on their significance, mechanisms, management, prevention, and potential long-term effects. Delving into the intricate anatomy of the brain, the study elucidates the biomechanics of concussions, detailing how external forces lead to functional disturbances in brain activity. The classification of concussions by severity and the challenges in their accurate diagnosis, especially in mild cases, are discussed. The immediate steps in concussion management, including cognitive and physical rest, and the importance of individualized treatment plans are highlighted. Furthermore, primary prevention strategies, such as protective gear and education, are examined in the context of minimizing the risk of concussions. The paper also delves into the potential long-term consequences of concussions, exploring the link between these injuries and neurodegenerative diseases, as well as their impact on mental health.

Introduction:

Concussions, a form of traumatic brain injury, have garnered increasing attention in recent years due to their prevalence and potential long-term consequences. Understanding the significance of concussions requires delving into the intricate anatomy of the brain and unraveling how these injuries occur at a neurological level. The human brain, a marvel of complexity, is susceptible to damage when subjected to external forces, leading to disruptions in its normal functioning. This paper aims to shed light on the management, prevention, and long-term effects of concussions. By examining the mechanisms through which concussions manifest in the brain, scientists seek to provide a comprehensive overview that not only helps readers comprehend the physiological processes involved but also addresses key questions surrounding effective management and prevention strategies, as well as the potential lasting impacts of these injuries on individuals.

Background Information:

A concussion emerges as a consequence of a forceful impact, jolt, or sudden acceleration to the head, resulting in functional disturbances in brain activity without visibly identifiable structural damage on imaging studies. The severity of concussions is categorized based on symptoms, ranging from mild cases with transient cognitive and physical impairments to more severe instances associated with prolonged and pronounced effects. Various incidents, including sports-related injuries, motor vehicle accidents, falls, workplace mishaps, and physical altercations, can lead to concussions. The biomechanics of these injuries encompass the transfer of external forces to the brain, causing shearing and stretching of neuronal structures. This mechanical strain initiates a cascade of events, including axonal stretching, neurotransmitter release, and alterations in ion concentrations, resulting in the disruption of normal brain function.

This illustrative comparison contrasts a brain without a concussion alongside a brain affected by a concussion, providing a nuanced understanding of the implications for working memory, motor planning, and number processing (DeGaetano, 2021). The image intricately delineates the various brain regions associated with these cognitive functions, offering a side-by-side view of the unaffected and concussed states. The unaffected brain serves as a reference, showcasing the typical neural activity related to working memory, motor planning, and number processing. In contrast, the concussed brain highlights alterations in these regions, underlining the potential disruptions caused by traumatic brain injury (DeGaetano, 2021). By focusing on working memory, the image illuminates the intricate neural networks responsible for short-term information retention and processing. Motor planning is visually emphasized, shedding light on the brain areas orchestrating coordinated movements, while the depiction of number processing zones underscores the impact of concussions on cognitive functions related to mathematical reasoning and calculation. The juxtaposition of the two brain states in the image underscores the

