
Last decade of research in depression and concussion among athletes: a systematic review

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Abstract

The present study aimed to consolidate the knowledge developed in the last decade regarding the relationship between affect and concussion in sports through a systematic review. A search in PubMed retrieved 3129 articles that dropped to 9 after exclusion criteria. Among this total, 4 (44%) of those studies were correlational, whereas 5 (56%) were quasi-experimental. Almost half, 4 (44%) had a sample of American football players which suggested low heterogeneity of types of sport. Those findings highlight the necessity of further research using other sport types samples beyond American football. Results also showed an association between depression and concussion followed by linear relations with anxiety, which reveals link between concussion and affect impairment in general. This study warns to the need for quantitative research in diverse kinds of sports, standardized measures and experimental designs that allow to infer causality between concussions, depression and other mood impairments.

KEYWORDS: concussion, depression, neuropsychology, sport, cognition.

Última década de pesquisa em depressão e concussão entre atletas: uma revisão sistemática

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Resumo

O presente estudo objetivou consolidar o conhecimento desenvolvido na última década sobre a relação entre afeto e concussões no esporte através de uma revisão sistemática. Buscas foram feitas na base *PubMed* e extraíram 3129 estudos que, após passarem pelos critérios adotados, caíram para 9. Desse total, 4 (44%) eram correlacionais, enquanto 5 (56%) eram quase-experimentais. Quase metade desses trabalhos, 4 (44%), estudaram atletas de futebol americano o que mostrou baixa heterogeneidade de modalidades representadas. Esses achados evidenciam a necessidade de estudos em esportes de contato que vão além do futebol americano. Os resultados sugerem relação entre depressão e concussão acompanhados por associação com ansiedade, mostrando que concussões estão vinculadas a prejuízos afetivos em geral. Esse estudo alerta para a necessidade de pesquisas quantitativas com diferentes modalidades esportivas, instrumentos padronizados e desenhos experimentais que permitam inferência de causalidade das concussões com a depressão e outros prejuízos no humor.

Palavras-chave: concussão, depressão, neuropsicologia, esportes, cognição.

Última década de investigación en depresión y concusión entre atletas: una revisión sistemática

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Resumen

El presente estudio tuvo como objetivo consolidar el conocimiento desarrollado en la última década sobre la relación entre afecto y concusión en el deporte a través de una revisión sistemática. Las investigaciones se realizaron en la base *PubMed* y extrajeron 3129 estudios que, después de pasar por los criterios adoptados, cayeron a 9. De ese total, 4 (44%) eran correlacionales, mientras que 5 (56%) eran casi-experimentales. Casi la mitad de estos trabajos, 4 (44%), estudiaron atletas de fútbol americano lo que mostró baja heterogeneidad de modalidades representadas. Estos hallazgos evidencian la necesidad de estudios en deportes de contacto que van más allá del fútbol americano. Los resultados sugieren relación entre la depresión y la concusión acompañados de asociación con ansiedad, mostrando que las concusiones están vinculadas a perjuicios afectivos en general. Este estudio alerta sobre la necesidad de investigaciones cuantitativas con diferentes modalidades deportivas, instrumentos estandarizados y dibujos experimentales que permitan inferencia de causalidad de las conmociones con la depresión y otros daños en el humor.

Palabras-clave: concusión, depresión, neuropsicología, deportes, cognición.

Introduction

Concussion has been aim of several studies among sports sciences and sport scientists around the world (Crocetta, Dominski, & Andrade, 2015). Throughout many years, the cerebral concussion (CC), a type of minor or mild head injury or trauma, was undervalued by western medicine, even though some neurologists and researchers highlight that major brain traumas would be able to be recovered, whereas minor and mild brain injuries could lead to death (Pollard, Guilford, Ankenbauer-Perkins, & Hedderley 2006).

