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RESEARCH

Differences in Processing Speed, Attention, and Executive Functions in Rugby and Padel Athletes

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Abstract

The aim of this study was to investigate whether participation in rugby or padel is associated with differences in cognitive functioning, specifically in processing speed, attention, and executive functions. Sixty-four participants were divided into rugby athletes, padel athletes, and non-athletes. Cognitive performance was assessed using the Digit Symbol-Coding and Symbol Search subtests of the WAIS-III (Processing Speed Index) and the Trail Making Test (Parts A and B). Significant group differences emerged in processing speed and executive functions, while no significant differences were found in attention. Rugby athletes showed significantly lower performance in these domains than padel athletes, performing similarly to non-athletes. In contrast, padel athletes significantly outperformed non-athletes in processing speed, suggesting an association between padel practice and enhanced cognitive performance. These findings are consistent with a possible association between participation in padel and higher cognitive performance, particularly processing speed, although causal inferences cannot be drawn from this small cross-sectional study. Further research is needed to clarify the cognitive correlates of padel as the sport gains popularity.

Keywords Padel · Rugby · Processing speed · Attention · Executive functions

Introduction

Physical exercise has consistently been highlighted in the literature for its wide-ranging health benefits, including metabolic, cardiorespiratory, and psychological improvements (Chan et al., 2019; Ruegsegger & Booth, 2018). More recently, research has also highlighted the positive cognitive effects of regular physical activity, which are attributed to the upregulation of neurotrophins that support synaptic plasticity (Fernandes et al., 2018). These cognitive benefits are especially relevant for athletes, whose performance is closely tied to essential cognitive domains, such as processing speed, attention, and executive functions (Haverkamp et al., 2020; Maeneja et al., 2022).

In dynamic sports contexts, rapid and accurate cognitive processing is crucial. Athletes must continuously filter relevant stimuli from their environment while ignoring distractions, enabling swift and effective decision-making. These abilities are particularly critical in team sports that require processing complex and high-volume information under time constraints (Lovett et al., 2022). However, sports' cognitive demands and associated outcomes may vary depending on specific characteristics, such as the presence or absence of physical contact (S. Rice & AAPCSMF, 2008; Singer, 2000).

Consequently, examining specific sports that differ in terms of physical demands, structural complexity and training practices can provide valuable insight into how different sport-specific characteristics may influence cognitive

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functions, such as attentional control, decision-making and processing speed. Within this framework, rugby presents unique cognitive and physical challenges. However, their association with cognitive domains, such as attention and processing speed, remains a topic of ongoing debate. Concerns about repeated head impacts and their potential implications for neurocognitive functioning have added complexity to this discussion (Shuttleworth-Edwards et al., 2014). Conversely, padel, a non-contact sport, has gained recognition for its possible cognitive benefits (Haryanto et al., 2024; Pacesova et al., 2018; Srinivas et al., 2021). Despite its increasing global popularity, padel remains underexplored in scientific research, particularly in terms of its association with cognitive performance.

To address these gaps, the present study investigates the correlation between participation in padel or rugby and cognitive functioning, focusing on visual attention, processing speed, and executive functions. We assessed visual attention because it is essential for sport-specific demands. Visual attention is crucial for athletes, as it facilitates rapid information processing, spatial awareness, and target tracking, critical skills in dynamic sports environments (Miller & Clapp, 2011). Rugby practice imposes high demands on selective and divided attention, as players must simultaneously monitor their opponents, teammates, and the ball while anticipating potential collisions (Millard et al., 2021). In contrast, padel primarily requires focused attention on ball trajectory and opponent movement (Espino Palma et al., 2023), with minimal risk of unexpected impacts (S. Rice & AAPCSMF, 2008). Significantly, repeated exposure to head impacts that result in subconcussive and concussive events in contact sports (such as rugby) has been associated with impairments in visual attention, particularly in tasks requiring rapid shifts of focus (Tsushima et al., 2019; Zoccola et al., 2019). Investigating visual attention in rugby and padel athletes can help identify whether high-impact sports may be associated with attentional deficits, which may affect sports performance and long-term cognitive health. We were also interested in assessing processing speed as it is a putative indicator of neurological integrity and concussion-related consequences (Dean & Sterr, 2013). Processing speed reflects the efficiency of neural communication and cognitive-motor integration, both of which are essential for athletic performance. Quick decision-making under pressure is crucial in rugby, necessitating the rapid assessment of game situations and prompt motor responses (Sherwood, 2020). However, research has shown that contact-sport athletes, particularly those with repeated head impacts, may experience slowed processing speed due to alterations in white matter (Brett et al. 2024a, b). By comparing processing speed in rugby and padel athletes, this study examines whether participation in sports with differing physical demands is associated with variations in cognitive efficiency, which may be related to exposure to repetitive head impacts. Padel athletes serve as an ideal comparison group, as this interceptive sport involves similar demands for fast reaction times(Martín-Miguel et al., 2023; Miralles et al., 2025) and lacks the neurological stress of direct collisions.