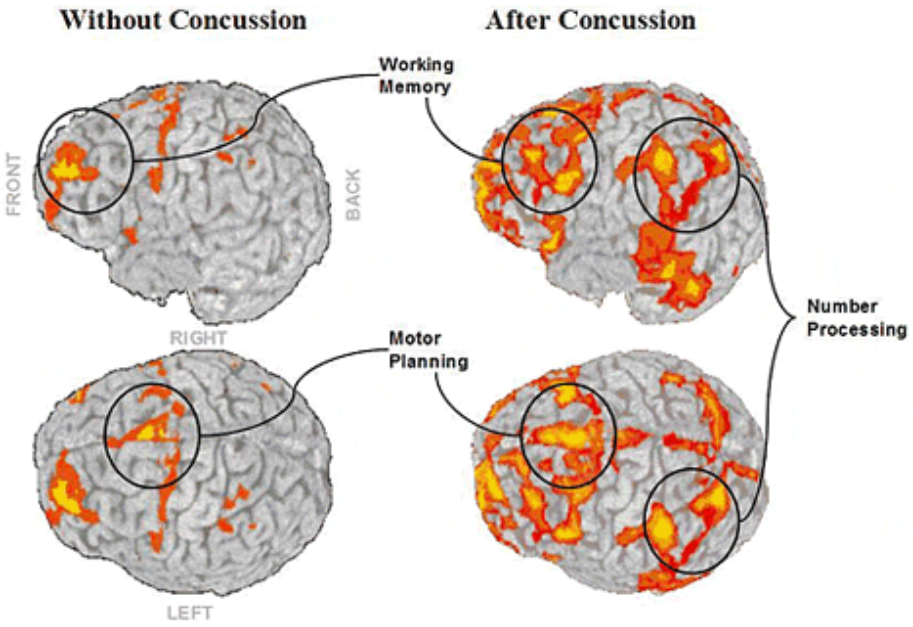


Figure 1. The brain without a concussion and with a concussion

significance of injury prevention and the imperative for comprehensive care to protect the intricate workings of the brain in contexts where concussions are prevalent (DeGaetano, 2021).

Understanding the intricate nature of concussions, from their diverse causes to the biomechanical processes involved, is imperative for effective prevention, management, and addressing potential long-term consequences on brain health. Examples of prolonged effects may include cognitive impairments, emotional disturbances, and an increased risk of neurodegenerative diseases, highlighting the importance of comprehensive care strategies.

Signs and Symptoms of Concussion:

Common signs and symptoms of concussions encompass a range of cognitive, physical, and emotional manifestations, including headaches, dizziness, confusion, memory impairment, nausea, and sensitivity to light or noise (Antenna, 2023).

Figure 2. Signs and Symptoms of Concussions (Antenna, 2023)

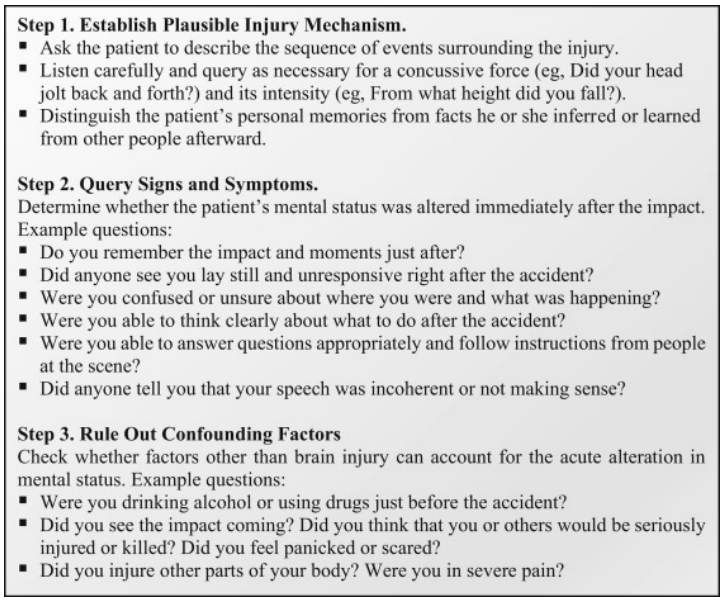
The image prominently features the human brain, segmented into four distinct categories: cognitive, physical, sleep, and emotional. Each category occupies a specific area of the brain, vividly illustrating the diverse manifestations of concussions (Antenna, 2023). The cognitive domain, representing functions such as memory, concentration, and problem-solving, is visually demarcated on the image, drawing attention to the

potential cognitive impairments associated with concussions. This visual emphasis on cognitive aspects provides a clear focal point for audience comprehension. Simultaneously, the physical category is meticulously delineated, encompassing areas associated with motor skills, coordination, and sensory functions. By allocating a specific region to physical manifestations, the audience gains a nuanced understanding of how concussions can impact the body beyond cognitive functions. The sleep-related effects of concussions are thoughtfully illustrated, dedicating a distinct portion of the brain to highlight disruptions in sleep patterns. This visual representation helps convey the significance of recognizing sleep-related symptoms, an often overlooked aspect in concussion assessments. Lastly, the emotional category is visually distinct, illustrating areas linked to mood regulation and emotional well-being. This segmentation serves to underscore the emotional disturbances that may accompany concussions, reinforcing the importance of a holistic approach to post-injury care (Antenna, 2023).