Neuropsychology is a field of Science that integrates neuroscience and psychology. It studies the many impacts of brain traumas in human emotion and cognition (Sohlberg & Mateer, 2017). The effects of those head injuries are several, however, what values the most to neuropsychology are the psychological disturbances and impairments developed during or after injury. Accordingly, Strauss e Savitsky (1934) were the first researchers to hypothesize that minor head injuries could lead to severe neuropsychiatric impairments, and, nowadays, it is possible that those brain traumas could lead to death (Dessy, Rasouli, & Choudhri, 2015).

Since 1995, head traumas overall were depicted in a different perspective. Epidemiological studies revealed that 15% of permanent brain lesions are caused by blunts to the head regardless of the severity of the head injury itself. Considering that approximately 70% of all cranioencephalic trauma (CET) are minor or mild, then, about 10% of CC reach severe brain lesions (Silver et al., 1999). Those same epidemiological data reveal that the number of CET are three times bigger than schizophrenia, bipolar disorder and panic disorder altogether. It seems to be a pivotal issue not solely among athletes, but it seems to be a matter of public health (Silver et al., 1999).

At the beginning of this millennia, Omalu et al. (2003) raised the concern of the scientific community toward CC risk among football (i.e., American football or *gridiron*) with possible neuropsychiatric impairment after retirement. Those mental-health problems would be caused by a high number of mild and minor CC that would lead to several unperceived CET throughout an athletes' career. Then, when retired, natural neurodegeneration of the central nervous system would make those individuals more vulnerable to those psychiatric conditions (Omalu et al., 2003).

Types of sports that require higher levels of physical contact and kinesthetic energy tend to reveal higher indexes of CC (Bay, Hagerty, & Williams, 2007; Covassin, Shcatz, & Swanik, 2007; Covassin et al., 2006, 2010, 2012). Also, women seem to be more susceptible to CC due to less muscle mass in the neck region to absorb impact (Covassin et al., 2006). Although there is enough evidence of the impacts of CC that leads to CET, sport neuropsychology only started looking to this phenomenon the last two decades (Dias, Ávila, Rocha, Pinto, & Ribeiro, 2014). American Football is the sport with highest CC ratings among men: there is a risk of 75% of an athlete to have at least one CC throughout his career; whereas football (soccer) shows the highest risk of CC (50%) among women (Dias et al., 2014). Epidemiological studies state that at least one among those CC athletes will eventually develop ECT with permanent brain lesions (Pryor, Larson, & DeBeliso, 2016).

Among athletes with CET, depression is the most common psychological disorder. Prevalence of depression among athletes with CET is approximately 6% in mild cases and it reaches 77% in severe situations of cranioencephalic trauma (Guskiewicz et al., 2005, 2007; Pryor et al., 2016; Ropper & Zafonte, 2015). Recently, CET has been identified as a risk factor for chronic depression (Ropper & Zafonte, 2015). It is also associated with early stages of neurodegenerative disorders such as mild cognitive impairment (MCI), Alzheimer's and Parkinson's diseases (Pryor et al., 2016). Although depression diagnosis is not usual among Alzheimer's disease patients, depressed humor tends to increase throughout severity of neurodegeneration (Ropper & Zafonte, 2015).

Based on the above depicted evidence, a sport neuropsychologist must be aware of the need of good and careful psychological assessment, prevention program training, treatment and rehabilitation of CC, CET and possible brain lesions among athletes. The role of this professional inside technical staff reveals itself pivotal to the health of athletes (Hansen et al., 2000; Teixeira et al., 2014). Scientific literature has been raising its concern toward CC that leads to CET (Omalu et al. 2005; Pryor et al., 2016; Ropper & Zafonte, 2015). The awareness among sports health professionals lead to the development of policies to prevent CET, despite of the difficulty to stop CC in physical contact sports. The American Neurological Association established norms and guidelines to prevention, treatment and rehabilitation of concussed athletes (Giza et al., 2013).

