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Analysis of cerebral concussion in combat sports

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Renan Floret Turini Claro[1], Ademir Testa Junior[2], Aline Russo Cassola[3], Amanda Alves Dutra[4], Gabriel Terin Fernandes[5], João Paulo Stocco Campos[6], Mariana Merighi Moreira Salles[7], Nathália Lima Araújo Nunes[8], Pedro Henrique Correa Peruzzo[9] and Viviane Lúcia Gomes[10]

ABSTRACT

Introduction: Through the action of external biomechanical forces that cause a change in brain acceleration within the braincase, there is the possibility of a change in mental state. This may be accompanied by a brief period of amnesia known as cerebral concussion. For a concussion to be characterized, it is not necessary for there to be loss of consciousness. In combat sports, this change occurs frequently and deserves attention to preserve the integrity of the athletes. Objective: To analyze the levels of cerebral concussion in combat athletes: kickboxing , muay thai , boxing and mixed martial arts (mma) after impact to the braincase. Material and methods : This research has a semi-qualitative approach characterized as a clinical trial and analyzed the levels of cerebral concussion using the SCAT3 behavioral study . Results: Moderate physical, cognitive and emotional symptoms were found in boxing, MMA and k1. Severe symptoms were also found in k1 athletes, not being predominant during sleep. And, the muay group thai showed statistical differences for physical and cognitive classifications, which suggest that cerebral concussion occurred. Glove specifications, the use of head protectors and the period in which the athlete is exposed to repeated blows to the head become determining factors in quantifying concussion levels in combat athletes. Conclusion: The changes found point to an important cerebral concussion in combat sports, especially in the physical and mental aspects of muay athletes Thai .

Keywords: Traumatic brain injury, Cerebral concussion and combat sport.

[1] E-mail: Renan_turini@hotmail.com
[2] E-mail: ademirtj@gmail.com
[3] E-mail: arcassola@gmail.com
[4] E-mail: amandadutrad@outlook.com
[5] E-mail: gabriel_terin@hotmail.com
[6] E-mail: joaostocco@icloud.com
[7] E-mail: marianamoreirasalles@gmail.com
[8] E-mail: nathalialanunes@gmail.com
[9] E-mail: peruzzopedrou@gmail.com
[10] E-mail: viveneluciagomes@hotmail.com

INTRODUCTION

Head injuries in fights involving knockouts are called cerebral concussions. In this situation, an alteration in mental state is found, accompanied by a brief period of amnesia due to external biomechanical forces that can be directly or indirectly transmitted to the brain. This can cause temporary or permanent impairment in cognitive, physical and psychosocial functions.

For a concussion to be characterized, it is not necessary for there to be a loss of consciousness, however in some situations there is a temporary loss of consciousness, as cerebral concussions can be mild, moderate or severe. Mild or moderate concussions are characterized by no loss of consciousness, in which the affected person experiences temporary confusion and, if symptoms such as headache, nausea and mental changes occur, they resolve in less than 15 days in a mild situation. or when characterized as moderate, it is remedied in more than 15 days. In severe classification, there is loss of consciousness for any period.

Those affected by concussion do not always develop post-concussion syndrome. However, when it extends to the days and weeks following the trauma, it presents a set of symptoms such as: disability, headache, dizziness, insomnia and difficulty concentrating. The incidence of headache and dizziness can be higher than 90% within a month. Furthermore, around 25% of those affected may experience headaches one year after the trauma. Furthermore, the number of people who experience memory problems can reach up to 59%, as symptoms can persist for months or up to 1 year (Pagura, Anginah , 2016).

Since cerebral concussion can also occur directly (after impact and/or blow to the head), the knockout becomes an essential factor for the final outcome to occur during the boxing event or practice.

Although there is proven research reporting cerebral concussion in boxers, studies of this nature in kickboxing *(* k1 *)* , *muay thai* and *mixed martial arts* (*mm*). Furthermore, understanding the changes found is important in developing new behaviors in the search for preserving the athlete's integrity.

The present study will analyze, using a *SCAT3 questionnaire* , the behavior of athletes after an impact on the cranial cavity or within seven days after the injury as an instrument for characterizing the sample, with the purpose of verifying whether there is a difference in the neurological outcome in situations of cranial impact. in boxing, *mixed martial arts* , *kickboxing* and *muay Thai* .

GOALS

Analyze cerebral concussion levels in combat athletes: k1, *muay thai* , boxing and mixed martial arts (*mma*) after impact to the braincase.

CEREBRAL CONCUSSION

Through the action of external biomechanical forces that occur directly through impact on the head or indirectly through the phenomenon of cerebral deceleration within the braincase, when transmitted to the brain there is the possibility of a change in the mental state, which can be accompanied by a brief period of amnesia being called cerebral concussion (PAGURA, ANGINAH, 2016).

Through impact on the cranial cavity, due to a direct blow to the head, neck, face or any part of the body, the posterior region of the brain separates from the cranial vault, which causes the rupture of vessels, leading to expansive injuries. This impulsive force transmitted to the brain generates a short-term impairment of neurological function, which resolves spontaneously and can evolve from minutes to hours (TATOR CH, 2013; MCCRORY et. al, 2015).

For a concussion to be characterized, it is not necessary for there to be a loss of consciousness, but it is possible in some situations to encounter a temporary loss of consciousness, as, as a result of a mild trauma to the head, brain cells can be damaged, causing a chemical imbalance in the brain, Furthermore, the rotational forces exerted on the region of the central nervous system, located between the midbrain and thalamus, cause a temporary interruption in the functioning of the reticular neurons, resulting in a brief fainting spell. Injuries closed by cerebral acceleration and deceleration forces trigger a disordered metabolic cascade or biochemical injury, such as glucose hypometabolism or adenine nucleotide disarray (TATOR CH, 2013).

The impairment in neurological function may be short-lived, with the possibility of resolving spontaneously and, in some cases, signs and symptoms may evolve from minutes to hours or be even longer lasting. 80 to 90% of concussions resolve within a short period of 7-10 days (MCCRORY et. al, 2013). Sometimes, acute clinical symptoms reflect a functional disturbance without structural damage, not being noticeable in neuroimaging studies (IANOF JN et. al, 2014).

