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Journal of Basic and Applied Psychology Research

Biannual Publication, Vol. 7, No. 13 (2025) 33-39

Memory and Executive Attention Impairments in Mexican Karate Practitioners with a Sport Related Concussion

Alteraciones de memoria y de atención ejecutiva en karatekas mexicanos con historia de conmoción cerebral

Mariana Yañez Jasso[a] & Gabriela Orozco Calderón[b]

Abstract:

Physical activity and sports have both physical and mental benefits. However, in contact sports such as karate, when using physical contact techniques, they pose a risk of suffering a head injury. The most common cause of brain damage is from trauma, which is called traumatic brain injury (TBI), these can be classified as mild, moderate or severe. Brain concussions (BC) are a subtype of mild TBI, a sudden and transitory altercation induced by traumatic biochemical forces of direct or indirect transmissions to the brain; although they are not characterized by loss of consciousness, they are associated with long term neurophysiological effects and are more commonly associated with contact sports. That is why, the objective of this research is to describe neuropsychological (attention, memory, executive functions) characteristics of a sample of karate professionals, in order to identify those characteristics which, present an altercation with clinical significance. The sample was divided into karate practitioners who do combat and have reported BC (n=14) and karatekas who do not fight and have not reported BC (n=18), to compare the results according to the history of concussions. It was found that karateka who reported a history of concussions obtained significantly lower scores in tasks of auditory-verbal memory and attentional control linked to executive functions. In conclusion, contact sports provide benefits at the cognitive and emotional level; however, concussions can negatively affect these results in long term despite previous belief that CC are benign.

Keywords:

Concussion, mild head injury, contact sport, neuropsychological evaluation, sports neuropsychology

Resumen:

La actividad física y deportes tienen beneficios tanto físicos como mentales. Sin embargo, en los deportes de contacto como el karate, al usar técnicas de contacto físico, implican un riesgo de padecer una lesión en la cabeza. Los traumatismos craneoencefálicos (TCE), se clasifican en leves, moderados y graves. Las conmociones cerebrales (CC) son un subtipo de TCE leve, alteración repentina y transitoria inducida por fuerzas biomecánicas traumáticas de transmisión directa o indirecta al cerebro; que aunque no están caracterizadas por una pérdida de consciencia, se asocian con secuelas neuropsicológicas a largo plazo, y están comúnmente asociadas a los deportes de contacto. Es por ello, que el objetivo de la presente investigación consistió en describir las características neuropsicológicas (atención, memoria, funciones ejecutivas) de una muestra de karatekas profesionales, comparando al grupo que hace combate y que ha reportado historia de CC (n=14), y karatekas que no realizan combate (n=18) para analizar las diferencias entre los resultados de acuerdo con el historial de conmoción cerebral. Se encontró que el grupo de karatekas con CC obtuvieron puntuaciones significativamente menores en tareas de memoria audio verbal y de control atencional relacionado, a las funciones ejecutivas. Se concluye que, aunque los deportes de contacto aportan beneficios a nivel cognitivo y emocional; incluso una sola CC puede afectar de forma negativa estos resultados.

***Palabras Clave**:*

conmoción cerebral, traumatismo craneoencefálico leve, deporte de contacto, evaluación neuropsicológica, neuropsicología deportiva

INTRODUCTION

The International Consensus on Concussion in Sport defines brain concussion (BC) as a complex pathophysiological process in the brain, induced by traumatic biomechanical forces (McCrory et al., 2009, 2012; Ortiz & Murguía, 2017). Sports neuropsychology has focused on the evaluation and treatment of athletes who have suffered one or more BC or who are at risk of suffering them in sports practice (Echemendía, 2006). Neuropsychology is based on clinical observation and the use of various psychological measurement instruments to determine the presence of cognitive and behavioral changes (Matute, Rosselli, & Ardila, 2010), which must be interpreted

[a] Autor de Correspondencia, Facultad de Psicología, Universidad Nacional Autónoma de México, https://orcid.org/ 0009-0003-8021-9239, Email: marianayajo@gmail.com

[b] Facultad de Psicología, Universidad Nacional Autónoma de México, https://orcid.org/ 0000-0002-4978-1667, Email: gabriela.orozco@psicología.unam.mx