Recently, another disorder related to CC and CET was found to be guilty of permanent brain lesions and even death of athletes: the Second Impact Syndrome (SIS). It happens when a sportsperson comes from unrecovered CC, called primary lesion, and days or weeks later gets another CC due to a second impact (Giza et al., 2013; Goldberg & Robbins, 2016). Accordingly, those who have SIS has three times more chance to develop chronic depression compared to those who fully recovered from the first CC (Dessy et al., 2015; Giza, Prins, & Hovda, 2017).

Despite of being a subject extensively studied in the last 15 years, the relationship between CC, CET, SIS and depression are still yet to be established (Ropper & Zafonte, 2015). In fact, there are no systematic reviews looking specifically to depression and those head injury related problems. The largest majority of studies in this field comes from case studies and small samples (Pryor et al., 2016). The present systematic review aims to provide a clearer rationale on CC, CET, SIS and psychological problems to improve understanding on their relationship for sport scientists and practitioners.

Method

A systematic search was conducted in Pubmed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tezlaff, & Altran, 2009; Urrútia, & Bonfil, 2010) method. Only articles within the inclusion criteria were assessed. Keywords were: "concussion", "second impact syndrome", "sports", "athletes" and "cranioencephalic trauma"; combined according to criteria: "sports" OR "athletes" + "concussion" OR "second impact syndrome" OR "cranioencephalic trauma".

Exclusion and inclusion criteria

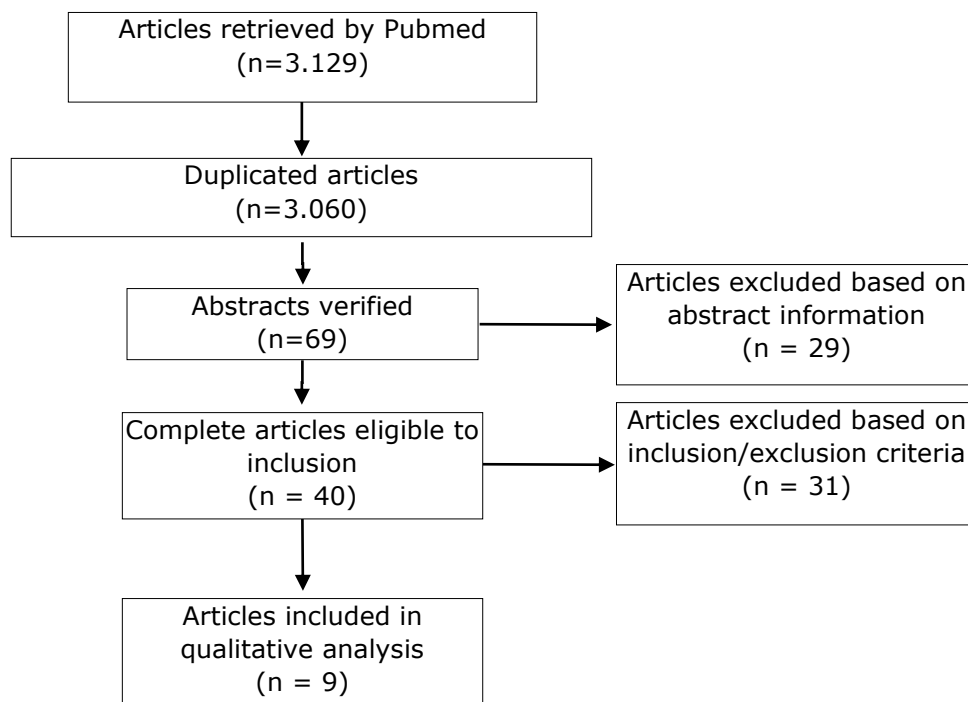
The exclusion criteria adopted were: case studies, literature reviews, patents, articles published without blind and peer review, editorials, monographs, dissertations and thesis were excluded, thus, any material with no peer revision process. Also, books, chapters, complete texts and abstracts on proceedings, symposium or congress annals were excluded due to lack of information regarding peer review. Finally, any other material that did not went through blind and peer review published in indexed journals were excluded to assure the best quality of the material used in this review.