A blow to the head that does not require immediate surgical treatment is not always simple and can become a hidden enemy (PAGURA, ANGINAH, 2016). In the presence of neuropathological changes, clinical signs and symptoms reflect a functional disorder rather than a structural lesion, thus there is no abnormality on standard structural neuroimaging (MCCRORY et. al, 2015).

Neuroimaging exams such as computed tomography and magnetic resonance imaging, when not performed using a diffusion technique, will not identify changes in cognitive functions or diagnose brain metabolic activity or visual signs such as headache, exaggerated drowsiness, loss of consciousness, dizziness, mental confusion or change in behavior. When not identified during a medical consultation, the involvement may take on a greater proportion. However, when following appropriate parameters and procedures such as: *PET tests Scan* (positron emission tomography) that superimposes anatomical images on metabolic images or resonance with tactography , the event can

become benign, directing decision-making regarding diagnosis and management (PAGURA, ANGHINAH, 2016; ABCMED, 2016).

Brain impact does not always trigger a concussion, and it is necessary to identify symptoms that indicate a change in the level of consciousness (PAGURA, ANGINAH, 2016). When the impact occurs, the determining factor in identifying the level of concussion are the symptoms and the time in which the condition is resolved. Therefore, it is classified as: mild, moderate or severe. Common symptoms include transient confusion, headaches, nausea and mental changes. In mild classification, such symptoms resolve in less than 15 minutes, when moderate, in more than 15 minutes and in severe concussion, in addition to the presence of the aforementioned clinical aspects, there is also loss of consciousness for any period (PAGURA, ANGINAH, 2016).

Such changes in consciousness can range from a small event such as disorientation or mental confusion to loss of consciousness for minutes. In the last one mentioned, a suspicion of concussion is noticeable through one or more visual signs that can be identified by the loss of consciousness or inability to respond, the confused look, the athlete lying motionless on the floor, being slow to get up, unstable standing, with imbalance or falls and lack of coordination. In addition, you may present signs and symptoms that suggest acute concussion, such as somatic symptoms, headache, cognitive symptoms (feeling like you are in a fog), emotional symptoms such as, for example, lability, as well as physical signs, which include loss of consciousness or amnesia, behavioral changes and cognitive deterioration demonstrating slower reaction times and sleep disturbance (PAGURA, ANGINAH, 2016).

In the presence of one or more components, concussion is suspected, requiring appropriate management and control. Structural concussion injuries cannot be detected using conventional neuroimaging tests. Acute concussion is a diagnosis based on clinical assessment that reflects functional disturbances through physical, cognitive symptoms, emotional and sleep disorders (HALL, CHAPMAN, 2005).

It is sometimes common for those affected by concussion to present post-concussion symptoms, such as: headaches, dizziness, insomnia and difficulty concentrating in the following days and weeks, and the incidence of headaches and dizziness can be high, lasting for months and/or or a year or more, in which the difficulty in concentrating, symptoms of anxiety and depression subsequently increase. The common signs and symptoms of a concussion are characterized into four categories: physical, cognitive, emotional and sleep (DOE, AB, 2015; PAGURA, ANGINAH, 2016). Furthermore, cognitive, vestibular and oculomotor impairments may occur (KONTOS et. al,. 2015).

Since many signs and symptoms associated with a concussion are vague, the most common disorders are outlined in the following table:

Table 1 - Common Signs and Symptoms of a Concussion

Physicists	Cognitive	Emotional	From sleep
Headache	Feeling mentally "foggy"	Irritability	Somnolence
Nausea	Feeling sluggish	Sadness	Sleeping less than normal
Vomiting	Difficulty concentrating	More emotional	Problems falling asleep
Balance problems	Difficulty remembering	Nervousness	
Dizziness	Forgetting recent information or dialogues		
Visual problems	Confusion about recent events		
Fatigue	Slow response to questions		
Light sensitivity	Repetition of questions		
Numbness/Tingling			
Stun or shock			

Source: Book - BURKE-DOE, A.; JOBST, EE Clinical cases in physiotherapy and neurological rehabilitation. Porto Alegre: AMGH, 2015.

An athlete diagnosed with a concussion may experience one or more symptoms. And, although symptoms resolve within 7 to 10 days, some individuals experience persistent changes that can last up to three months (DOE AB, 2015).

A recent study carried out on football athletes finds that after concussion there is the presence of post-traumatic migraines and cognitive impairments. However, this does not conclude whether the effects are persistent or whether there is a specific recovery time (KONTOS et. al, 2013).

According to McCrea et. al 2013, clinical concussion related to sports concussion occurs in days, with prolonged reports associated with acute indicators of more serious injuries being common.

The neuropsychiatric test is an important aid for the decision to return to sport, and the recovery stages after concussion for full return to daily activities must occur gradually, respecting rest and, after this, tasks for the brain gradually. Thus, the athlete will be able to return without restrictions and with medical clearance to be subjected to situations that could result in a new head trauma (MCCRORY et.al, 2012).

RELATIONSHIPS BETWEEN RULES AND ATHLETE'S VULNERABILITY IN THE MODALITIES INVESTIGATED

Boxing: According to rules 19 and 20 of the International Boxing Association (AIBA) respectively, it is mandatory to use a genital protector throughout the fight. Furthermore, it is mandatory to use a mouthguard, as it protects the dental arch and mouth against orofacial trauma, according to evidence, which can result in bone fractures and injuries to the neck and brain (CAVALCANTI et. al, 2012).

In addition, the glove specifications for elite men's competitions are also a rule: Ten (10) *Oz gloves* for the light fly (49 kg) to medium light (64 kg) category, and twelve (12) *Oz gloves* for the medium category medium (69 kg) to super heavy (more than 91 kg). Gloves were inserted into the

sport to prevent or postpone hand fractures and not to protect the practitioners' faces (ARNONI, DUARTE, 2014).