Received: 06/01/2025, Accepted: 23/05/2025, Published: 05/07/2025

DOI: https://doi.org/10.29057/jbapr.v7i13.14422

considering three systems: cognition, emotion, and executive functions (Lezak et al., 2012). Although the literature suggests that most BC (80% - 90%) resolve in a short time (7 to 10 days), there is a percentage in whom the symptoms persist, and may present as a post-concussion syndrome (PCS), second impact syndrome (SIS) or chronic traumatic encephalopathy (CTE) (Arellano, et al., 2019). These syndromes have clinical manifestations in different spheres: behavioral, mood, cognitive and motor; where changes in personality, impulsive behaviors, decreased attention and concentration, and visuospatial difficulties are mainly observed (Tarazi, 2016; Montenigro, 2014); more attention has been paid worldwide to BC occurring during sport, at school, amateur or professional level. Sport related concussion (SRC) should be suspected in any athlete who suffers a traumatic brain injury (TBI), whether or not they have lost consciousness (Tsushima, et. al., 2018). When a SRC is identified, the athlete should not return to practice immediately, and a few days of mental and physical rest are recommended for full recovery. Repetitive trauma should be avoided, as this increases the severity of cognitive and emotional sequelae (Tsushima, et al., 2018).

SRC represents a significant health concern for those who participate in contact sports. According to the fifth international conference of SRC (Berlin, 2016), they are defined as traumatic injuries induced by biomechanical forces, they can be caused by a direct blow to the head, face or neck, or some other part of the body with an impulsive force transmitted to the head. It typically results in the rapid onset of a short-lived alteration of neurological function that resolves spontaneously, however, most SRC do not occur with loss of consciousness and even, in milder cases, the person may not even realize that they have suffered a concussion. Therefore, some of the symptoms may not be evident at first, but may arise over the course of hours or in subsequent days (INFOCOP, 2015). It can result in neuropathological changes, but acute clinical signs and symptoms largely reflect a functional alteration rather than a structural injury. Many athletes are not aware of the symptoms that occur after a SRC, and in cases where these usually appear and are evident to the person, it is common for athletes not to report anything for fear that they will be removed from the team and not be able to continue playing (Delaney, Caron, Correa, & Bloom, 2018). This represents a risk to the health of athletes since having multiple SRC throughout life can cause changes in brain structure and could lead them to present more severe symptoms or develop chronic traumatic encephalopathy (McKee, et al., 2009, 2013; Omalu, et al., 2005, 2006), affecting their cognitive functioning, autonomy and consequently their quality of life in the long term (Langlois, Rutland, Brown, & Wald, 2006). The number of concussions has been correlated with increased cognitive symptoms (Manley et al., 2017). When BC occurs, in the acute phase, there may be some microscopic change in the brain such as stretching and rupture of the axons, which has been reported in only 25% of cases in which magnetic resonance imaging (MRI) is performed, since in Computed Tomography (CT) it is only observed when the BC is moderate or severe. In the post-concussion phase, the transmission of linear and/or rotational forces from the brain causes an alteration in cellular homeostasis and the presence of a metabolic cascade. These forces result in a lesion in the plasma membrane, in which proteins are deployed from the lipid layers releasing potassium and depolarization of the membrane that favors the release of excitatory neurotransmitters such as glutamate. It promotes potassium outflow through ligand-activated channels and binds to N-methyl-D-aspartate (NMDA), resulting in continuous depolarization and hyperexcitability. Activation of these receptors leads to calcium entry through activated channels or through the release of intracellular calcium reserves. The increase in calcium produces intracellular neurotoxicity, increasing cytosine, which inflames the cell (and the entire brain) (Norton, 2018; Rădoi, et al., 2016; Kochanek, et al., 2000). Goswami et al. (2016) reported that soccer players with a history of BC (n=19) had significant cortical thinning of the anterior temporal lobe and orbitofrontal cortex compared to controls (n=17). In addition, Koerte et al. (2016) identified cortical thinning in former professional soccer players (n=15), evidencing long-term injuries. Strain et al. (2015) found that retired athletes, with at least one BC with loss of consciousness, even if distant in time, had significantly lower bilateral hippocampal volumes and lower performance in mnesic tests (Strain et al., 2015; Manley et al., 2017). Players with more than three concussions during their career had a 5-fold increased risk of being diagnosed with mild cognitive impairment after the age of 50, compared to those without a history of BC (Manley et al., 2017). The deficits in attention and memory seen after a mild TBI (L-TBI) resemble those seen in Alzheimer's disease (Leddy, et al., 2012).