While padel and rugby differ in various aspects, including team structure and equipment use, the most significant distinction for this study is their classification as a non-contact and a contact sport, respectively (Keeler, 2007). Rugby involves frequent physical collisions, requiring athletes to anticipate and respond to dynamic interactions with teammates and opponents. Conversely, padel emphasizes precise motor execution and strategic anticipation without the added challenge of physical impact. This fundamental difference may influence cognitive processing (Ntikas et al., 2022; Prien et al., 2020), as the demands placed on visual attention, executive functions, and processing speed vary according to the type and intensity of in-game interactions (Cunningham et al., 2018; Díaz-García et al., 2024). By selecting rugby and padel, two sports that differ in their physical and cognitive demands, we highlight how sport-specific characteristics, including but not limited to physical impact, may be associated with cognitive function. This distinction is crucial, as it enables a more nuanced investigation into how cognitive performance may be shaped by the specific demands of different sports, rather than relying on simplistic structural categories.

Executive functions, particularly cognitive flexibility, inhibitory control, and working memory, are crucial to strategic decision-making in sports and cognitive resilience in the face of injury. Recent systematic reviews (Contreras-Osorio et al., 2022; Gu et al., 2019) indicate that higher levels of physical fitness are associated with improved executive functioning (e.g., verbal fluency, attention control, cognitive flexibility and inhibitory control) across the lifespan. More specifically, studies examining specific fitness components show that upper-body muscular strength is associated with enhanced working memory and inhibitory control, whereas speed-agility performance is linked to improvements in cognitive flexibility. Importantly, these cognitive benefits are not uniform across all forms of physical activity and appear to be shaped by the characteristics inherent to each sport. In addition, athletes engaged in open-skill sports (e.g., handball) exhibit improvements across multiple executive function domains, likely reflecting the sport's elevated tactical complexity, high speed processing demands, and frequent decision-making requirements. These findings suggest that the cognitive benefits of physical activity are differentially modulated by sport-specific characteristics, resulting in specific executive function profiles. Open-skill sports, such as rugby and padel, take place in dynamic and unpredictable

environments that require continuous monitoring of changing cues, anticipation of opponents' actions, and rapid, flexible decision-making. These demands engage core executive functions differently compared with closed-skill or lower-complexity sports. Rugby players must quickly adapt to evolving game dynamics, suppress inappropriate responses (e.g., avoiding unnecessary tackles that could lead to penalties), and maintain goal-directed behavior under physical duress. However, studies suggest that repeated head impacts in this sport may lead to deficits in executive functions, particularly in inhibitory control and cognitive flexibility (Hume et al., 2017; Montenigro et al., 2017).

Since padel requires strategic planning, quick decision-making, and response inhibition, but does not carry the risks associated with impact-related cognitive decline as rugby, it serves as an appropriate control condition. This comparison allows us to assess whether the observed differences in executive function are more closely related to sports-specific cognitive demands or the neurobiological effects of repeated impacts. Moreover, a recent systematic review indicates that sport-specific characteristics not only modulate the general cognitive benefits associated with physical activity but also give rise to distinct executive function profiles (Gutiérrez-Capote et al., 2024). By offering comparative insights into these distinct sporting contexts, this study aims to enhance the understanding of how sport-specific characteristics (contact vs. non-contact) may influence cognitive health and performance.