Inclusion criteria were: empirical studies with exploratory or experimental designs, considering depression as the main or one of the main variables to be analyzed. Participants had to be sportspersons at any level (amateur, college or professional) with at least one group of the sample with CC history diagnosed by any instrument, such as Impact, SCAT or the American Neurological Association criteria (Giza et al., 2013). Only articles published in the last decade was considered: from July/2007 to July/2017. All types of empirical and quantitative studies were included: experimental, quasi-experimental, correlational and exploratory as long as it presents inferential statistics. Finally, only articles using standardized measures were included.

Results

The systematic search retrieved 3.129 publications eligible for this review. Figure 1 depicts the flowchart of PRISMA (Moher, Liberati, Tezlaff, & Altran, 2009) from the first search to the last step of inclusion/exclusion. After exclusion of duplicates, 69 articles were left. Based on title and abstracts, only 40 articles remained.

Figure 1. Flowchart of articles retrieved in the systematic search



Those 40 articles were analyzed in its full extension. Based on inclusion and exclusion criteria, the following articles were removed from the review: 4 literature reviews, 13 case studies, 3 editorial, 1 full-text in congress annals, 10 studies with non-standardized measures. In the end, 9 articles were suitable for this review. Sample characteristics, study’s design and main results of those works are presented in table 1.

Regarding date of publication, 1 articles was published in 2007 and all other were published between 2012 and 2016. Among all, 4 articles (44%) used correlational design, whereas 5 (56%) were quasi-experimental (with a no-CC control group). From the ethics point of view, an experimental design would be impossible, due to the need of provoking a CC in a person. The total sample was $n = 6129$, with $N = 4026$ (66%) in correlational studies and $N = 2103$ (34%) in quasi-experimental studies.

Regarding assessment measures, there was a high heterogeneity. For example, 3 studies used the Beck Depression Inventory II (BDI-II) to assess depression, 1 study used the Center for Epidemiologic Studies Depression Scale Revised (CESD-R), 2 studies used the Measurement Model for Functional Assessment of Health and Well-Being (MMFAHW), 1 study used the standardized scale from the Michigan University for humor disorders, 1 study used the standardized criteria of image classification of the International Affective Picture System (IAPS) and 1 study used the depressive humor scale of the Computerized Neuropsychological System-Visual System (CNS-VS) online test.

Table 1 – Number of the article, author in alphabetic order, year of the study, sample size and characteristics, study’s design and main results

Article number	Author (in alphabetic order)	Year	Sample size and characteristics	Study’s Design	Main results
1	Covassin et al.	2012	College athletes of unspecified sports $N = 1616$	Quasi-experimental	Athletes with CC history showed significant differences when compared to athletes without CC history in: depression, memory, migraine, anxiety, stress, motor processing speed and reaction time.
2	Guskiewicz et al.	2007	Retired American/ <i>gridiron</i> Football athletes $N = 2552$	Correlational (cohort)	Association of CC history and CET diagnosis with depression, poorer well-being and health indexes.
3	Helmich et al.	2016	College athletes of unspecified sports $N = 19$	Quasi-experimental	Athletes with recent CC (less than a week), recovered CC and no CC history showed significant differences in balance tasks, depression and affective disorders symptoms and frontal-cortex activity.
4	Hume et al.	2017	Retired amateur and professional rugby players and retired athletes from non-contact sports $N = 366$	Quasi-experimental	Former rugby players showed no significant difference regarding mood symptoms when compared to non-contact athletes. Although differences were found in cognitive flexibility, memory, attention and executive functioning.