Neuropsychology is considered fundamental for the evaluation and management of athletes who have suffered from BC (Echemendia et al., 2013). Evidence suggests the presence of cognitive alterations in various processes such as: memory, attention, mental flexibility, verbal fluency, impaired judgment, planning, working memory, inhibition, and processing speed (Echenmedia, et al., 2001; Chen, Johnston, Petrides, et al., 2004; Pontifex, O'Connor, Broglio, et al., 2009). Memory and learning of new information involves the cerebral cortex, subcortical connections, hippocampal formation (dentate gyrus, hippocampus, and parahippocampal gyrus), and the diencephalon, especially the medial portions (Adams, Victor, Ropper, 1997), regions sensitive to BC, so the ability to process information may be reduced. In addition, frontal lobe injuries can cause changes in behavior, including loss of inhibition and judgment. For this reason, neuropsychological symptoms can be variable and not only the location of the injury but also the pathways involved in the top-down regulation of information processing must be considered. The damaging effects of injury to nerve fibers and neurons are proportional to the degree to which the head accelerates, and these changes may be cumulative (Gennarelli, Seggawa, Wald, et al., 1982). Although BC is known to occur in karate, the incidence is still unclear. According to Arriaza et al. (2016), the risk of concussion in karate increases when it is done at an amateur level and the risk is higher in men than in women. A karate practitioner on average competes once a month, with an average of 4 bouts per competition (which represents 12 minutes of active combat in men's categories and 8 minutes in women's) (Arriaza, et al., 2016). In addition, starting contact sports before the age of 12 has shown long-term repercussions (Alosco, et al., 2017). Repeated blows to the head, with or without concussion, can alter the structure of the brain, especially if these blows occur at critical periods of development, such as between 5 and 14 years of age when the brain undergoes substantial maturation in males (Shaw, et al., 2006; Lebel, Walker, Leemans, Phillips, & Beaulieu, 2008). Repeated blows to the head during neurological development can disrupt normal brain maturation and increase vulnerability to long-term impairments, especially

if sports are continued (Stamm, et al., 2015; Guskiewicz, et al., 2013). The purpose of this research is to describe the characteristics in neuropsychological performance (attention, memory and executive functions) of a group of professional Mexican karate practitioners, as well as to describe the differences in neuropsychological performance according to the tests applied, considering the history of concussion.

METHODS

A non-experimental, cross-sectional and correlational design was used, comparing between groups (Sampieri, 2014).

Participants.

The sample consisted of 32 adults, 18 men (56.3%) and 14 women (43.8%). Aged between 18 and 35 years (M = 25.78; SD = 5.302), with a minimum level of high school education that was quantified in years of schooling (M = 18.75; SD = 2,300), an uninterrupted practice of karate as a sport at least one year before; and a minimum total practice of 10 years (M = 14.41, SD = 6.579). Of these, 14 were part of the group with a history of concussion (8 men and 6 women) due to the answers of the initial interview where they were questioned about the type of competition, use of protection during tournaments, blows received to the head, loss of consciousness and medical attention, reported not wearing protective equipment during the fights in competition, two reported using it before their 18th birthday. And 18 were part of the group without a history of concussion (8 men and 10 women). Inclusion criteria: a) men or women between the ages of 18 and 35, b) normal or corrected vision, c) minimum high school education, d) at least one year of consecutive practice prior to confinement and at least 10 years in the practice of karate, e) participation in at least 5 tournaments, f) respond to the initial data form and sign the informed consent.

Instruments

Concussion in Sport Assessment Tool (SCAT-5). Standardized method of evaluating athletes injured by concussion and can be used in athletes over 9 years of age. Enables calculation of the Standardized Concussion Assessment and Maddocks score and assessments for concussion assessment in the area of sport or training.