Diagnostic methods for identifying concussions involve a comprehensive and multifaceted approach. Clinical assessments play a crucial role, as healthcare professionals evaluate cognitive, physical, and emotional symptoms exhibited by individuals who may have experienced a head injury. Cognitive testing is often employed to assess various aspects of brain function, including memory, attention, and processing speed (Sinclair et al., 2021). Additionally, neuroimaging, such as computed tomography (CT) scans or magnetic resonance imaging (MRI), may be utilized to visualize the brain's structure and identify any abnormalities (Sussman et al., 2018). To briefly elaborate, while CT scans are efficient in detecting acute structural abnormalities, MRI scans provide a more comprehensive and detailed assessment of both structural and functional aspects of the brain, making them valuable in the comprehensive evaluation of concussions. The choice between the two depends on the specific clinical

requirements and the information needed for an accurate diagnosis and management of concussions (Sussman et al., 2018).

The diagnostic method for concussions outlined to the right involves three key steps. The first step is to establish a plausible injury mechanism, requiring a critical analysis to determine the likely cause of the injury (Silverberg et al., 2019). This initial phase encourages a comprehensive understanding of the circumstances surrounding the event, facilitating the identification of potential causes. The second step involves querying signs and symptoms, emphasizing the importance of a thorough evaluation. By delving into the specific manifestations associated with concussions, this step ensures a comprehensive assessment of the individual's condition (Silverberg et al., 2019). The third and final step focuses on ruling out confounding factors that may mimic or exacerbate concussion symptoms. This critical aspect aims to ensure a more accurate diagnosis by considering other potential contributors to the observed signs and symptoms (Sussman et al., 2018). The visual representation of these steps within the image provides a structured framework for healthcare professionals, offering a systematic and organized approach to the diagnostic process for concussions (Sinclair et al., 2021). The simplicity and clarity of the image contribute to its effectiveness in guiding practitioners through the essential steps of evaluation.



Step 1. Establish Plausible Injury Mechanism.

- Ask the patient to describe the sequence of events surrounding the injury.
- Listen carefully and query as necessary for a concussive force (eg, Did your head jolt back and forth?) and its intensity (eg, From what height did you fall?).
- Distinguish the patient's personal memories from facts he or she inferred or learned from other people afterward.

Step 2. Query Signs and Symptoms.

Determine whether the patient's mental status was altered immediately after the impact. Example questions:

- Do you remember the impact and moments just after?
- Did anyone see you lay still and unresponsive right after the accident?
- Were you confused or unsure about where you were and what was happening?
- Were you able to think clearly about what to do after the accident?
- Were you able to answer questions appropriately and follow instructions from people at the scene?
- Did anyone tell you that your speech was incoherent or not making sense?

Step 3. Rule Out Confounding Factors

Check whether factors other than brain injury can account for the acute alteration in mental status. Example questions:

- Were you drinking alcohol or using drugs just before the accident?
- Did you see the impact coming? Did you think that you or others would be seriously injured or killed? Did you feel panicked or scared?
- Did you injure other parts of your body? Were you in severe pain?

Figure 3. Diagnostic Interview for Concussions (Silverberg et al., 2019)

However, it's important to note that accurately diagnosing concussions, especially in mild cases, poses challenges. Unlike more severe traumatic brain injuries, concussions may not result in visible structural damage on standard imaging, making the reliance on subjective reporting and clinical judgment crucial (Sinclair et al., 2021). Timely diagnosis can be complicated by delayed symptom onset, and individuals may underreport their symptoms, emphasizing the need for a nuanced and comprehensive diagnostic approach that considers both objective measures and patient-reported experiences (Teasdale et al., 2018).

Management and Prevention of Concussions:

In the nuanced landscape of managing concussions, immediate measures play a pivotal role in steering the course of recovery. A foundational step involves the implementation of cognitive and physical rest, offering the brain the necessary time and environment to recuperate (Silverberg et al., 2019). This strategic approach often entails a temporary reduction in both mental and physical activities, a crucial intervention aimed at minimizing the risk of exacerbating symptoms during the delicate recovery phase (Silverberg et al., 2019). For more severe cases, where symptoms may be pronounced, medical interventions become essential components of the management strategy. Tailored medications addressing specific symptoms, such as headaches or nausea, are prescribed to alleviate discomfort and enhance the overall well-being of the individual. Furthermore, the implementation of therapeutic interventions, including vestibular rehabilitation and cognitive rehabilitation, adds depth to the management approach (Leddy et al., 2018). These targeted therapies address persistent issues, focusing on rehabilitation to improve specific cognitive or physical functions affected by the concussion. This multi-faceted approach acknowledges the varied nature of symptoms and their impact on different aspects of an individual's well-being (Leddy et al., 2018). A cornerstone of effective