5	Kerr et al.	2012	Retired American/ <i>gridiron</i> Football athletes N = 1044	Correlational (cohort)	Epidemiological research revealing prevalence of 10.2% of depression among athletes with CC history. At least 25.8% of athletes reported one CC throughout career.
6	Kontos et al.	2012	High School and College athletes of unspecified sports N = 75	Quasi-experimental	Longitudinal data was collected in athletes with diagnosed CC: 2 days, 7 days and 14 days after the concussion happened. Results showed that depression, stress and anxiety symptoms, attention and working memory measures worsened throughout time.
7	Kontos et al.	2016	Youth league (12-to 18-years old) hockey players N = 404	Correlational	CC history increased with age. Also depression and anxiety symptoms increased, whereas executive functions worsened when age was used as covariation to number of CC.
8	Pryor et al.	2016	Amateur and Elite American/ <i>gridiron</i> Football athletes N = 27	Quasi-experimental	Participants with diagnose depression (experimental group) revealed significantly higher number of CC throughout career when compared to those without depression diagnosis (control group).
9	Strain et al.	2013	Retired American/ <i>gridiron</i> Football athletes N = 26	Correlational	Diffusion tensor imaging revealed pre-frontal cortex atrophy among athletes with CC history. Frontal functioning: working memory, executive functions, attention and memory, as well as depression were also associated with number of CC.

The standardized measure most used to assess CC throughout career was the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT). This measure is extensively used in the literature and it seems to be the most important instrument so far (Guskiewicz et al., 2005, 2007).

Results revealed that athletes with CC history presents higher levels of depression, emotional symptoms overall and impairment in neurocognitive variables, specially: working memory, executive functions, attention and memory. Table 2 depicts significant results toward the relationship of CC and impairments on other neuropsychological variables. Studies also showed positive correlation between number of CC throughout career and levels of depression, which suggests that severity of CET and depression are related. However, there is no information regarding SIS that could mean even larger association between CC and depression.

Table 2 – Studies numbered according to table 1, categorized by study’s design, sample size, type of sport and neuropsychological variable associated to CC or CET

Study’s design	Sample Size	Type of Sport	Neuropsychological variable associated to CC or CET							
			Mem.	Atte.	Dep.	Anx.	Str.	Executive Functions		
								Cog.Fl.	W.M.	Global
Correlational (N = 4)	N = 4026	American football			2,5,9	5				
		Hockey			7	7				7
Quasi-experimental (N = 5)	N = 2103	American Football			8					
		Rugby	4	4					4	4
		Unspecified sports	1	1, 6	1, 3,6	1, 3	1, 6	1	6	1, 3

Note: neuropsychological variables are abbreviated as such: Mem. = Memory; Atte. = Attention; Dep. = Depression; Anx. = Anxiety; Str. = Stress; Cog.Fl. = Cognitive Flexibility; W.M. = Working Memory; CC = cerebral concussion; CET = cranioencephalic trauma.

Regarding types of sports, American or *gridiron* football represented the largest number of studies (N = 4; 44%) followed by athletes with CC history in unspecified sport types (N = 3; 33%). The other two studies were conducted among hockey and rugby athletes. The only study that did not find any relation between CC history and depression had a sample with rugby players, although other impairments in memory, attention, working memory and overall executive functioning were found. It means that 8 in 9 articles (89%) found levels of depression associated with CC or CET. Other impaired psychological dimensions were: executive functions (5 de 9; 56%), anxiety (4 de 9; 44%), and attention (3 de 9; 33%).

Discussion

Main results of the present systematic review shows that CC indeed associates strongly with depression, more than other mood symptoms such as anxiety and stress, and other neurocognitive impairments such as executive functioning, attention and memory (Guskiewicz et al., 2005, 2007; Pryor et al., 2016). It happens in almost every study of the last decade. Despite of those findings, there was no difference between depression during first concussion recovery (Giza et al., 2013; Pryor et al., 2016) or only after years of repetitive CC and during retirement (Guskiewicz et al., 2005, 2007; Omalu, 2005). Based on those results it is possible to suggest that a good index to allow athletes to go back to practice of his/her sport is level of depression (Giza et al., 2013).

