

Where White Coat Meets Black Belt: Recognition & Prevention of Head Injury in Combat Sports

Introduction

Combat sports such as boxing, wrestling and mixed martial arts are a popular pastime, well-known for key characteristics, most famously being their brutality. The very practice of combat sports carries inherent risks of bodily injury, of particular concern being injuries to the head which have consequences that range from mild and temporary to prolonged and disabling.^{1,2,3} Despite this, millions of people practice in combat sports daily in the United States alone.⁴ Healthy People 2030 highlights that current head injury prevention efforts in the U.S. are inadequate.⁵ Fortunately, there are ways to improve these metrics that combine the expertise of coaches, the education of clinicians and the passion of combat sport athletes to improve head injury incidence and outcomes.

Target Audience

The target audience of this paper is the current competitive fight team at the local martial arts gym Enso Brazilian Jiu Jitsu located in Portland, Oregon, where an array of combat sport disciplines are taught. This is a group of highly motivated combat athletes to which the research of this paper directly applies.

Background Information

The term combat sports encompasses a wide range of subtypes, including but not limited to: boxing, karate, muay thai, taekwondo, and mixed martial arts. At their essence, their practice involves two opponents facing off in hand-to-hand competition with few rules and only one goal in mind: to subdue or knock-out their opponent in order to gain victory.

Head trauma is a leading concern in combat sports due to their increased incidence and short- to long-term impacts on the brain. The most commonly attacked bodily regions are the head, neck and face, as opponents will attack these areas for a quick win with a definitive KO.⁶ A

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primary concern of injury to this region is the accumulation of strikes to the head resulting in traumatic brain injuries (TBI). Concussions, a commonly known consequence of head injury, are classified as a mild TBI.⁷ The mechanism behind concussions involves movement of the skull with or without direct contact to the head that inflicts acceleration/deceleration or rotational forces onto the brain.⁸ These forces can lead to a cascade of ionic shifts, metabolic changes, impaired neurotransmission and microscopic physical damage resulting in symptoms across multiple domains.⁸ These symptoms include, but are not limited to: confusion, disorientation, headache, nausea, dizziness, ataxia, vision problems, photo and auditory sensitivity, slower decision making, impaired concentration, memory problems, and emotional lability.¹ Therefore, the practice of combat sports increases the risk of concussions due to their very nature, the severity of which can range from mild to disabling.

A more serious condition with high morbidity and mortality known and feared by many combat athletes is chronic traumatic encephalopathy (CTE). CTE is a progressive, degenerative brain disease that is a consequence of repeated concussive and sub-concussive blows to the head.² This repeated damage can cause permanent microstructural changes in the brain resulting in symptoms that develop over a period of time that usually manifests ten to twenty years after an athlete retires. The course of the disease first can manifest as neuropsychiatric symptoms such as rage and mood swings, and then develop into Parkinsonism and Alzheimers-like syndromes.^{2,9} The effects of CTE are irreversible. There are medications that can help with symptom management, but the symptoms of the disease can be life altering.⁹

In addition to these conditions there is another rare, often fatal head-injury related consequence of combat sports, which is known as Second impact syndrome. This is a condition that occurs when an individual sustains a second head injury before fully recovering from an

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initial concussion.³ After a concussion is sustained, the initial neurometabolic changes typically take 7–10 days to resolve; a process that may be even more prolonged in younger athletes.³ If a second blow is sustained during this vulnerable period, it can lead to dysregulated cerebral blood flow, increased intracranial pressure (ICP), and subsequent brain herniation.³ Clinically, this condition is marked by a rapid progression from altered mental status to loss of consciousness within seconds to minutes, often resulting in death within 2–5 minutes.³ Although only 36 deaths have been reported since the 1980s, the severity of its consequences makes second impact syndrome a critical concern.³ Because symptom progression is often too rapid to reach medical attention reverse once it is recognized, prevention through proper diagnosis, rest, and strict return-to-play protocols remains the most effective approach.