concussion management lies in the recognition of the inherent variability in the severity of concussions across individuals. Hence, the concept of individualized treatment plans emerges as paramount. Acknowledging that what works for one person may not be universally applicable, tailoring interventions based on specific symptoms and the unique needs of each patient becomes fundamental (Leddy et al., 2018). This personalized approach optimizes the prospects of recovery while minimizing the risk of long-term complications associated with concussions. In essence, a comprehensive and individualized management strategy is key to navigating the intricacies of concussion care successfully (Silverberg et al., 2019).

The prevention of concussions is a multifaceted endeavor, with primary prevention strategies serving as a crucial element in mitigating the risk of these traumatic brain injuries (Sussman et al., 2018). The emphasis on protective measures encompasses the utilization of appropriate gear, notably helmets in contact sports, as a physical barrier against head injuries. Beyond mere protection, the incorporation of rule changes in sports stands as an instrumental approach to minimizing high-impact collisions and promoting safer play, thereby contributing significantly to the reduction of concussion incidence (Sussman et al., 2018). Education plays an equally vital role in the prevention landscape, focusing on fostering awareness and instilling proper techniques to minimize the risk of head injuries. This educational initiative extends to athletes, coaches, parents, and the broader community, creating a collective understanding of the signs and symptoms of concussions (Teasdale et al., 2018). Stressing the importance of promptly reporting and seeking medical attention for potential head injuries fosters a proactive approach to injury prevention (Sussman et al., 2018). The synergy between physical safeguards and informed practices is pivotal in the development of comprehensive primary prevention strategies. By combining the tangible protection provided by gear and rule modifications with the

knowledge and awareness imparted through education, a more robust defense against concussions is established. This approach is particularly crucial in sports and activities where the risk of concussions is prevalent, ensuring a safer environment for participants. Ultimately, the multifaceted nature of primary prevention strategies highlights the need for a holistic approach, addressing both the physical and cognitive aspects of injury prevention to create a well-rounded and effective protective framework (Sussman et al., 2018).

Looking ahead, ongoing research suggests promising developments in concussion treatment. Innovative technologies for early detection and advances in protective equipment are areas of exploration. Additionally, there is a growing emphasis on understanding the link between concussions and neurodegenerative diseases, prompting research into preventive measures (Silverberg et al., 2019).. While these potential advancements are promising, it's crucial to underscore the importance of continued research, education, and advocacy to safeguard individuals from the immediate and potential long-term impacts of concussions. As the field evolves, these efforts aim to enhance our understanding and inform more effective and targeted treatment strategies for concussions in the future (Silverberg et al., 2019)..

Long-Term Effects:

The burgeoning exploration of the long-term repercussions of concussions has emerged as a focal point in contemporary research, shedding light on a nexus between these traumatic brain injuries and neurodegenerative diseases (Dwyer et al., 2018). The investigative spotlight has particularly intensified in recent years, with a growing body of evidence underlining the association between concussions, especially those incurred in sports, and an augmented susceptibility to neurodegenerative conditions such as chronic traumatic encephalopathy (CTE)

(Skjeldal et al., 2022). This debilitating syndrome is distinguished by the aberrant accumulation of tau protein in the brain, instigating cognitive decline and behavioral impairments that pose profound challenges to affected individuals (Dwyer et al., 2018). Notably, compelling recent findings have not only affirmed the cumulative impact of repetitive head trauma but have also elucidated the precarious nature of even a singular severe concussion, potentially acting as a harbinger of heightened vulnerability to neurodegenerative disorders in later life.

Furthermore, the insidious repercussions of repeated concussions extend beyond cognitive domains, permeating into the realm of mental health. Accumulated evidence paints a nuanced picture, indicating a discernible correlation between recurrent concussions and an increased propensity for mental health issues (Dwyer et al., 2018). Depression and anxiety, in particular, have surfaced as conditions to which individuals with a history of repeated concussions may be more susceptible. This revelation underscores the imperative of comprehending the multifaceted and lasting consequences of concussions, not solely in the neurological sphere but also in the intricate landscape of mental well-being (Dwyer et al., 2018).