In boxing, a knockout is considered any blow or combination of blows that renders the boxer unable to continue fighting, therefore, if a participant goes to canvas and does not get up within a specific period of ten seconds he is considered knocked out and the opponent receives victory by *knockout* (*ko*) . National level fights consist of six 3-minute rounds, with title fights consisting of ten 3-minute rounds, with intervals between fights lasting 10 to 30 days.

AIBA is the entity that regulates Olympic boxing and its medical team decided, in October 2013, that elite category boxers would no longer use head protectors, stating that disuse would minimize the occurrence of concussions. However, the *British of Sports Medicine* evaluated the linear and angular acceleration force, finding a significant reduction of at least half compared to the absence of the protector. Through empirical knowledge through practice, the technical team and fighters state that the use of protective equipment only reduces facial injuries, while the use of protective equipment aggravates brain damage. However, there is no consensus within boxing regarding the use or removal of this protective equipment.

The referee is the boxer's first protection, taking care of the athlete's physical integrity during the fight and immediately opening the count when an athlete is hit and falls. Therefore, even if you are fit for the fight, the eight-second count is opened, and it is the referee's role to request medical intervention in the event of any injury.

Mixed martial arts (mma)- In *MMA* , according to the unified rules described by the National Confederation of *Mixed Martial Arts* (*CNMMA*) and the Brazilian Confederation of *Mixed Martial Arts* (*CBMMA*), the use of a mouth guard and genital protector approved by the confederation is mandatory. glove specifications approved and provided by the commission, which must weigh: 4 *OZ* (113 grams), not exceeding 6 *OZ* (170 grams), and some larger size gloves *2XL – 4XL* (*2XL – 4XL*) being permitted even that slightly exceed 6 ounces (170 grams).

MMA gloves are poorly padded, making fractures more frequent (MATOS A, 2017).

In all types of fights, weekly *sparing* is recommended at most twice a week, as training is much more intense than a fight. This occurs because the competition lasts about 15 minutes while training can last up to two hours a day on a daily basis (THOMAZINI et. al, 2008).

During competitions there is no count given after the fall, as the sport allows submission, and there is a combination of techniques from different martial arts disciplines, without limitation of grappling, finishing blows, kicks and effective attacks. Therefore, if a fighter is knocked down and loses consciousness or does not immediately defend himself, he is declared knocked out by *ko* or *technical knockout* (*tko*) , being called *ko* when the opponent is unconscious, and, *tko* when the referee stops the fight because the athlete no longer defends himself intelligently. Given this, since in

MMA *the* end of the fight is not just through the *ko* or *tko* , the main objective of this is not to generate concussion, however the period in which the athlete is exposed to blows can become is a determining factor for the event to happen.

Kickboxing (k1)- According to the Brazilian *Kickboxing Confederation* (*CBKB), the k1* modality is characterized by full contact combat and, in it, the application of all *full contact blows is permitted.* and *low kicks* , as well as knees and spinning punches. Therefore, blows to the head in the frontal and lateral areas are legal areas when using combat techniques. The following safety equipment is mandatory: Shin guards only in the "sock" style that cover the instep; Anklets; Helmet; Bandages for wrapping wrists; Genital protector; Mouth guard; Gloves 10 *OZ* .

When comparing boxing gloves with k1, it is possible to observe that in the first mentioned modality the gloves are thicker on the front, while in the second the gloves are more flexible (MATOS A, 2017).

The referee is responsible for the physical integrity of the athlete, also certifying that a *kickboxer* weakened person does not suffer unfair or unnecessary blows. After the athlete is hit by a direct blow that takes him to the canvas, the eight-second count begins. If the athlete does not show signs of returning to the fight during the count, the fight is ended by *tko* .

In *k1,* the greatest volume of combinations of blows is given by the upper limbs, due to the fact that the greater the forcefulness of the blow, the better scored the athlete who delivered the blow will be - a factor that will weigh on the worsening of symptoms due to the intensity when there is effective contact. .

Muay thai - The Brazilian Confederation of *Muay Thai* (*CBMT*) is one of the confederations that regulates the sport in Brazil, which originated in Thailand and is considered a national sport. The *muay Thai* is an art recognized as "the art of eight weapons", requiring physical and mental discipline, which includes standing combat strikes, characterized by the combined use of fists, elbows, knees, shins and feet, which makes it a fight effective and full contact.

The protective equipment used during combat is: Genital protector; mouth guard and gloves (depending on the category they can be: 6, 8, 10, 12, 14 or 16 *Oz*).

In the sport, the greatest force of blows is delivered through knees and elbows, it is important to highlight that there is no protective equipment for the place from which the blows will be delivered, thus resulting in an aggravating point for the athlete who receives such combinations of attacks. blows, as there is great force when such contact occurs. Therefore, it is the referee's responsibility to ensure the athlete's physical integrity.

CONTROL OF CEREBRAL CONCUSSION

Concussion control must exist from the beginning of the season, before training and competitions. Furthermore, it is essential to position the medical team through general checks of the athlete's health at the beginning of the season, the sports coach and the referee, prioritizing the athlete's physical and mental integrity. Recently, the medical committee of the *Federation Internationale de Football Association* (*FIFA)* proposed a new protocol for concussion management, under the chairmanship of Dr Michel *D' Hooghe* , who highlighted an education program for staff doctors, coaches, referees, officials and players, which must be carried out.

The immediate conduct of whether or not an athlete should be removed from the match in the event of a concussion can be based on the current tool of the IV World Consensus on Concussion in Sport, which is *SCAT3* . This is a standardized assessment of signs and symptoms of the condition and, when correctly applied, provides preventive information regarding the athlete's current clinical status, history of injuries, as well as cognitive aspects of orientation, immediate and delayed memory, concentration, coordination and balance. . The individual's ability to respond to stimuli will also be consistent with the level of consciousness and can be measured through scales and scores, based on motor and verbal responses and eye opening to external stimuli. In the presence of post-concussion symptoms, a neurologist should perform baseline assessments of pre-season neuroimaging, *Pet- CT* and MRI scans (PAGURA, ANGINAH, 2016).