In summary, combat sports pose a significant risk for head trauma with consequences ranging from mild and short-term concussions to chronic and disabling conditions like CTE, to immediately life-threatening conditions like second impact syndrome. Because the nature of combat sports predisposes an athlete to these injuries, it is of the utmost importance to recognize the scope of the problem, what the contributing factors are and make appropriate interventions that prioritize athlete safety and treatment efficacy.

The Importance of the Problem

Despite the risks, combat sports as a hobby have exploded in popularity. People from diverse backgrounds train regularly at varying levels of intensity—from casual enthusiasts to career professional fighters. In 2022, approximately 2.52 million people in the U.S. participated in combat sports for fitness purposes alone.⁴ The sport's reach among youth is equally significant: in the U.S. alone, an estimated 5.5 million adolescents and 3.2 million children under

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the age of 13 train in combat sports, rivaling participation rates seen in mainstream sports like football and baseball.¹¹

With combat sports growing more popular each year, educating athletes, coaches, and healthcare professionals on head injury prevention becomes more critical. A study by Virgilio et al. assessing the injury profiles of 20,789 competitive combat sport athletes found that many fighters experience chronic symptoms of head injury.¹² Alarming, signs such as dementia or amnesia were seen in 61.8% of boxers, and 52.29% showed abnormal findings on brain imaging tests.¹² According to Healthy People 2030, the overall rate of mortality from traumatic brain injury continues to rise in the United States.²² These trends highlight the need for evidence-based preventive measures protect the growing number of individuals drawn to combat sports.

Contributing Factors

Combat sports carry an inherent risk of head injury, but several modifiable factors significantly increase both the incidence and severity of TBI. These factors include insufficient concussion education among athletes and coaches, lack of medical oversight during training, high-risk sparring practices, and suboptimal weight-cutting strategies. By addressing these issues, it may be possible to reduce the risk of head injuries and improve the long-term health of athletes.

Compounding the dangers of concussion in combat sports is the lack of medical oversight during training, particularly sparring sessions, where concussions often go unreported and improperly managed. Although medical professionals are required at competitions, no such requirement exists for training.² This absence fosters a culture of “team doctoring,” in which non-medically trained athletes and coaches take on the responsibility of diagnosing injuries.¹ A study of 70 Muay Thai fighters and 35 coaches found that 79% of athletes self-diagnosed

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concussions, and 43.4% were diagnosed by a coach.¹² While often well-intentioned, this practice can lead to inaccurate diagnoses and increase the risk of further harm. A major contributor to this issue is the widespread lack of concussion education among fighters and coaches. In one survey, only 5.7% of coaches recognized concussions as traumatic brain injuries, and just 14.3% had pursued further education on the topic.¹² Another study revealed that 73.6% of boxers and 70% of trainers scored below 60% on concussion symptom recognition.¹³ These alarming statistics highlight the urgent need for formal concussion protocols and comprehensive education programs that empower coaches and athletes to recognize and manage head injuries safely.

Sparring is a primary source of injury in combat sports, with 63% to 82% of injuries occurring during training.¹⁴ While intended to simulate real competition in a controlled setting, sparring frequently results in repeated subconcussive impacts that can alter motor function and impair memory—even in the absence of a diagnosed concussion.¹⁰ These findings underscore the need for safer sparring practices to protect brain health and reduce long-term neurologic consequences. One contributing factor to sparring-related injuries is weight class and the importance of appropriate partner matching. A longitudinal study by Mańka-Malara et al. analyzing 2,488 MMA fights between 2000 and 2021 found that while lower weight classes had higher overall head punch totals, knockouts were significantly more frequent in heavier divisions—occurring in 54% of heavyweight versus 38% of light heavyweight bouts.¹¹ Over time, heavyweights experienced greater cognitive decline and decreased brain volume, likely due to the higher force of head impacts.¹¹ Conversely, although lightweight fighters exhibited less overall brain volume loss, they showed a higher degree of brain volume loss between fights, suggesting that external stressors such as extreme weight-cutting may disproportionately impact