In light of these revelations, it becomes evident that a deeper understanding of the enduring impacts of concussions is not merely an academic pursuit but a critical impetus for the formulation and implementation of preventive measures and comprehensive care strategies (Skjeldal et al., 2022). Acknowledging the potential long-term consequences on both cognitive function and mental well-being amplifies the urgency surrounding proactive initiatives aimed at safeguarding individuals from the latent, yet formidable, aftermath of concussions. This multifaceted awareness is pivotal for clinicians, researchers, policymakers, and the broader community to collaboratively strive for advancements in preventive measures, effective

interventions, and supportive frameworks that address the intricate interplay between concussions and the lasting health of the brain (Skjeldal et al., 2022).

Discussion:

As the author of this research review paper, I bring a unique perspective to the discussion, having experienced multiple concussions firsthand, all of which were sports-related. The personal impact of these injuries has provided me with insights that extend beyond the academic exploration of concussions. The vivid portrayal of brain states in Figure 1, illustrating the contrast between a brain without a concussion and one affected by a concussion, resonates with my personal experiences. The enduring headaches when exposed to light for extended periods and persistent balance issues, especially with closed eyes, underscore the lasting effects of concussions. This intersection of personal experience and scientific understanding emphasizes the relevance and importance of the research conducted. The diagnostic methods outlined in Figure 3 resonate deeply, as the complexity of accurately diagnosing concussions, particularly in mild cases, aligns with my own challenges. The reliance on subjective reporting and clinical judgment, coupled with the potential for delayed symptom onset, reflects the intricate nature of these injuries. This firsthand knowledge reinforces the need for a nuanced diagnostic approach that considers both objective measures and patient-reported experiences. In the management and prevention discussion, the emphasis on individualized treatment plans strikes a chord. The acknowledgment that each person's journey with concussions is unique aligns with my experience, where tailoring interventions based on specific symptoms has been crucial in navigating the recovery process effectively. Moreover, the multifaceted approach to prevention, integrating both physical safeguards and informed practices, resonates strongly. The educational initiatives highlighted in Figure 2, promoting awareness and proper techniques, are instrumental

in injury prevention. Stressing the importance of reporting and seeking prompt medical attention aligns with my own journey, where timely intervention played a critical role in managing symptoms and preventing potential complications. The exploration of potential long-term effects and the link between concussions and neurodegenerative diseases is particularly poignant. As someone who has experienced these injuries, understanding the potential implications on cognitive function and mental well-being reinforces the urgency of comprehensive care and preventive measures.

Conclusion:

In conclusion, this paper illuminates the intricate dynamics of concussions, emphasizing the significance of understanding their biomechanics, immediate management, and potential long-term effects. The implications of these findings on the management and prevention of concussions are profound. Tailoring individualized treatment plans, promoting education on recognizing and reporting symptoms, and implementing effective primary prevention strategies are essential steps. The identified link between concussions and neurodegenerative diseases necessitates ongoing research to deepen our understanding and inform preventive measures. Future studies could explore innovative technologies for early detection and advances in protective equipment. It is imperative that stakeholders, including athletes, coaches, healthcare professionals, and policymakers, collaborate to establish comprehensive protocols that prioritize brain health. A call to action is sounded for continued research, education, and advocacy to safeguard individuals from the immediate and potential long-term impacts of concussions.

References

Antenna, R. (2023, August 28). *Symptoms of concussion*. Brain Injury Association of America. https://www.biausa.org/brain-injury/about-brain-injury/what-is-a-brain-injury/concussion-mtbi/common-symptoms-of-concussion

DeGaetano, M. J. (2021, January 9). *Law of inertia and head injuries*. North Alabama Spine & Rehab. https://ihurtdoc.com/law-of-inertia-head-injuries/

Dwyer, B., & Katz, D. I. (2018, November 24). *Postconcussion syndrome*. Handbook of Clinical Neurology. 158:163-178 https://www.sciencedirect.com/science/article/abs/pii/B9780444639547000173?via%3Dihub