The most represented type of sport among the samples is American or *gridiron* football (Guskiewicz et al., 2005, 2007; Omalu, 2005; Pryor et al., 2016), followed by rugby and hockey. Those evidence suggest two things: (a) studies in football/soccer and other contact sports tend to be based on case studies rather than larger samples (Dias et al., 2014), and (b) because the large number of direct blunt and impacts to the head in American football is clear to athletes and people to see, it raises more concern than other sports, although it is not clear whether the risks are lower in rugby or hockey, for example, thus other sports lack behind in evidence and need more large scale research.

Among human scientists, quasi-experimental and correlational designs with large samples are more revealing and reliable; which allows the

development of intervention policies and standardized systems of measurement (Crocetta et al., 2015). Because of that, other types of sport need their own systems of measurement, prevention, recovery and rehabilitation policies in order to protect their athletes (Giza et al., 2013), giving extra care to risks of SIS that are quite common among boxing and kickboxing fighters (Dessy et al., 2015; Giza et al., 2017).

Another important finding of the present research was to identify anxiety symptoms as the second mood disorder more common to concussed athletes (Bay et al., 2007). In fact, 4 of the 8 studies (50%) that pointed to depression associated to CC and CET found that also anxiety was increased among those sportspersons. This data is important to all sport psychologists, practitioners and health professionals because depression and anxiety are disorders that can lead an athlete to problems in all aspects of his/her life: mental health, performance and well-being (Sohlberg & Mateer, 2017). Although it was not the aim of the present study, it was also clear that frontal functioning is also impaired in athletes with CC history, showing impairments in: working memory, attention, memory, cognitive flexibility and executive functions (Crocetta et al., 2015; Covassin et al., 2012; Guskiewicz et al., 2007).

The risk of depression among athletes with CC and CET should be considered a health problem. Studies actually pointed out that head injuries can lead to hormonal dysregulation, which can cause depression and other mood disorders, such as anxiety (Bay et al., 2015). Accordingly, American football, football/soccer, hockey and rugby players, boxing, kickboxing and other Fighters should be followed by trained sport neuropsychologists, because SIS can lead to death (Dessy et al., 2015; Giza et al., 2017), as well as mood disorders are able to lead to suicidal ideation and attempts (Bay et al., 2015).

Lastly, regarding methods of retrieved research, the sample was large with 6129 participants. All studies were correlational or quasi-experimental, which raises the reliability of results. The adopted method assured that previously revised evidence that severity of CC and levels of depression are linearly associated was confirmed (Crocetta et al., 2015; Covassin et al., 2012; Guskiewicz et al., 2007). In extension, among the 5 articles with quasi-experimental design, only 1 (20%) with rugby players showed no significant difference in levels of depression when athletes with (experimental group) and without CC (control group) were compared (Covassin et al., 2012; Pryor et al., 2016). The quasi-experimental design does not provide certainty regarding causality, however it is a strong indicator whenever experimental designs are not possible (Teixeira et al., 2014). On the other hand, the relationship between CC, CET and depression is clear, even though it is not possible to assume causality. Omalu et al. (2005) already raised the hypothesis that CET leads to hormonal changes in molecular levels that causes cognitive and affective disorders. Although it is not possible to confirm this hypothesis with the present study, the evidence is strong in this direction.

Conclusion

Sport Sciences are looking to concussion and its consequences with deeper interest in the last decades. Accordingly, findings and results of

several studies raise the necessity of qualified, trained sport neuropsychologists to follow closely athletes with risk of concussion, although it is not a reality in countries such as Brazil (Crocetta et al., 2015).

The present study points out the need for those practitioners to be part of the daily routine of athletes in order to prevent, treat and rehabilitate CC to avoid CET or SIS.

The quality of design and the large sample in the studies retrieved by this systematic search is a strong point that confirms the reliability of results. On the other hand, the lack of heterogeneity in types of sports only reveal that American/*gridiron* football is the only sport really capable of developing standardized procedures to CC and CET prevention, whereas other types of sports should be further explored in future studies.

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