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their brain health.¹¹ These findings emphasize the need for tailored recommendations to reduce head trauma and protect athletes across all divisions

Weight cutting, a widespread practice in combat sports used to gain a competitive edge by competing in a lower weight class, poses serious risks to brain health—particularly when achieved through acute dehydration. Functional MRI studies have shown that rapid fluid loss in the days leading up to competition can cause anatomical changes in the brain related to fluid loss, particularly in the cerebral spinal fluid which acts as a cushion to mechanical impacts. Reductions of this cushion potentially increases both the likelihood and severity of concussions.¹⁵ The study by Camarco & Neto et al. compared two MMA fighters of the same age and weight class undergoing different magnitudes of rapid weight loss between weigh-ins and competition. This study showed that the athlete that underwent a higher degree of rapid weight loss (9.1% of total bodyweight) experienced a decreased level of salivary NO— levels of which are associated with lower oxygen transport capacity and therefore athletic performance—and a poorer recovery of cognition and muscle strength on competition day.¹⁶ The athlete that underwent a lesser degree of weight loss (5.3%) had lessened deficits in all domains.¹⁶ Notably, these deficits were still present at 2% of body weight loss, albeit to a lesser degree.¹³ Therefore, in order to optimize performance and safety in competition, athletes should mitigate dehydration to as little as possible on competition day, not just for performance standards, but for safety of the fighter as well.

In summary, the risks of brain injury in combat sports are influenced by a range of modifiable factors, including insufficient education, risky sparring practices, and weight cutting. Addressing these factors through improved education, better concussion management practices,

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and changes to training and competition protocols can help reduce the incidence and severity of head injuries, ultimately protecting the long-term health of combat sports athletes.

Interventions

Combat sports inherently involve high physical risk, but the incidence and severity of head injuries can be significantly reduced through evidence-based interventions that leverage the existing coach-athlete dynamic. While the lack of medical oversight during training fosters a culture of "team doctoring" that often leads to misinformation, it also presents a valuable opportunity for collaboration between coaches and medical professionals. By combining a coach's expertise in training with a clinician's knowledge of injury prevention, new strategies can be developed that simultaneously enhance athletic performance and reduce the burden of head trauma. Improving concussion education, modifying sparring practices, and implementing safer weight-cutting protocols are key steps in optimizing athlete safety without compromising competitive advantage.

Such an approach includes formal education programs for coaches that emphasize recognition of signs and symptoms of head injuries and better utilization of sideline concussion assessment tools.¹⁷ Sideline assessment tools such as the Concussion Recognition Tool-6 is a sideline assessment tool that can be used by non-medically trained individuals to educate them on evaluation techniques, warning signs to pull an athlete from training/competition, and red flag symptoms that warrant urgent intervention.¹⁷ Research suggests that athletes who receive comprehensive education about concussion implications tend to engage in fewer sparring sessions per week and exhibit a higher likelihood of reporting concussive episodes.¹² Coaches can deliver this information in a way that emphasizes the link between concussions and poor

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performance in the ring which aligns with athletes' motivations and may ultimately result in increased concussion recognition and ultimately, recovery.

Alterations in sparring strategy can protect fighters from significant head injuries while still capitalizing on the gains from practice. Researchers from Johns Hopkins University alongside the Cleveland Clinic examined combat athletes brains after sparring and along with the transient brain changes associated with transient brain injury, there was a significant increase in size in the areas of the brain involved in movement, memory and learning.¹⁸ This is evidence reinforcing the whole purpose of sparring, which is to teach the body how to move reflexively in order to avoid a KO in the first place. While sparring possesses its own dangers, when implemented in an intelligent way can be more beneficial than harmful. An educated coach can provide proper supervision to the appropriate matching of fighters according to weight-class and skill level to minimize unnecessary neurotrauma during sparring. Additionally, limiting the frequency, duration, and intensity of sparring sessions would reduce the opportunities for head injury. Spacing out sparring days with rest days in between can provide ample recovery time if a sub-concussive head injury does occur. Coaches can also instruct fighters to "pull" their punches during sparring, allowing them to gain proprioceptive benefits from movement and evasion while minimizing the risk of injury.