Post concussion syndrome (PCS) is a complex condition characterized by a range of symptoms affecting somatic, cognitive, and emotional domains. It is controversial due to varying consensus criteria, presentation variability, and lack of specificity to concussion. The clinical consequences are seen as two phases: early-phase posttraumatic disorder with acute symptoms like headache and impaired cognition, and late-phase disorder with somatic, emotional, and cognitive symptoms influenced by psychosocial factors. The article explains that risk factors for late-phase disorder include high early symptom burden, multiple concussions, psychiatric conditions, longer unconsciousness, and younger age. Successful treatment involves differential diagnosis, considering comorbid conditions, and a sequential approach addressing treatable symptoms. Aerobic exercise is recommended for both phases after concussion. PCS lacks consensus in definition, diagnosis, and understanding its epidemiology, pathophysiology, time course, and prognosis. It may be more beneficial to conceptualize postconcussion symptoms as early- and late-phase posttraumatic disorders.

Leddy, J. L. (2018, August). *Exercise is medicine for concussion : Current Sports Medicine Reports*. Current Sports Medicine Reports. 17(8):262-270 https://journals.lww.com/acsm-csmr/fulltext/2018/08000/exercise_is_medicine_for_concussion.5.aspx

The article explores how autonomic nervous system dysfunction contributes to exercise intolerance, with elevated carbon dioxide levels affecting cerebral blood flow and limiting exercise performance. It suggests that subthreshold aerobic exercise can normalize cerebrovascular physiological dysfunction and act as "medicine" for patients with concussion and persistent postconcussive symptoms (PPCS). The Buffalo Concussion Treadmill Test (BCTT) and Buffalo Concussion Bike Test (BCBT) are presented as methods for evaluating exercise tolerance and prescribing individualized aerobic exercise programs. The article emphasizes the role of exercise in concussion management, challenging the traditional paradigm of prolonged rest. It concludes by calling for further research on the optimal timing and dose of guided aerobic exercise for concussion treatment.

This article also contains four to five charts and graphs.

Silverberg, N. D., Iaccarino, M. A., & Panenka, W. J. (2019, October 23). *Management of concussion and mild traumatic brain injury: A synthesis of Practice Guidelines*. Archives of Physical Medicine and Rehabilitation. 101(2):382-393 https://www.sciencedirect.com/science/article/pii/S000399931931305X?via%3Dihub

Traumatic brain injury (TBI) results from an external force altering brain function, with falls being the leading cause. Almost half of Americans experience TBI in their lifetime, and the incidence is increasing. The majority are mild TBIs (mTBI), often managed outside the hospital, making primary care providers crucial in early intervention.

The article continued by noting that historically, mTBI was managed with watchful waiting, but evolving evidence of chronic symptoms led to proactive intervention standards. The review synthesizes recent knowledge for non-specialist clinicians, offering evidence-based recommendations across age groups and injury settings. The diagnostic process involves establishing a plausible injury mechanism, assessing immediate signs of altered mental status, and considering confounding factors. Prognosis varies, with 20% experiencing persistent symptoms, and recovery influenced by preexisting conditions. Furthermore, early clinical management prioritizes ruling out neurosurgical emergencies and educating patients on mTBI, with gradual return to activity advised. Follow-up care involves investigating persistent symptoms, screening for anxiety and depression, and managing symptoms with a focus on headaches, sleep disturbance, and mood disorders. The article provides practical guidance for clinicians to navigate mTBI care, incorporating the latest evidence and consensus statements.

Contains many tables and images in relation to the study.

Sinclair, A., & Scher, A. I. (2021, May 19). *Post-traumatic headache attributed to traumatic brain injury: Classification, Clinical Characteristics, and treatment*. The Lancet Neurology. 20(6):460-469 https://www.sciencedirect.com/science/article/abs/pii/S1474442221000946?via%3Dihub

This article talks about Post-traumatic headache (PTH) is a disabling secondary headache disorder associated with traumatic brain injury. Its clinical presentation involves recurrent episodes of headache with varying frequency, duration, and intensity. Classified as a secondary headache disorder, PTH is attributed to traumatic brain injury, whiplash injury,

or craniotomy. The natural course of PTH remains a key clinical interest, but variations in case definitions hinder conclusive findings. In sports (one of my points of emphasis), mild traumatic brain injury is common, often termed sport-related concussion. Management depends on severity, with primary care providers handling mild cases and introducing preventive therapy for increasing frequency. Due to a lack of controlled trials, a primary headache phenotype-guided approach is suggested for clinical management. Despite progress in understanding clinical features and comorbidities, questions persist about the natural course of PTH, warranting further research and potential revision of diagnostic criteria. The review includes a proposed treatment algorithm based on the shared biological foundations of PTH with migraine and tension-type headache.