This study contributes to theoretical advancements in sport-cognition interactions by examining how the structural characteristics of different sports, particularly rugby versus padel, may influence cognitive functioning through distinct neuropsychological mechanisms. Existing theoretical frameworks (Hillman et al., 2019; Maeneja et al., 2024) and empirical studies (Lim et al., 2025; Maeneja et al., 2023) commonly emphasize the overall benefits of physical activity for cognitive health. Moreover, various types of exercise have been shown to have different benefits (Akalp et al., 2024). However, these studies often overlook how the qualitative nature of sports (i.e., the presence of physical impact, task demands, and decision-making complexity) differentially modulates neurocognitive trajectories. By directly comparing athletes from a high-impact, collision-based sport (rugby) with those from a low-impact, interception-based sport (padel), we aim to provide empirical support for a theoretical distinction: cognitive enhancement driven by skill complexity and motor coordination (as in padel) versus potential cognitive vulnerability associated with repetitive head impacts and stress (as in rugby). This comparison extends existing cognitive-sport models and emphasizes the need for new frameworks that consider sport-specific cognitive demands and neurobiological factors. One influential theoretical model, the cognitive component skills approach (Nougier et al., 1991), posits that the cognitive advantages seen in athletes arise from consistent engagement with the specific cognitive processes required by their sport. Over time, this sustained practice may enhance both sport-specific abilities and broader cognitive domains, depending on the overlap between the demands of the sport and the cognitive functions being assessed. Previous literature indicates that team sports, such as rugby, characterized by dynamic and unpredictable environments, place greater demands on executive functions, including cognitive flexibility, inhibitory control, and working memory (Haverkamp et al., 2020; Maeneja et al., 2022). In contrast, racquet sports (e.g., padel) prioritize rapid visuomotor coordination, sustained attention, and processing speed due to the continuous exchange of stimuli in a more confined and structured environment, where players must track fast-moving balls and respond with precise movements (Espino Palma et al., 2023). These differing profiles may result in sport-specific cognitive adaptations, consistent with theories of cognitive transfer and neuroplasticity (Scharfen & Memmert, 2019). The intersection of cognitive transfer and neuroplasticity represents a significant avenue for exploring how sport-specific training can enhance specialized and generalized cognitive abilities (Scharfen & Memmert, 2019).

Materials and Methods

Participants

To estimate the appropriate sample size, the G*Power software (version 3.1.9.7) was used to conduct an a priori power analysis for *F* tests, specifically using the MANOVA: Global effects approach. The analysis included three groups and three dependent variables, with an effect size of $f^2(V) = 0.16$, a power value of 0.90, and a significance level of $\alpha = 0.05$. The results showed that a sample size of $N = 60$ was necessary. This effect size was based on meta-analytic evidence (Akalp et al., 2024), which demonstrated a large effect size of exercise interventions on cognitive function. More specifically, large effect sizes were also observed for different types of exercise, including aerobic and resistance training. A non-random convenience sample was recruited based on geographic accessibility, comprising 78 participants, distributed across three groups: 26 amateur rugby players, 27 amateur padel players, and 25 non-athletes. In this study, the term "amateur" refers to individuals who practice the sport regularly (minimum of 2 sessions per week) but do not receive financial compensation or compete at a professional or national level.

To ensure consistency in participant selection, the following inclusion criteria were applied: men aged between 18 and 30, with a minimum educational level equivalent to ninth grade, and proficiency in the Portuguese language. For athlete-specific selection, additional criteria were established: engagement in the respective sport at least twice a week and a minimum of two years of consistent practice. For non-athletes, the inclusion criterion required no regular participation in sports or structured exercise programs for at least two years, except for school-based physical education classes. Light recreational activities were not allowed, ensuring that the non-athlete group had minimal exposure to structured or unstructured physical activity. The study included only male participants to reduce variability associated with sex-related differences in physical and cognitive performance, although this choice limits the generalizability of the findings.

Exclusion criteria included the following: a history of neurological and/or psychiatric disorders, excluding concussions sustained during participation in the sports under study; a history of substance-related disorders (alcohol, drugs, and/or medication); sensory, motor, or language impairments that could interfere with performance on neuropsychological assessments; and a history of concussion within the past week.

Based on these criteria, eight participants were excluded: three due to a recent concussion (within the past week), one due to a sensory impairment (visual), two due to a history of psychiatric disorders, and two due to language impairments. As a result, the final sample consisted of 70 participants, divided into three groups: 23 amateur rugby players, 24 amateur padel players, and 23 non-athletes. All participants were men aged between 18 and 29 years.

To ensure group homogeneity and the validity of cognitive performance comparisons (Alves et al., 2012; Green et al., 2008), we considered the homogeneity of variables such as age, education level, and estimated premorbid intelligence across the groups.