In boxing, for returning after a knockout, there are specific rules for time off, which may vary in *ko* or *tko situations* between: 30 days, without loss of consciousness; 90 days, with loss of consciousness lasting less than 1 minute; 180 days, with unconsciousness lasting more than 1 minute; reaching up to 12 months for a third attack without loss of consciousness, and 18 months for a third attack with loss of consciousness (PAGURA, ANGINAH, 2016).

MMA modalities , *k1* and *muay Thai,* no actions were found in the literature that control concussion through damage.

SPORTS CONCUSSION ASSESSMENT TOOL – SCAT3

Document developed for use by doctors, therapists, certified athletic trainers, healthcare professionals, trainers and others involved in caring for injured athletes, whether at the recreational, elite or professional level (MCCRORY et.al,2013).

SCAT3 questionnaire is a clinical examination protocol that lists 22 possible symptoms of concussion, with only the presence of one symptom being sufficient for diagnosis. SCAT3 *is* the third edition of the sports concussion tool which replaces *SCAT* and *SCAT2* published in 2005 and 2009, being a useful diagnostic aid for practitioners, which is composed of a combination of clinical tests

including balance tests, which can be as accurate as a computerized neuropsychological screening tool (TATOR, CH, 2013).

The symptom assessment summary includes:

- ✓ Assessment of symptoms (clinical status);
- ✓ History of previous injuries;
- ✓ Cognitive aspects of orientation, immediate and delayed memory and concentration;
- ✓ Balance exam;
- ✓ Coordination exam;
- ✓ Education on the topic.

All of these points provide a standardized assessment of signs and symptoms, and for the score summary to be complete, it is necessary to complete all the sections above, which are divided into several steps. They are: Symptom scale; Immediate memory (concentration of digits backwards, months in reverse order and delayed recall); Balance examination (two-legged position, single-legged position and tandem posture); Upper limb coordination exam. However, due to limited time for data collection in fight events (10 minutes after the fight), only the symptom assessment stage (ANNEX I) was used to carry out the study, making it necessary for there to be complete completion of all sections of the assessment a study with collections 7-10 days post impact. With this information and post-trauma application, baseline testing with *SCAT3* is useful for interpreting post-injury exam results.

In October 2016, in Berlin, at the international sports concussion conference, a new concussion control tool, *SCAT5* , was validated, which is composed of the following sections: Recognize; To remove; Reevaluate; Rest: Rehabilitate; Refer; To recover; return to sport; Reconsider; residual effects and sequelae; Risk reduction (MCCRORY et. al, 2016).

METHODOLOGY

The present study was registered with the Research Ethics Committee under CAAE: 67239517.4.0000.5427. The research had a qualitative approach, being characterized as a cross-sectional clinical trial to evaluate the levels of cerebral concussion in combat athletes. Participants had access to the free consent form and those who agreed to participate voluntarily were informed of the ethical standards for research with human beings, as guaranteed by the National Research Ethics Commission (CONEP) of the National Health Council, of the Ministry of Health, did not receive financial incentives. Participation took place with the application of the *Scat3 questionnaire* ten minutes after the end of the fight in athletes who suffered an impact on the cranial cavity in boxing, *mixed martial art (MMA), K1 and muay Thai* . A control group consisting of pedestrian runners was also included. The reports were recorded for later analysis and this was guaranteed by an

authorization signature. The data collected was guaranteed confidentiality in accordance with ethical precepts of the research. Carrying out the application of the behavioral study via SCORE has authorization from the organizers of combat events and *runners* .

For the application and collection of data, there are standards for scoring the questionnaire, and the results considered normal often depend on the individual's age and education. To this end, the following inclusion criteria were used: Practitioners of the aforementioned modalities with minimum experience of 2 years; have at least primary education; Have not suffered any previous head trauma; Do not constantly use medication.

The exclusion criteria were: Having severe cognitive disability; have a diagnosis that confirms any neurological alteration.

Repeated blows to the head can, in the long term, develop chronic degenerative disease, and the analytical nature of the research will help to understand the changes found, being an important process in the development of new behaviors in order to preserve the integrity of the athlete.

The sample analyzed through a behavioral study via *score* , using the *SCAT3 questionnaire,* shows the levels of cerebral concussion after the cerebral impact. The test will be administered verbally 10 minutes after the impact or within seven days after the impact. The population will be made up of 3 (three) athletes practicing *mixed martial arts arts - mma* , 3 (three) boxing athletes and 3 (three) street running athletes *(runners)* at the end of the race. The study aims to compare the occurrence of concussions in the four modalities mentioned above in which there is an impact on the head and in a fifth modality in which there is no impact (athletics/street running), with the aim of highlighting early symptoms and possible evolution of trauma. .

Through the data collected, the results were evaluated by calculating the average of symptoms by athletes and modalities.

For data analysis, values that presented a normal distribution (*Kolmogorov -Smirnov Test*) were analyzed, allowing the use of mean and standard deviation calculations for the variables (Physical, Cognitive, Emotional and Sleep). The *Student t test was* used to compare the group itself. All statistical analyzes were performed using the *SigmaStat* 3.5 program, adopting a significance level of $p<0.05$.

Therefore, the research consists of searches in public and private digital libraries, books, magazines, and also a field study, characterized as a clinical trial to obtain the results.

RESULTS

The collection results were separated by the respective groups: Control, boxing, *mma , k1* and *muay thai* , for which a table was arranged for each sample group, according to the 22 questions that

make up the *SCAT3 questionnaire* , analyzed individually in response from each athlete, and further identified through the categories: Physical, cognitive, emotional and of sleep.

CONTROL GROUPS - *RUNNERS*

Athlete 1- Female; practicing athlete between 3 and 5 years; first place in the general category; presented moderate symptoms of pressure in the head, sensation of slowing down and fatigue, totaling a score of 7.

Athlete 2- Male; athlete for more than 5 years; presented moderate fatigue and emotional symptoms, totaling a score of 4.

Athlete 3- Male; practicing athlete between 3 and 5 years; presented moderate fatigue and emotional symptoms, totaling a score of 7.

