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Psychology of Health

The Impact of Concussion on Processing Speed and Attention in Athletes: A Systematic Review

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Abstract: The present study investigated if concussions would be associated with decreases in cognitive performance, especially attention and processing speed. A systematic review of the literature was conducted in the PubMed, PsycInfo and ScienceDirect databases. The aim of this review is to ascertain the quality of the evidence in parallel with seeking a convergent answer to the guiding research question. The results showed that attention and processing speed are compromised at least one week after the concussion occurs. However, two problems were indicated by the judges: the heterogeneity of the instruments used in the studies, and the bias of the results, given that most of them did not use blind data collection or blind compilation of the results of the evaluations. Although solid evidence was found, further meta-analyses will be needed to increase homogeneity and validity, and ensure the size of the effect of concussion on the cognitive functions of athletes.

Keywords: brain concussion, attention, processing speed, review, sports

O Impacto da Concussão Cerebral na Velocidade de Processamento e Atenção de Atletas: Uma Revisão Sistemática

Resumo: O presente trabalho estudou se as concussões estariam associadas a quedas de desempenho cognitivo, em especial atenção e velocidade de processamento. Uma revisão sistemática da literatura foi conduzida nas bases PubMed, PsycInfo e ScienceDirect. O objetivo desta revisão é verificar a qualidade das evidências em paralelo a buscar uma resposta convergente a essa pergunta de pesquisa norteadora. Os resultados mostraram que a atenção e a velocidade de processamento ficam comprometidas em pelo menos uma semana após a concussão ocorrer. No entanto, dois problemas foram citados pelos juízes, a heterogeneidade dos instrumentos utilizados nos estudos e o enviesamento dos resultados, dado que a maioria não utilizou o método de coleta cega de dados ou compilação cega dos resultados das avaliações. O presente estudo encontrou sólidas evidências, e para aumentar a homogeneidade e a validade serão necessárias novas meta-análises para garantir o tamanho do efeito da concussão sobre as funções cognitivas de desportistas.

Palavras-chave: concussão encefálica, atenção, velocidade de processamento, revisão, esportes

El Impacto de la Conmoción Cerebral en la Velocidad de Procesamiento y Atención de los Atletas: Una Revisión Sistemática

Resumen: El presente estudio estudió si las conmociones cerebrales se asociarían con disminuciones en el rendimiento cognitivo, especialmente en la atención y la velocidad de procesamiento. Se realizó una revisión sistemática de la literatura en las bases de datos PubMed, PsycInfo y ScienceDirect. El objetivo de esta revisión es determinar la calidad de la evidencia, a la vez que se busca una respuesta convergente a la pregunta de investigación. Los resultados mostraron que la atención y la velocidad de procesamiento se ven comprometidas al menos una semana después de que ocurra la conmoción cerebral. Sin embargo, los jueces indicaron dos problemas: la heterogeneidad de los instrumentos utilizados en los estudios y el sesgo de los resultados, dado que la mayoría de ellos no utilizaron el método de recolección de datos a ciegas ni la compilación ciega de los resultados de las evaluaciones. Si bien se encontró evidencia sólida, se necesitarán más metaanálisis para aumentar la homogeneidad y la validez, y asegurar la magnitud del efecto de la conmoción cerebral en las funciones cognitivas de los atletas.

Palabras clave: conmoción encefálica, atención, velocidad de procesamiento, revisión, deportes

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Concussion is the name given to the consequences of a blow or sudden shaking of the head that causes the brain to impact the cranial wall (Barcelos et al., 2023; Melo et al., 2017). These shocks generate microlesions with immunological repercussions on the central nervous system, especially on glial cells. The inflammatory process can cause everything from swelling of microglia to strangulation of axons by oligodendrocytes in more severe cases, temporarily or permanently interrupting the electrical transmission of information through the membrane action potential process (Omalu et al., 2006).