More evidence-based recommendations include behavior modification in the ring, specifically when athletes are wearing headgear. While studies show that headgear can increase fighters' confidence due to the belief that it provides protection from concussions, this confidence may inadvertently lead to a decrease in defensive behavior and result in more significant strikes to the head.^{8,19} Coaches can optimize the protective benefits of headgear by encouraging fighters to adopt a mindset of "put it on and forget it," maintaining a strong focus on

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defense. Therefore, it is reasonable to require fighters to wear headgear during sparring to protect against facial injuries like lacerations and fractures, but coaches should always maintain emphasis on defensive strategies during sparring.

The current weight-cutting model incentivizes extreme dehydration, and gives an unfair advantage to athletes with bodily phenotypes that are better suited for rapid rehydration, which makes victories in this sport less exemplary of pure skill and athleticism, and more like gambling with the health and safety of the fighters on the line. Dehydration has a wide range of harmful effects: fighters who lose more than 5% of their body weight in under a week are three times more likely to experience fatigue, muscle weakness, and slowed reaction time during competition.²⁰ Muscle force output can drop by 4–6%, maximal strength by up to 11%, aerobic capacity by 20–30%, and reaction times may slow by 10–15%.²⁰ To protect athlete health and optimize performance, gradual weight loss of no more than 2% per week and proper hydration should be prioritized.²⁰ Evidence-based strategies to discourage rapid weight loss include expanding weight classes, moving weigh-ins closer to fight time, and setting individualized minimum fighting weights based on body composition and hydration. Additional measures include annual certification by neutral professionals and ongoing nutrition education.²¹ These interventions, supported by clinical data and the Association of Ringside Physicians, promote safer weight management without compromising competitive integrity.

Reducing head injuries in combat sports requires a multifaceted approach grounded in education, behavior change, and systemic reform. Equipping coaches with formal concussion training, promoting intelligent sparring strategies, and minimizing the physiological stress of rapid weight loss through policy and education all serve to protect athletes' brains while preserving their performance. When medical professionals and coaches collaborate, they create a

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safer training environment where fighters can thrive physically, cognitively, and competitively. By shifting the cultural norm from reactive to proactive care, the combat sports community can move toward a future where athlete longevity and neurological health are prioritized alongside success in the ring.

Conclusion

Injuries to the head are a common consequence of combat sports. In fact, most competitive combat sport athletes will be affected from head injuries in their careers, with symptoms that affect nearly every domain of mental processing and in turn, can negatively impact quality of life in many aspects. The popularity of combat sports is in the millions and growing every year, however according to Healthy People 2030, morbidity and mortality from head injuries is getting worse. Contributing factors include a gap in the understanding of head injuries from athletes and coaches, lack of medical provider representation during training, and opportunities for improvement in safety in training and weight cutting practices. These problems can be addressed by educating combat sports practitioners on the risks and dangers of TBIs, capitalizing on the natural top-down dissemination of information from coaches to athletes by empowering coaches with evidence-based knowledge, using the coaches existing knowledge of combat sports to create training strategies that use evidence based medicine, and promoting weight cutting strategies that optimizes athlete performance. While many athletes see head injuries as a necessary sacrifice to achieve greatness in their chosen combat discipline, with evidence based medicine these risks can be mitigated. With these changes implemented, combat athletes can fight smarter, fight longer, and when the final bell tolls, still possess the cognitive clarity to revel in their hard-earned glory—as well as the capacity to pass on their wisdom to the next generation.

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