Athlete 4- Female; practicing athlete between 3 and 5 years; did not present any symptom score.

Athlete 5- Male; athlete practicing for more than 5 years; presented moderate symptoms of feeling slowed down and fatigue, totaling a score of 4.

Athlete 6- Male; practicing athlete between 2 and 3 years; did not present any symptom score.

Table 2- Control group- *runners*

Symptoms	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5	Athlete 6
Physicists	3 ├2	2	3	0	2	0
Cognitive	2	0	0	0	2	0
Emotional	0	2	4	0	0	0
From sleep	0	0	0	0	0	0
Total score	**7**	**4**	**7**	**0**	**4**	**0**

Symptom classification: 0-1 (none) and 2-4 (moderate). Where ├: interval between different symptoms of the same symptom class.

Boxing Athletes

Confrontations consisting of 3 rounds of 2 minutes each and a 1-minute break. The athletes used protective equipment: mouth guard, helmet and 10 *oz gloves* .

Athlete 1- Female; practicing athlete between 2 and 3 years; category 61 kg; fight #4; using a helmet; combat duration of 3 *rounds* of 2 minutes each; red corner; although the athlete is the champion of the confrontation, she received repeated blows to the head; presented moderate symptoms of pressure in the head, slowing down and fatigue and severe symptoms related to the emotional aspect, totaling a score of 11.

Athlete 2- Female; practicing athlete between 2 and 3 years; category 61 kg; fight #4; using a helmet; combat duration of 3 rounds of 2 minutes each; blue corner; in the 2nd round she suffered a

knockdown ; presented moderate symptoms of fatigue and severe symptoms related to the emotional aspect, totaling a score of 6.

Table 3- Boxing athletes

Symptoms	Athlete 1	Athlete 2
Physicists	3	0
Cognitive	2	2
Emotional	6	4
From sleep	0	0
Total score	**11**	**6**

Symptom classification: from 0 to 1 (none), from 2 to 4 (moderate) and from 5 to 6 (severe).

Arts Athletes

The clashes consisted of 3 rounds of 3 minutes and a 1-minute break. The athletes used the following protective equipment: 06 Oz gloves, mouth and genital protectors.

Athlete1- Male; athlete for more than 5 years; mma modality ; category 90 kg; suffered *knockout* at 2'55 of the 1st round; presented severe symptoms of headache, emotional pain and irritability, totaling a score of 18.

Athlete 2- Male; athlete for more than 5 years; mma modality ; category 120 kg; suffered *technical knockout* at 3'15 of the 2nd round; through visual perception he presented severe emotional symptoms, however the athlete reported not presenting any classification of symptoms in the questionnaire.

Table 4- *MMA athletes*

Symptoms	Athlete 1	Athlete 2	Athlete 3
Physicists	6	0	0
Cognitive	0	0	3
Emotional	6 ├6	0	6
From sleep	0	0	0
Total score	**12**	**0**	**9**

Symptom classification: 0-1 (none), 2-4 (moderate) and 5-6 (severe). Where ├: interval between different symptoms of the same symptom class.

Kickboxing athletes

Confrontations consisted of 3 *rounds* of 3 minutes each, with a 1-minute break. All athletes used the following safety equipment: 10 oz gloves, helmet, genital protector and mouth guard.

Athlete 1- Male, practicing the sport for 2 to 3 years, has completed high school, won the confrontation, and, during effective confrontations involving punches and knees, although he won the fight, the athlete presented physical and emotional symptoms at moderate levels , totaling a score of 8.

Athlete 2- Male, practicing the sport for 3 to 5 years, completed high school, was the winning athlete of the fight, received blunt blows to the braincase and presented severe physical symptoms, totaling a score of 12.

Athlete 3- Male, practicing the sport for 2 to 3 years, has completed high school, won the match, had effective clashes during the match, presented moderate physical symptoms, totaling a score of 9.

Athlete 4- Male, practicing the sport for 2 to 3 years, has completed high school, received blunt blows to the head, was declared the loser and presented moderate to severe physical symptoms, and moderate emotional symptoms, totaling a score of 26.

Athlete 5- Male, practicing the sport for 3 to 5 years, has completed primary education, as a result of fighting for *no contest* (there being no winner of the fight), it was a confrontation composed of blunt blows to the body and head, the athlete presented moderate and severe physical symptoms, totaling a score of 9.

Athlete 6- Male, practicing the sport for 3 to 5 years, has completed high school, suffered four *knockdowns during the fight ,* two in the first *round* , one in the second and one in the third, the confrontation was for the judges' decision, in the in which the athlete was declared a loser and presented moderate to severe physical, moderate cognitive and severe emotional symptoms, totaling a score of 27.

Table 5- K1 athletes

Symptoms	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5	Athlete 6
Physicists	4	6 ├6	3 ├2 ├1 ├2	6 ├3 ├4 ├3 ├6	3 ├6	3 ├3 ├2 ├4
Cognitive	0	0	1	0	0	4
Emotional	4	0	0	4	0	5
From sleep	0	0	0	0	0	6
Total score	**8**	**12**	**9**	**26**	**9**	**27**

Symptom classification: 0-1 (none), 2-4 (moderate) and 5-6 (severe). Where ├: interval between different symptoms of the same symptom class. The presence of physical symptoms is frequent at moderate to severe levels.

Muay Thai athletes

Fights consisting of 5 *rounds* of 2 minutes each and a 1-minute break. Athletes used the following protective equipment for categories up to 69 kg: Shin pads, genital protector, mouth guard and 6 *oz gloves* .

And for categories above 70 kg, fights consisting of 5 rounds of 3 minutes each and a 1.5 minute break, the protective equipment used were: genital protector, mouth guard and 08 *Oz gloves* .

Athlete 1- Male, practicing the sport for 20 years, has completed high school, received and was affected by blunt knees and elbows to the body and head, was the winner of the confrontation

and had moderate physical symptoms and moderate to severe symptoms of the cognitive, totaling a score of 23.

Athlete 2- Male, practicing the sport for 5 years, has completed high school, received and applied blunt blows to the body and head, was the winner by decision of the judges, presented moderate physical and sleep symptoms and also severe emotional symptoms, totaling a score 13.