In sports, concussion can have mild, moderate, and severe consequences in athletes of all ages across various sports (Rezaei et al., 2024). Some of the necessary requirements for the athlete's successful return to training and future competitions include making the correct diagnosis and following the appropriate treatment protocol. The complete treatment must be followed to prevent future injuries such as second-impact syndrome (SIS) and neurodegenerative diseases, other psychological disorders, and executive functions such as attention and processing speed (Rezaei et al., 2024).

Athletes face an imminent risk of concussion every day during training and competition. Martial arts, American football, rugby, soccer, boxing, and water polo are among the most prominent modalities (Melo et al., 2017). As these sports involve physical contact to interrupt the opponent's movement and some of this contact occurs directly to the head, concussions can occur if adequate protection is not used. In combat sports, protection is rarely recommended and when it is, many athletes refuse it, often unaware of the full extent of the risk they are taking (Moosa et al., 2024).

Although concussions (some with a history of fatalities) have been exposed in sports media cases in competitions over the past five years, they are still overlooked or ignored by athletes (Bessusko & Borges, 2022). According to Allan et al. (2024), this phenomenon occurs due to pressure from sponsors and fans for results in sports. Although many athletes need to stop for recovery after an injury, they often do not because the team, confederation, or athletes themselves would face financial losses, as each competition generates monetary returns (Allan et al., 2024).

The sequence of recurrent shocks can lead to SIS, which is caused by consecutive concussions in athletes who have already suffered other brain microinjuries (Bauer, 2021). A medical team that monitors athletes during training and competitions is present in most teams and sports, and a concussion protocol is commonly used to ensure appropriate management of mild and severe cases (Moosa et al., 2024). Observation within the first 24 hours is crucial to assess if the athlete will experience symptoms such as dizziness, headache, tinnitus, vomiting, and others, and to properly assess if they can return to training or need a longer break.

However, there is evidence that delayed symptoms after the first 24 hours of concussion may also be relevant in identifying the risk of SIS (Melo et al., 2017). With new knowledge and updates on new research on the topic, the entire coaching staff must be prepared to identify symptoms of depression, anxiety, and other psychological and cognitive disorders that may emerge over time, as already highlighted in studies on the relationship between concussion and depression (Barcelos et al., 2023; Melo et al., 2017). Psychological and neuropsychological support is essential for monitoring athletes who have already suffered a concussion in order to assess possible psychological declines and effectively guide treatment to preserve their physical and psychological health (Bauer, 2021).

Executive functions are among the potential cognitive disorders caused by concussions. They are extremely important for humans and represent a set of skills that allow for the correction, maintenance and execution of an action plan. Although there is still no consensus on which executive functions are the most affected in concussion situations, existing evidence shows particular impact on working memory and inhibitory control (Barcelos et al., 2023).

The supervisory attention system is one of the executive skills that also appears to be affected post-concussion. It is highly relevant in all sports; without it, the degree of difficulty of a sporting action can become much greater than it actually is. With a deficit in attention or any other impairment, athletes can experience significant setbacks during training and competitions as a result of a series of details that are missed due to a lack of attention (Bauer, 2021).

Attention can be defined as an individual's ability to select and focus their mental processes on some aspect of the internal environment, such as ideas stored in memory or the external environment, responding predominantly to meaningful stimuli and inhibiting distractors (Silva, 2021). Lack of focus, impatience, difficulty concentrating, and subsequent errors in technical execution are some of the main difficulties experienced by athletes due to a lack of attention. These are important details that can compromise performance when it comes to improving and competing. Some technological and manual programs can help with mental training of this skill and consequently aid in practice (Rogowska & Tataruch, 2024).

Processing speed is a cognitive ability that can be defined as the time taken by a person to perform a mental task. It relates to the speed with which a person captures and reacts to received information, whether visual (letters and numbers), auditory (language), or motor (movement). In other words, processing speed is the time it takes between receiving a stimulus and responding to it (Fernandes, 2024).