Attention assessment. Scheduled Auditory Serial Addition Test or TASD (PASAT) (Gronwall, 1977; Rao et al., 1989). It provides an estimate of the speed of information processing, attention, and working memory (Strauss, Sherman, & Spreen, 2006 in Puerta, Dussán, Montoya, & Landínez, 2018). An audio is presented to ensure standardization in the rhythm of the presentation of stimuli. Rey-Osterrieth Complex Figure Test (NEUROPSI attention and memory; Ostrosky, et al., 2019). Appreciates the level of perceptual-motor development, attention and immediate visual memory; It is also used in clinical with the adult population to evaluate visuospatial ability, agnosias, apraxia and visual memory problems.

Procedure

A call was made on sports social networks (CONADE, SENDERO, FEMKA, UNAM, WAKO) where the inclusion criteria were explained, interested participants were sent consent and initial interview. With full knowledge and having clarified doubts, they signed the informed consent, safeguarding the privacy and confidentiality of the information provided and in in accordance with the WMA Declaration of Helsinki – Ethical Principles for Medical Research on Human Beings. Through the initial questionnaires (SCAT-5 and general data) the group with a history of concussion was identified. Subsequently, the cognitive evaluation was carried out where the battery of tests and instruments aimed at various cognitive domains was applied. All neuropsychological tests were applied in the same order to all participants. All evaluations lasted an average of one hour. After completing the application, qualification, analysis and interpretation of the tests, a personal report was made to each of the participants, with individual recommendations, sent to

them by email and doubts were clarified.

Statistical analysis

All the information extracted from the study was recorded in a database using the statistical program SPSS (Statistical Package for Social Sciences) version 22. Both parametric and non-parametric statistics were applied. In all analyses, a value of alpha < .05 was taken as significant (Sampieri, 2014). Shapiro Wilk was tested for normality due to the sample size (<50). From this analysis, the variables that had normal distribution were analyzed with a student's t for independent samples, to find the differences between the groups. Those that did not meet this criterion were compared using the Mann-Whitney-Wilcoxon U test (Siegel & Castellan, 2015). And finally, a Pearson correlation coefficient was performed to determine the degree of relationship between the neuropsychological assessment scores and the number of concussions received in the karate group with a history of brain concussion

RESULTS

Significant differences were found in the correct answers of the PASAT in the two-second version (t= 2.787; p = .009), where the group with a history of concussion obtained lower scores, indicating less sustained attention span and maintenance of stimuli. Within the 3-second version (t=12.02; p=.052) there is a trend towards statistical significance that indicates differences between both groups. Significant differences were found in both TAVEC subtests. The group with a history of concussion scored significantly lower than the group without a history of concussion, indicating lower short-term memory capacity. In the short-term memory process, significant differences were found in the short- and long-term free recall subtests of the TAVEC (t=4.452; p =.000; t= 5,493; p = .000) and in the memory with short- and long-term keys of the TAVEC (t= 3.169; p=.004; t= 3,645; p=.001) that denote differences in the short-term memory capacity of verbal auditory material, with the group without a history of concussion having the highest scores. No significant differences were found in the encoding of Rey Figure, which may indicate greater alterations in the use of audioverbal material. Significant differences were found in the types of errors of the different tests: intrusions made during the retrieval of information from the TAVEC test (U=-2.25; p=.024); and WCST perseverations (U=-1.987; p=.34). Also in the PASAT test, both in the incorrect answers of the PASAT version 3 seconds (U=68.50; p= .028) and in the non-answers of the PASAT version two seconds (U=70.50; p= .035).

Table 1. Correlation Between Concussion Count and Test.

Prueba	Subtest	R Pearson	Sig
TAVEC	RLCP	-0.533	0.002 **
	RCLCP	-0.404	0.022 *
	RLLP	-0.614	0.000 **
	RCLLP	-0.458	0.008 **
	Intrusions	0.194	0.287

PASAT 3’	Correct answers	-0.223	0.219
	No answers	0.175	0.337
	Incorrect answer	0.182	0.317
PASAT 2’	Correct answers	-.432	0.014 *
	No answers	0.322	0.072
	Incorrectanswer	0.179	0.328
WCST	Correct answers	-.424	0.016 *
	Perseveraciones	0.48	0.005 **
NEUROPSI	Total semántico PE	-0.243	0.180

*Correlation is significant at the 0.05 level (bilateral).**
Correlation is significant at the 0.01 level (bilateral)

According to the literature, the number of concussions received throughout the practice has a direct effect on the results of neuropsychological tests. Within the present study, strong relationships were found in the results of the different TAVEC subtests, demonstrating a relationship between the number of concussions and performance in both short- and long-term memory of audio-verbal material. A relationship was also found in processing speed (PASAT 2') that is visible when cognitive demand increases. And finally, in the Wisconsin chart test, which can mean a relationship between the number of concussions and the ability to plan and cognitive flexibility (Table 1).