Athlete 3- Male, practicing the sport for 3 to 5 years, has completed high school, applied blunt blows and, although he was the winner, was also affected by blows to the brain and body, presenting moderate cognitive symptoms and severe physical symptoms and emotional, totaling a score of 17.

Athlete 4- Female, practicing the sport for 3 to 5 years, has higher education, lost the fight by decision of the judges, in which she received blunt blows from the knee and elbow to the body and head, presented moderate to severe physical, cognitive and emotional, totaling a score of 26.

Athlete 5- Female, practicing the sport for 3 to 5 years, has higher education, won the fight by the judges' decision, in which she received knee and elbow blows to the body and head, presented moderate physical symptoms, totaling a score of 4.

Athlete 6- Male, practicing the sport for 3 to 5 years, has higher education, in a balanced fight, received effective blows to the body and head, becoming the winner of the fight by the judges' decision, presented moderate to severe physical and moderate emotional symptoms, totaling a score of 13.

Athlete 7- Male, practicing the sport for 3 to 5 years, has high school education, was the loser of the match by decision of the judges in a balanced fight, received blunt blows to the body and head, presented severe cognitive symptoms, totaling a score of 12.

Athlete 8- Male, practicing the sport for 3 to 5 years, has high school education, suffered *a KO* in the 1st *round* , presented severe emotional symptoms, totaling a score of 12.

Athlete 9- Male, practicing the sport for more than 5 years, has completed high school, was the winner of the fight in the first round, in which he had an effective exchange of blows, presented moderate to severe physical symptoms, severe symptom related to sleep , moderate to severe emotional symptoms and also severe cognitive symptoms, totaling a score of 28.

Table 6 - Muay athletes thai

Symptoms	Athlete1	Athlete2	Athlete3	Athlete4	Athlete5	Athlete6	Athlete7	Athlete8	Athlete9
Physicists	4 ├3 ├3	2 ├3	6	3 ├2 ├5	4	1 ├2 ├6	0	0	2 ├2 ├5
Cognitive	5 ├4 ├3 ├1	0	3 ├2	5 ├2 ├2	0	2 ├2	6 ├6	0	5
Emotional	0	6	6	5 ├2	0	0	0	6 ├6	6 ├6 ├2
From sleep	0	two	0	0	0	0	0	0	0
Total score	**23**	**13**	**17**	**26**	**4**	**13**	**12**	**12**	**28**

Symptom classification: 0-1 (none), 2-4 (moderate) and 5-6 (severe). Where ├: interval between different symptoms of the same symptom class. The presence of physical and cognitive symptoms is frequent at moderate to severe levels.

Muay Thai Modality

Figure 1. Physical analysis: *Runner's* : control group performed the 6 km run ; *Muay Thai* : group that carried out fighting as a modality; data expressed as mean ± standard deviation; statistical analysis, *Student 's t-test* , significance value, p <0.05.
* p = 0.048

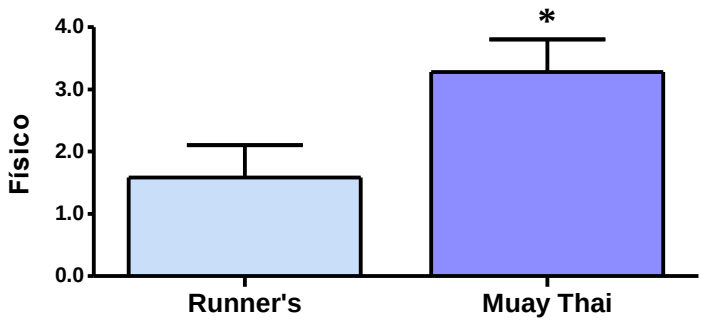


Figure 2. Cognitive Analysis: *Runner's* : control group performed the 6 km run ; *Muay Thai* : group that carried out fighting as a modality; data expressed as mean ± standard deviation; statistical analysis, *Student 's t-test* , significance value, p <0.05.
* p = 0.044

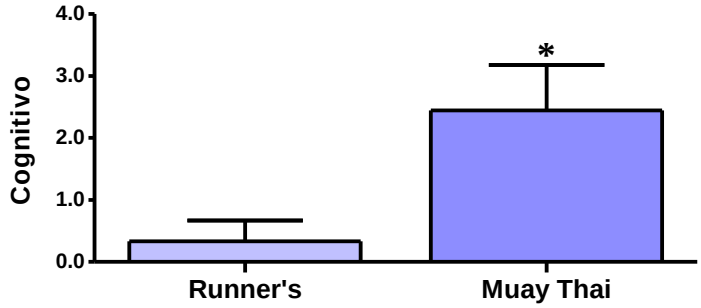


Figure 3 . Emotional Analysis: *Runner's* : control group ran 6 km as a modality; *Muay Thai* : group that carried out fighting as a modality; data expressed as mean ± standard deviation; statistical analysis, *Student 's t-test* , significance value, p <0.05. Not significant
NS: p = 0.184.

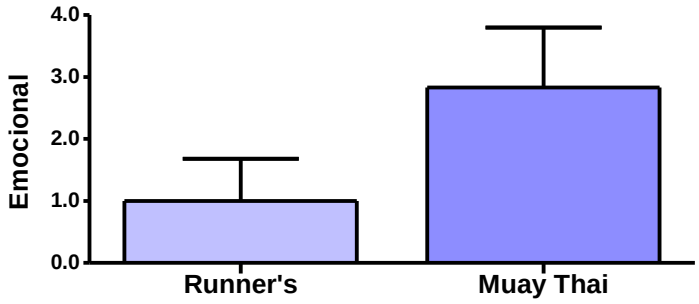
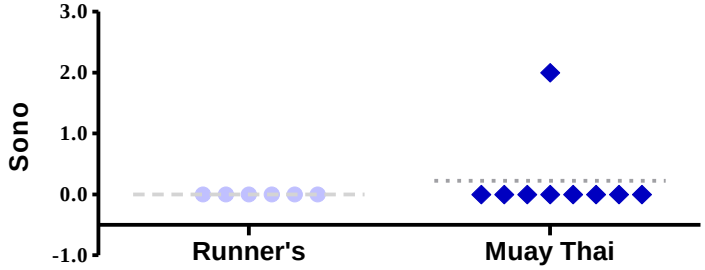


Figure 4. Sleep Analysis: *Runner's* : control group performed the 6 km run ; *Muay Thai* : group that carried out fighting as a modality; data expressed as mean ± standard deviation; statistical analysis, *Student 's t-test* , significance value, p <0.05. p = 0.435



INDIVIDUAL SYMPTOM AVERAGES

Some athletes presented more than one symptom within the variables, making it necessary to quantify the symptoms and calculate the athletes' individual averages for each variable category (physical, cognitive, emotional and sleep).