It is also essential and mediated so that the athlete can receive the information and process it before executing. Poor execution can result in a significant loss in response or reaction time (Fernandes, 2024). In sports with high response demands, such as swimming, shooting, running, and others, this speed is essential to ensure the athlete's starting time is not altered. Even a lost millisecond can significantly impact the rest of the competition, potentially leading to elimination in the first qualifying round (Conde, 2020).

In general, late-onset concussion symptoms (those appearing after 24 hours of injury) are diffuse and diverse. They may be related to mood, especially depressed mood

(Melo et al., 2017), and cognition, particularly executive functions (Barcelos et al., 2023). The supervisory attentional system is fundamental for executive functioning, and the central role of attention and processing speed in sports performance is clear (Allan et al., 2024).

However, there is still no consensus on the impact of concussion on these cognitive constructs that underpin other human cognitive processes. Seeking to improve and consolidate what is already known about the relationship between concussion, attention, and processing speed, this article developed its systematic review based on the following research question: what is the impact of concussion on athletes' attention and processing speed? The objective of this review is to assess the quality of the evidence while simultaneously seeking a convergent answer to this guiding research question.

Method

A search for articles was conducted in the Pubmed, ScienceDirect, and PsycoInfo databases. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Moher et al., 2009; Urrútia & Bonfill, 2010) was adopted to develop the procedures. Articles that met the inclusion criteria were evaluated. The descriptors used in the review process were selected based on the research theme. The following descriptors in English were considered in the searches: (1) – "concussion," (2) – "speed processing," (3) – "attention," (4) – "athletes," (5) – "sport." The combination of terms and Boolean operators was performed as follows: (1) AND (2) OR # (3) AND (4) OR #5.

The inclusion criteria were developed considering deficits in attention and processing speed as predominant variables among athletes (control groups) who had suffered a concussion, chronic traumatic encephalopathy, or SIS, properly diagnosed according to the methods established by the American Academy of Neurology (AAN) (Giza et al., 2013). Articles had to feature athletes of any level, as reported by the authors themselves; they could be professional or amateur. Experimental and quasi-experimental (with a control group), correlational, and exploratory studies were included, provided they presented quantitative data and inferential statistical analyses. Only studies with standardized measures and tests for all investigated variables were included: concussion, attention, processing speed, and other neuropsychological variables.

In accordance with the objectives of this article, the exclusion criteria were: literature review articles, patents, articles that did not undergo double-blind peer review, and editorials. Studies presented in chapters, books, full texts, and abstracts in conference proceedings, symposia, or scientific proceedings were also excluded because they did not undergo double-blind peer review. Finally, theses, dissertations, monographs, and undergraduate thesis papers were excluded, as they did not undergo the same screening process. We took care to include only evidence that had undergone peer review and had been published in specialized scientific journals to ensure the quality of the methods and results.

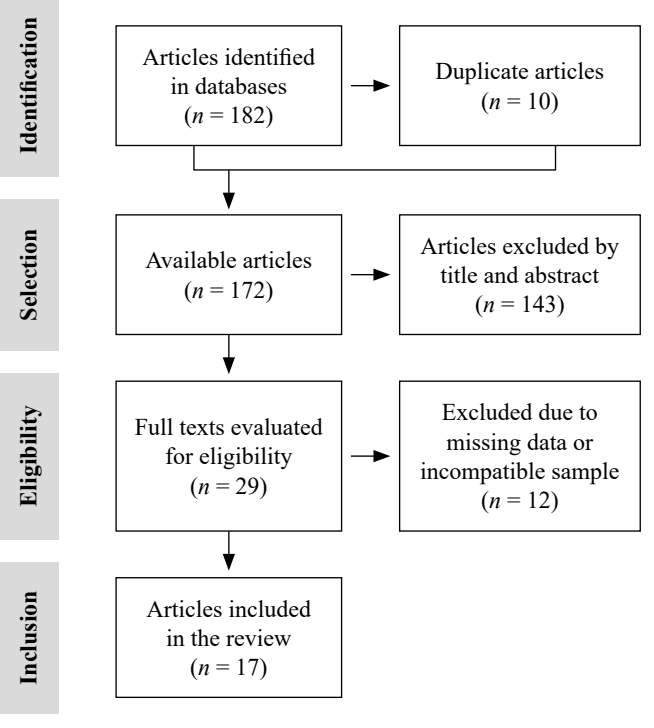
The selected articles underwent a thorough quality assessment by two reviewers with doctoral degrees in sports science, who followed a list of 14 requirements from the Quality Assessment Instrument for Observational Cohort and Cross-Sectional Studies (National Heart, Lung, and Blood Institute [NHLBI], 2013) (Appendix 1). After the reviewers' individual and independent assessment, in cases of disagreement, they met to reach a consensus. Based on the reviewers' consensual responses, the Risk of Bias Domains table (Appendix 2) was completed. It presented the reviewers' responses to each question in each article, with the mode of this responses representing the overall assessment of the study's quality (favorable or unfavorable).