Skjeldal, O. H., Skandsen, T., Kinge, E., Glott, T., & Solbakk, A.-K. (2022, August 17). *Long-term post-concussion symptoms*. Tidsskrift for Den norske legeforening. 142(12) https://tidsskriftet.no/en/2022/08/long-term-post-concussion-symptoms

In summary, the article discusses long-term post-concussion symptoms, which persist in 10–15% of patients. These symptoms encompass somatic, cognitive, and emotional aspects and are often more prevalent in individuals with pre-existing somatic and mental health issues. The causes of these prolonged symptoms are not entirely clear, but a biopsychosocial model is considered the most appropriate approach for diagnosis and treatment.

The article explores complex causes, suggesting that post-concussion symptoms may result from a combination of psychosocial and biological factors. Factors such as being female, personality traits, life stresses, and previous pain conditions may contribute to the

development and persistence of symptoms. Additionally, there is growing interest in understanding post-concussion symptoms from a neurobiological perspective, exploring the impact of metabolic changes, altered regulation of ionic flux, and inflammatory responses in the brain.

Sussman, E. S., Pendharkar, A. V., Ho, A. L., & Ghajar, J. (2018, November 24). *Mild traumatic brain injury and concussion: Terminology and classification*. Handbook of Clinical Neurology. 158:21-24 https://www.sciencedirect.com/science/article/abs/pii/B9780444639547000033?via%3Dihub

In essence, the article discusses traumatic brain injury (TBI), particularly mild TBI (mTBI) and concussion. The lack of standardized definitions for these terms in both clinical and research settings leads to confusion, potentially causing delayed diagnosis and inconsistent patient management. Globally, TBI is a significant cause of morbidity and mortality, with mTBI accounting for a substantial portion, especially in sports-related injuries.

Furthermore, the article addresses the historical treatment of concussion as a homogeneous condition, emphasizing the need to classify subtypes for better clinical management and research outcomes. It discusses the challenges in diagnosis and the limitations of conventional treatment options for concussion, often relying on uniform recommendations of physical and cognitive rest.

Teasdale, G., Aubry, M., Bazarian, J. J., Bruns, J., Carney, N., Collins, M. W., Dabek, F. J., Ellis, M. J., Katz, D. I., & Langlois, J. A. (2018, November 24). *Mild traumatic brain injury and concussion: Terminology and classification*. Handbook of Clinical Neurology. 158:21-

24

https://www.sciencedirect.com/science/article/abs/pii/B9780444639547000033?via%3Dihub

In essence, the article discusses traumatic brain injury (TBI), particularly mild TBI (mTBI) and concussion. The lack of standardized definitions for these terms in both clinical and research settings leads to confusion, potentially causing delayed diagnosis and inconsistent patient management. Globally, TBI is a significant cause of morbidity and mortality, with mTBI accounting for a substantial portion, especially in sports-related injuries.

Furthermore, the article addresses the historical treatment of concussion as a homogeneous condition, emphasizing the need to classify subtypes for better clinical management and research outcomes. It discusses the challenges in diagnosis and the limitations of conventional treatment options for concussion, often relying on uniform recommendations of physical and cognitive rest.

Traumatic brain injury (TBI) is a significant global health concern, contributing to millions of deaths and hospitalizations annually. Mild TBI (mTBI) constitutes the majority of TBIs, accounting for 58–88%. The lack of a standardized definition for mTBI and concussion, often used interchangeably, poses diagnostic and treatment challenges. In the United States, there are approximately 1.4 million TBI-related emergency visits, hospitalizations, or deaths annually. However, many mild TBIs, especially sports-related ones, may go unreported. The interchangeable use of the terms mTBI and concussion has clinical and research implications, impacting diagnosis, treatment, and trial outcomes. Efforts have been made to refine definitions, classify subtypes, and better stratify patients for

individualized treatment and optimized clinical trials. The need for clear diagnostic criteria for mTBI and concussion persists, urging neurotrauma investigators to focus on delineating their clinical, radiographic, and laboratory features.