DISCUSSION

Neuropsychological tests allow us to approximate brain functioning (Echemendia et al., 2013). The test that best discriminated between the two groups in the present study was the Spanish-Complutense Verbal Learning Test (TAVEC). The performance of participants with a history of CB was significantly lower than that observed in the group of participants without a history of BC in learning ability and immediate and delayed verbal memory, with statistically significant differences. These results denote a decrease in short- and long-term information retrieval performance, a poor learning curve, and an ability to inhibit, self-monitor, and identify errors with less accuracy, compared to the group without a history of BC. This performance highlights lesions in frontotemporal connections and fronto-subcortical regulation, which are shown in autoregulatory and attentional control failures (Chen and d’Esposito, 2010 y Stuss, 2011). The group with a history of BC had significantly lower scores in selective attention capacity, having difficulty choosing the relevant stimulus, which also requires inhibition capabilities. In addition, this group had difficulty maintaining attention for long periods of time, compared to the group without a history of BC. This evidences not only failures in sustained attention, but also in the executive control of attention that is required to maintain attention and concentration on the relevant stimulus (Pelegrín, Fernández, Tirapu, & Muñoz-Céspedes, 2001; Perea-Bartolomé, Ladera-Fernández, & Morales-Ramos, 2002; Stuss, 2011; Quijano & Cuervo, 2011). The participants with a history of concussion scored significantly lower for audio-verbal long-term memory. This is mainly due to the organizational strategies used during the registration phase. Participants with a history of BC used fewer strategies to organize information, so the record was altered and later the retrieval was altered. In addition, there were failures in executive attention, which allows modulating cognitive efforts in order to improve registration. Participants obtained significant differences in executive attention, which prevents them from being able to direct their cognitive effort towards new information. These results are consistent with research in athletes who practice other sports where verbal mnestic impairment has been reported based on left hippocampal atrophy (Wall, et al., 2006; Williams, Potter, & Ryland, 2010). In the assessment of executive functions, participants with a history of concussion had significant differences in the errors that can be made within the tests, such as perseverations and intrusions. During free retrieval, participants in this group tended to make contaminations (mention words that were not on the learning list or interference list), however their performance improved when using the recognition list, suggesting that it is an error in the organization and access to the learned information and not the ability to discriminate the information. Suggesting that the group with a history of BC has difficulty accessing new information and using strategies, but not in creating the memory footprint as they can compensate with the use of cues and recognition. Although alterations in executive functions have been described to a greater extent in moderate or severe TBI, alterations in executive functions were found in this study (NEUROPSI and WCST), which could indicate that the severity of the injury does not necessarily determine the neuropsychological characteristics of the condition. In addition, people with one or more BC were characterized by a slowing down of processing speed and a lower inhibition capacity (Pelegrín, Fernández, Tirapu, & Muñoz-Céspedes, 2001), causing a greater number of errors when discriminating information and inhibiting behaviors that are not appropriate to the environment. This is also related to the decrease in memory capacity since the speed of processing is altered and the recording of new information is affected. These results are directly related to the number of concussions they have suffered over time. It should also be considered that most of these athletes start their practice on average at 6 years of age and have an average practice time of 15 years, this increases the possibility of suffering repeated and even underreported BC throughout the athlete's life. The presence of BC at an early age or in youth results in alterations in memory and attention (Ramalho & Castillo, 2015). The sample coincides with the data in the literature, having an average practice of 16 years and having started its practice in early childhood (around 5-7 years). Starting contact sports before the age of 12 has long-term repercussions (Alosco, et al., 2017). In conclusion, the results obtained confirm that, contrary to the widely held belief in the clinical field, BC classified within L-TBIs should not be considered banal events. The results of the neuropsychological assessment indicate that in the medium term the cognitive status of these patients continues to be altered and that they have memory and executive attention problems.

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