Results

The search began on October 1, 2022, and ended on March 20, 2023, using all keywords and retrieving a total of 182 publications potentially eligible for inclusion in this review. Figure 1 presents the process flowchart according to the PRISMA guidelines (Moher et al., 2009; Urrútia & Bonfill, 2010). After removing duplicates from each database combination, 172 articles remained. The abstracts were then reviewed, and based on the exclusion criteria, 143 articles were removed.

Twenty-nine selected articles were analyzed in full. Based on the exclusion and inclusion criteria, 12 studies in which the variables were not assessed by standardized instruments or lacked important information for the review were excluded. Ultimately, 17 articles met all inclusion criteria and are presented in Figure 1.

Figure 1
PRISMA Flowchart



The flowchart in Figure 1 presents general information on the number of studies included. Regarding general information, note that only three articles were published after 2020. All others were published between July 2003 and March 2019. Eight articles (47%) used correlational design, five (29%) used longitudinal design, two were cohort studies (12%), and two were case studies (12%). The total sample of 17 studies consisted of 2,390 participants: 1,412 (59%) in correlational studies, 510 (21%) in longitudinal studies, 425 (18%) in cohort studies, and 43 (2%) in case studies.

Table 1 presents the article data, including the name and date of publication, the number of participants (*N*), the average age, gender ratio, and the athletes' sports. The average age of participants was 15-30 years, although it was not specified in six studies. One study (Fields et al., 2019) included data on retired athletes with an average age of 65 years. All studies included male participants, and six included female athletes. In 14 out of the 17 articles presented, American football was the most practiced sport among athletes who suffered a concussion, followed by hockey (ice and field), which was present in six articles reporting a great number of athletes practicing this sport.

Regarding the instruments used in the articles shown in Table 2, heterogeneous measures were used. Among the instruments to assess attention, the STROOP test (Trenerry et al., 1989) was used in four studies; the Brief Visuospatial Memory Test–Revised (BVMT-R) (Benedict, 1997), the Hopkins Verbal Learning Test–Revised (HVLT-R) (Leroi et al., 2004), and the Symbol Digit Modalities Test (SDMT) (Smith, 1991) in one study; the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) (Lovell et al., 2000) in one study; the N-back test in one study; the Sustained Attention to Response Task (SART) in one study; the Digit Span Test in three studies; the Trail Making Test A & B in one study; and the IED test in one study.

To assess processing speed, the Symbol Digit Modalities Test was used in three studies; the Go-No-Go test in one study; the ImPACT in one study; the King-Devick (K-D) test in one study; the CTMT/PSU cancellation task/TSMD/SCWT/Continuous Wake Performance Test-W in one study; the WAIS-III PSI in one study; the WAIS-IV Coding Test in one study; the RBANS in one study; the SAWAIS/TMT/Trail Making Test B in one study; and the Wechsler Adult Intelligence Scale—III (WAIS-III) (Wechsler et al., 1998) in one study.