To analyze sample data, the measure of central tendency was used: Mean. To obtain the arithmetic mean, simply add up all the values of all the data and divide by the total number of data. Since the mean in statistics refers to the equilibrium point of a given concentration of data in a distribution, all values are added together and divided by the number of added values.

In arithmetic, the mean for ungrouped data is represented by: $X=\frac{\sum x}{x}$, where $\sum_x$ = sum of all values of $_x$. Therefore, the average will indicate the center of gravity of a set of data (CALLEGARI, SIDIA; 2009).

In this way, the presence of individual symptoms per scale for each athlete, which represent levels: None, moderate or severe, was simplified based on the individual average through the variable categories, represented in the following table.

TABLE 7 – Individual Means of the Modalities Investigated

1- *RUNNERS*	TO 1	A2	A3	A4	A5	A6			
PHYSICIST	2.5	2	3	0	2	0			
COGNITIVE	0	0	0	0	2	0			
EMOTIONAL	0	2	4	0	0	0			
SLEEP	0	0	0	0	0	0			
2- BOXING	TO 1	A2							
PHYSICIST	3	0							
COGNITIVE	2	2							
EMOTIONAL	6	4							
SLEEP	0	0							
3- *MMA*	TO 1	A2	A3						
PHYSICIST	6	0	0						
COGNITIVE	0	0	3						
EMOTIONAL	6	0	6						
SLEEP	0	0	0						
4- *KICKBOXING*	TO 1	A2	A3	A4	A5	A6			
PHYSICIST	4	6	4.5	4	4.5	3			
COGNITIVE	0	0	1	0	0	4			
EMOTIONAL	4	0	0	4	0	5			
SLEEP	0	0	0	0	0	6			
5- *MUAY THAI*	TO 1	A2	A3	A4	A5	A6	A7	A8	A9
PHYSICIST	3.5	2.5	6	3.5	4	3	0	0	3
COGNITIVE	3.5	0	2.5	3	0	2	6	0	5
EMOTIONAL	0	6	6	2.5	0	0	0	6	5
SLEEP	0	2	0	0	0	0	0	0	0

0-1	NONE
2-4	MODERATE
5-6	SEVERE

DISCUSSION

According to the data analyzed, it is possible to observe the following changes in the boxing modality **:**

- ✓ Physical and cognitive symptoms: Moderate levels;
- ✓ Emotional: From moderate to severe.

MMA modality :

- ✓ Physical and emotional: Severe levels;
- ✓ Cognitive: Moderate.

MMA modality does not have the main objective of generating concussion, as it is a modality in which it allows submission, therefore the data collected has the influence of this factor on the collection results (CNMMA, 2017). Due to the small sample size, it is not possible to say that in this modality there will be the presence of symptoms at such levels.

In *k1* it is possible to observe the following frequencies of symptoms:

- ✓ Physical: From moderate to severe;

- ✓ Cognitive: Moderate;
- ✓ Emotional: From moderate to severe;
- ✓ From sleep: Isolated case at a severe level.

The presence of physical and cognitive symptoms in the *k1 modality* is very common, since the forcefulness of the blows applied has great efficiency, not disregarding the greater flexibility of the gloves that cover a larger impact area (MATOS A, 2017).

muay mode *thai* , as it had a larger sample size, it was possible to carry out statistical analysis, comparing the modality with the control population, in which the following results are evident:

- ✓ Physical: Moderate to severe symptoms, with statistical difference.
- ✓ Cognitive: moderate to severe symptoms, which has a statistical difference.
- ✓ Emotional: From moderate to severe, however when comparing with the control population there is no statistical significance.
- ✓ Sleep: Just an isolated situation at a moderate level, without statistical significance.

In a combat situation, the cerebral impact called *knockout* (ko) or the period in which the athlete is exposed to blows, becomes a determining factor in the occurrence of cerebral concussion, given that, in combat sports, the objective is often is to generate attack on the opponent (ANGHINAH, PAGURA, 2016).

The use of a head protector (helmet) was evaluated by the *British of Sports Medicine,* analyzing the linear and angular acceleration force, and found a reduction of at least half compared to the absence of the protector in boxing. According to Tator , wearing a helmet prevents catastrophic injuries such as brain lacerations and intracranial hematomas, however it does not prevent all brain trauma as it does not inhibit the brain's rotational acceleration. Regarding the use of protective equipment, an important concept of risk compensation is also highlighted, in which the insertion causes a change in behavior, bringing greater safety to the athlete, adopting more violent techniques, thus increasing the rate of injuries. . It is still empirically known by technical teams and fighters that the helmet only reduces facial injuries, in which the use of it worsens brain damage, by increasing the impact area, and there is no consensus between its use or removal.

The helmet inhibits the visibility of cuts and injuries, and, as cerebral concussion is an “internal” condition not seen by the naked eye, it ends up becoming a hidden enemy, because if there are cuts, bruises and apparent injuries, the athlete is immediately treated by a doctor or referred for further examinations and, if there is no evidence, the patient is released and continues a normal life. An injury that is not visible does not generate concerns with protocols that prioritize the integrity of the athlete, and can thus lead to a hidden enemy, and when the perception of signs and symptoms of concussion appears, it is only after a long period of practice (ANGHINAH, PAGURA , 2016).