Table 1

Description of sample characteristics of the studies included

Author and year	Sample characteristics			
	n	Age	Sex	Modality
Guty & Arnett, 2018	122	*m* = 19.5	M and F	Football, wrestling, lacrosse, ice hockey, basketball, baseball, softball, rugby, swimming, diving, and golf
Iverson et al., 2005	72	*m* = 17	M	Soccer, hockey, basketball, wrestling
Fickling et al., 2019	47	*m* = 18.49	M	Ice hockey
Espinoza et al., 2021	123	*m* = 17	M	American football
Ray et al., 2022	12	*m* = 16	M and F	Soccer, basketball and volleyball
Terpstra et al., 2019	61	NS	M	Soccer
Gardner et al., 2010	73	*m* = 24,5	M	Rugby
Peterson et al., 2003	350	NS	M and F	Men's and women's soccer, softball, basketball, and cheerleading
Fields et al., 2019	35	*m* = 65.49	M	American football
Kontos et al., 2011	63	*m* = 15.89	M and F	Soccer
Killam et al., 2005	28	*m* = 20	M	Ice hockey, field hockey, lacrosse, and soccer
Schatz et al., 2006	138	NS	M	Tennis and soccer
Shuttleworth-Rdwards & Radloff, 2008	124	NS	M	Rugby
Pearce et al., 2014	43	*m* = 24.1	M	Soccer
Barr, 2003	100	*m* = 15.9	M and F	Soccer and field hockey
Solomon & Haase, 2008	168	NS	M	American football
Thomas et al., 2021	831	*m* = 18.50	M and F	Men's and women's soccer, wrestling, men's and women's lacrosse, women's ice hockey, men's and women's basketball, baseball, softball, volleyball, and rugby

Note. *n* = sample size; *m* = mean; NS = not specified

Table 2

Methodological data and results

Author and year	Type of study	Cognitive assessment instruments	Main results
Guty & Arnett, 2018	correlational	BVMT-R / HVLT-R / SDMT / Stroop	Attention and processing speed↓
Iverson et al., 2005	longitudinal	Go / No-Go Symbol-Digit Modalities Test	Processing speed and reaction time↓
Fickling et al., 2019	longitudinal	ImPACT	Basic attention and processing speed ↓
Espinoza et al., 2021	longitudinal	NP Battery N-back	Divided attention and processing speed ↓
Ray et al., 2022	case-control study	Teste de King-Devick (K-D)	Processing Speed, attention, and Reaction time ↓
Terpstra et al., 2019	correlational	SART	Sustained Attention ↓
Gardner et al., 2010	correlational	WAIS-III PSI	Processing Speed ↓
Peterson et al., 2003	cohort study	Symbol Digit Modality Test Digit Span test	Attention - Processing Speed ↓
Fields et al., 2019	correlational	WAIS-IV Coding Trail making A & B	Attention - Processing Speed -
Kontos et al., 2011	cohort study	NE	Processing Speed ↓
Killam et al., 2005	correlational	STROOP / RBANS	Attention - Processing Speed ↑
Schatz et al., 2006	correlational	NE	Processing Speed ↓
Shuttleworth-Rdwards & Radloff, 2008	correlational	SAWAIS / TMT Trail Making Test A and B	Visuomotor Processing Speed ↓
Pearce et al., 2014	case study	IED test	Attention↓
Barr, 2003	longitudinal	Digit Span Digit Symbol WAIS-III	Attention ↓ Processing Speed -
Solomon & Haase, 2008	longitudinal	ImPACT	Processing Speed ↓
Thomas et al., 2021	correlational	Stroop Color-Word Test Symbol-Digit Modalities Test	Processing Speed and Attention↓

Note. ↑ = increase / larger; ↓ = decrease/smaller; NS = not specified; BVMT = Brief Visuospatial Memory Test-Revised; HVLT = Hopkins Verbal Learning Test-Revised; SDMT = Symbol Digit Modalities Test; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; NP Battery = consists of a series of five short NP subtests with multiple trials, each assessing information processing speed, working memory, and executive function; SART = Sustained Attention to Response Task; WAIS-III = Wechsler Adult Scale; RBANS = Assessment of Neuropsychological Status; SWAIS = South African Wechsler Adult Intelligence Scale.