In contact fighting sports, due to the repetitive impact, the action can lead to future neurological consequences and thus the accumulation of microlesions , with high levels of fatigue, low energy, mental confusion and high mood disturbances, unlike musculoskeletal injuries. (KONTOS et. al, 2015). To this end, it is already understood and guided by boxing confederations that, during weekly training sessions, sparing using gloves is carried out a maximum of twice. THOMAZINI et. al. emphasize that sparing is the most vivid part of living with pain and experienced several times before the fight itself every week.

It is extremely important to analyze the size of gloves: In *MMA ,* glove sizes are from 4 to 6 OZ; In Boxing and K1 it is 10 to 12 OZ and in *Muay Thai,* depending on the weight, it can vary from 6 to 16 OZ. Therefore, the smaller the size of the glove, the greater the intensity of the blow.

It is important to evaluate changes related to mood and more pervasive affective symptoms, as when ignored or improperly managed, they can lead to chronic symptoms, with the possibility of even suicidal intentions (KONTOS et. al, 2015). During the collection, many athletes (mainly *muay thai*) said they did not present signs or symptoms at the moment, however, athletes with more than three years of practice reported sometimes presenting physical and cognitive signs in their daily lives characterized as acute symptoms “NOT NOW, BUT I NORMALLY FEEL IT”.

Second impact syndrome is due to inadequate diagnoses, in which athletes do not respect the time off and return to competitions before fully recovering, leaving themselves exposed to a new injury (PAGURA, ANGHINAH, 2016).

The global consensus to prioritize athlete integrity also aims to transfer knowledge, so that the ability to treat or reduce the effects of concussive injury after the event is minimal, with education and detection for athletes, referees, coaches and the general public a pillar for progress in concussion control (MCCRORY et. al, 2016).

In the types of fights analyzed, there is the presence of physical symptoms basically due to the fact that the athlete seeks to improve results in combat, the emotional aspects are accentuated when the athlete is exposed to blows for a longer time and is affected by *ko* or *tko* . Cognitive predominance is represented in higher classifications in the *muay modality thai* , the characteristics of the size of the gloves as well as the use of elbows and knees that deliver blunt blows which do not have protective equipment designate the efficiency of the impact, determining the presence of symptoms in the cognitive category. Sleep symptoms appear in isolated situations and do not present significant percentages.

Due to the absence of official events in some of the modalities investigated, as well as the low rate of fight closures not being defined by *ko* , the numbers of participants as samples are small so that advanced statistical calculations can be carried out, with statistical application being used only in the modality where it has the largest population (*muay Thai*).

Currently, athletes are stronger, and have greater tactical rather than technical concentration, increasing the intensity of the blows and, on the other hand, resisting subsequent blows for a longer period, and the stronger the impact, the greater the risk. concussion, not disregarding the mechanism of acceleration and deceleration of the brain inside the skull (ANGINAH, PAGURA; 2016).

Therefore, during combat, as a rule of numerous confederations, the referee is the athlete's first protection, striving for physical integrity during the fight. And so that the other current protections (technical and medical team) efficiently manage the influencing mechanisms, preventing the effects of cerebral concussion, in the long term, from causing the evolution of symptoms, reaching chronic effects.

CONCLUSION

The present study aimed to analyze the levels of cerebral concussion in combat athletes: boxing , *mma* , *k1* and *muay thai* after the impact on the braincase (there was no fall or moment of concussion in the control group).

Through the sample average, moderate physical, cognitive and severe emotional symptoms were found in the boxing modality, while in *MMA,* physical and cognitive symptoms were at moderate to severe levels and a severe presence of emotional levels, however, the sample in both modalities did not It was enough to state that in every practitioner there will be the presence of such symptoms after the cerebral impact. For *k1* , physical, cognitive and emotional symptoms of moderate and severe levels are evident in the sample, not being predominant in sleep. And, the *muay group thai* in which statistical analysis was applied *Student* 's *t-test* significance of $p<0.05$, showed statistical differences for physical and cognitive classifications in the modality, which suggests that cerebral concussion occurred.

In analysis of the frequent presence of symptoms in the physical classification in the *muay sport thai* , is explained by the momentary presence due to the fatigue installed as a result of physical effort in combat, whereas the statistical difference and presence of cognitive symptoms in the long term can become an aggravating factor, which is already verified verbally during data collection.

However, understanding the changes found is important in the development of new behaviors to preserve the physical and mental integrity of the athlete, making it necessary to carry out further studies in the area, as well as raising awareness among the population involved in combat modalities, so that concussion control is applied before, during and after each season, in order to prevent chronic effects such as: neurological and psychosocial damage.

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ANNEX 1- DATA COLLECTION FORM

Inclusive data

Evaluated athlete:

Modality:

( ) Boxing; ( )MMA; ( ) K1; ( ) *Muay Thai ;* ( ) Street race;

Education level:

( ) Complete elementary school; ( ) Complete Medium; ( ) Graduated;

Practice time:

( ) From 2 to 3 years; ( ) From 3 to 5 years; ( ) More than 5 years;

Do you use medications:

( ) Yes; ( ) No;

Previously suffered head trauma:

( ) Yes; ( ) No;

Annex 1- *Scat3*

***SCAT 3* QUIZ – BOXING**			
Scat3- Boxe Sport Concussion Assessment tool			
		SCORE	
SYMPTOMS	**None 0 ├ 1**	**Moderate 2 ├ 4**	**Severe 5 ├ 6**
Headache			
Pressure in the head			
Neck ache			
Nausea or vomiting			
Dizziness			
Blurred vision			
Balance problem and dizziness			
Light sensitivity			
Noise sensitivity			
Feeling of slowing down			
Feel like in a fog			
Do not feel good			
Difficulty concentrating			
Difficulty remembering (memory)			
Fatigue/lack of energy			
Confused			
Somnolence			
Problems falling asleep			
More emotional			
Irritability			
Sadness			
Nervous or anxious			
QUESTIONNAIRE COMPLETED VERBALLY BY THE ATHLETE VIA SCORE ON A SCALE OF 0 ├ 6			