The most widely used standardized test for assessing the history and severity of concussions suffered throughout a career was the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT). This instrument is used extensively in the literature and tends to be the most important measure in this field (Guskiewicz et al., 2005, 2007).

The judges' evaluations of the selected studies returned a total of seven articles (41.2%) rated as good (Espinoza et al., 2021; Fickling et al., 2019; Fields et al., 2019; Guty & Arnett, 2018; Peterson et al., 2003; Shuttleworth-Rdwards & Radloff, 2008; Thomas et al., 2021). Another five (29.4%) articles were considered fair (Gardner et al., 2010; Iverson et al., 2005; Killam et al., 2005; Kontos et al., 2011; Tersptra et al., 2019), and only one (5.9%) was considered poor. The judges pointed out low sampling in two articles considered good (Fickling et al., 2019; Fields et al., 2019). However, this issue was not relevant because it was a limitation cited by the authors on the studies, suggesting a future meta-analysis associated with similar data. Studies evaluated as fair were determined by low sampling. The only negative evaluation given by one of the judges referred to the study design, in which some confusing statements were pointed. However, after discussion among the evaluators regarding conflicts in analysis, the opinion of one of the judges prevailed, leading to a consensus, and the article continued in the study. The judges' evaluations of the questions in the Questionnaire in Appendix 1 using the symbols (+) yes, (-) no, and (x) other is available in Appendix 2.

Among the quantitative results obtained, athletes who suffered concussions showed increased processing speed (taking longer to respond to stimuli) and decreased divided and sustained attention. In one study, the authors suggested that headaches influenced the evaluation and testing of participants, which impaired attention tests (Iverson et al., 2005).

Discussion

The main results of this study corroborate the literature, showing the association between concussion and deficits in attention and processing speed in virtually all studies where this relationship was investigated (Espinoza et al., 2021; Fickling et al., 2019; Thomas et al., 2021; Guty & Arnett, 2018; Iverson et al., 2005; Ray et al., 2022). In particular, the quality of the studies that included the association between concussion and attention and processing speed as part of the investigation was positive, demonstrating low bias and adequate methodologies.

Even though the studies were generally of high quality with a low risk of bias, the majority (72.2%) lacked follow-up data. This prevented a determination of whether symptoms were temporary or indicative of a gradual, permanent cognitive decline, thus making it impossible to conclude if the symptoms were cumulative (Barcelos et al., 2023; Omalu et al., 2006).

Likewise, the studies also did not present methods for controlling researcher bias. In experimental and quasi-experimental studies, particularly those evaluating and measuring behaviors or symptoms, it is recommended that the data collector be blind to the participants' group assignment. Similarly, the data analyzers should be blind to the nature of the compiled groups. A blinded study procedure mitigates researcher bias during data compilation or analysis. This approach prevents a researcher's initial hypothesis from unconsciously influencing the interpretation of results toward a desired outcome (NHLBI, 2013). In only two (11.8%) of the studies found, a blinded study method was used in data compilation and analysis, i.e., data collectors and analyzers were unaware of the participants' groups. This points to a latent risk of bias in the studies presented, in an attempt to confirm the hypothesis that attention and processing speed are related to concussion. Although the quality of the studies found is generally positive, these results need to be analyzed with caution.

Regarding the instruments used, there was considerable heterogeneity in the measurement of attention and processing speed. The Stroop test and the Symbol Digit Modalities Test were the most frequently used protocols in the assessment of processing speed and attention, in three out of the 17 studies (17.6%). Multiple instruments were used in two of the 17 studies (11.8%), such as the TMT - version A, Digit Span, WAIS, and ImPACT. The latter is a validated instrument for measuring psychological dimensions in concussion protocols. However, most of these measures are not specific to processing speed or specific attention modalities. For example, the Stroop test is traditionally known as an instrument for measuring inhibitory control, especially behavioral inhibition (Barcelos et al., 2023). The same is true for the Digit Span and the Symbol Digit Modalities Test, which are instruments for assessing working memory and short-term memory (Barr, 2003).

The ImPACT instrument has been validated for measuring processing speed, which appears adequate and reliable. However, there is no information in the literature on the type of attention measured by the instrument, leaving a gap in its scope (Iverson et al., 2005). The heterogeneity of instruments and their low validity in measuring types of attention and processing speed appear to be challenges for the future of literature on concussion (Linden & Hönekopp, 2021). The search for a uniform testing protocol should be an investment by the scientific community to enable the interaction between studies from different countries and cultures for the benefit of athletes.

Perhaps an important finding of the study was the identification of memory and reaction time deficits linked to headache in athletes with moderate to severe concussion, altering levels of attention and processing speed (Iverson et al., 2005). These data are of paramount importance for all neuropsychology and neuroscience studies related to sports, from treatment, prevention, and psychological rehabilitation to the performance of athletes in their sport. This study clearly demonstrated the compromise of cognition in athletes with repetitive concussion, specifically attention in all its divisions, processing speed, and consequently, executive functions (Thomas et al., 2021).

The impact on attention and processing speed in sports athletes, including grassroots and high-performance athletes with a higher propensity for concussion, should be considered before other possible diagnoses to identify the cause and reduce the risk of further concussions, which significantly impact the degree of deficits in these skills (Fickling et al., 2019). One study found a higher risk of decreased processing speed and attention in athletes with anxiety and depression. Athletes with either diagnosis exhibit cognitive and neuropsychological deficits, so the authors suggest determining if the mood changes occurred before or after the concussion to avoid confusion during post-concussion exams (Espinoza et al., 2021). According to this view, athletes in American football, rugby, hockey, lacrosse, and other impact sports should be more careful in treating these symptoms to avoid a greater impact on executive and cognitive functions, which could affect the production of high-performance athletes (Ray et al., 2022).

Considering the importance of concussion and its impact on athletes, perhaps a limitation that hinders research is the lack of diversity in experimental studies in the search databases. In addition, studies in other languages, such as German and Russian, were largely excluded from this study, and only those in English, Spanish, and Portuguese were considered.

Finally, the total sample size of the studies in this review is quite significant, with 2,390 participants, although in some studies (Fickling et al., 2019; Fields et al., 2010; Gardner et al., 2010; Killam et al., 2005; Kontos et al., 2011; Pearce et al., 2014; Ray et al., 2022) the judges considered the number of participants to be low. This was not a negative consideration, as in some of the studies, the authors themselves mentioned this limitation, highlighting the need for a future meta-analysis combining data from similar studies.

The challenge, as previously noted, is how to condense the results if the measures and their validations for the study

objects are so distinct. The heterogeneity of the instruments impacts the quality of future meta-analyses (Linden & Hönekopp, 2021). The studies based on correlational and quasi-experimental research present bias problems, as identified in the results of the present work. However, the studies suggest that the hypothesis of the association between successive concussions and deficits in attention and processing speed in contact sports athletes is closer to being confirmed than the opposite.

Concussion in sports is a common event and causes symptoms and sequelae that affect athletes of various ages with negative impacts. An in-depth analysis of all possible issues that arise over time after the initial injury is necessary to optimize rehabilitation potential and ensure appropriate treatment. The cognitive and executive skill consequences (especially attention and processing speed) indicate that a thorough clinical approach is necessary to manage the affected skills. Adequate knowledge of technology and training support programs are crucial for successful recovery, and therefore, the training of selected professionals should be a requirement.

Most of the studies identified in this review present good sample sizes (although there is a need to increase the homogeneity of the measures to allow for future meta-analyses), which corroborates the reliability of the study and highlights the low levels of attention and processing speed skills in athletes who suffered concussions and consequently experienced greater difficulty in performing their sport at competitive levels.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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