Materials

A comprehensive questionnaire was designed to ensure that participants met the eligibility criteria and to gather relevant information. This questionnaire collected data on demographic characteristics (e.g., age, education), clinical history (e.g., sensory or nervous system disorders, and other health conditions), and physical activity patterns (e.g., engagement in exercise and sports). Additionally, a history of concussions was obtained through self-reported accounts.

Standardized and validated assessment tools were employed for all other measures. Premorbid intelligence quotient was estimated using the Irregular Word Reading Test (Alves et al., 2012) to confirm the equivalence among the study groups and, therefore, the validity of comparing their cognitive performance. Processing speed was assessed through the Digit Symbol-Coding and Symbol Search subtests of WAIS-III (Wechsler, 2008), which enabled the calculation of a Processing Speed Index. In our context, the WAIS-III is the most recent version that has been formally adapted and standardized for the Portuguese population, and its Processing Speed Index is widely used as a robust marker of processing speed in adult samples. Attention was measured using the Trail Making Test part A, while executive function was evaluated using the Trail Making Test part B (Cavaco et al., 2013; Reitan & Wolfson, 1993). The Trail Making Test is a brief but sensitive measure of processing speed, visual attention, and cognitive flexibility, with well-established norms in our population. The selection of these instruments was guided by their local standardization, psychometric robustness, extensive use in the literature on sport and cognition, and their capacity to capture the core domains of interest (processing speed, attention, and executive functions).

Procedures

The Ethics Committee of the Universidade Católica Portuguesa (Lisbon) approved the study. In accordance with the Declaration of Helsinki of the World Medical Association and the Code of Ethics of the American Psychological Association, participation was voluntary. All data were anonymized in compliance with European data privacy and security regulations [General Data Protection Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016]. Participants were recruited via social media platforms and on-site at the university. Individuals had to provide approval and sign an informed consent form to participate in the study. Assessment sessions were held individually, lasting about 30 min each. These sessions occurred either at the university or in another suitable space arranged for the participant's convenience, with privacy and a quiet environment ensured in both settings. All participants completed the same sequence of cognitive tests, and short breaks were provided between tasks to minimize fatigue.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 30.0 (IBM Corp., 2025). Descriptive analyses characterized the sample and outlined the variables. The independent variable was the type of sport practiced (rugby, padel, and non-athletes), while the dependent variables included scores on the

Trail Making Test part A, Trail Making Test part B, and the Processing Speed Index (a composite measure derived from the Digit Symbol-Coding and Symbol Search subtests).

A one-way multivariate analysis of variance (MANOVA) was conducted to assess the effect of the independent variable on multiple dependent variables. MANOVA was chosen for its ability to control Type I error, account for covariance among dependent variables, and increase statistical power (Tabachnick & Fidell, 2019). Significant MANOVA results were followed by one-way ANOVAs for each dependent variable, with Tukey's HSD post hoc tests applied where necessary.

The assumptions for MANOVA were evaluated. Six multivariate outliers were identified and excluded based on Mahalanobis distances and leverage values. Although normality, assessed by the Shapiro-Wilk test, was not fully met, the analysis remained robust due to group sizes greater than 20 and acceptable skewness ($|Sk| < 3$) and kurtosis ($|Ku| < 7$) (Kline, 1998; Tabachnick & Fidell, 2019).

Multicollinearity was assessed through bivariate correlations, revealing moderate correlations between the dependent variables, which is crucial for multivariate analysis and thus validates the assumption. The homogeneity of variance-covariance matrices was verified using Box's M test [$M = 48.321$; $F(30, 11745.065) = 1.419$; $p = .064$], and homoscedasticity was confirmed for all dependent variables.

Results

Sample Demographics

Sixty-four men, aged 18 to 29 years, participated in this study and were divided into rugby players, padel players, and non-athletes. The results reported below are based on this sample after the exclusion of six outliers identified during data screening. The *mean* (*M*) ages and corresponding *standard deviations* (*SD*) for the groups were as follows: Rugby ($M = 22.00$, $SD = 2.89$), Padel ($M = 22.77$, $SD = 2.54$), and non-athletes ($M = 21.90$, $SD = 2.44$). Participants had between 12 and 18 years of education, with the mean years of education shown below: Rugby ($M = 14.05$, $SD = 1.65$), Padel ($M = 14.09$, $SD = 1.71$), and non-athletes ($M = 13.90$, $SD = 1.67$).

Rugby players reported an average of 10.14 years of practice ($SD = 4.09$) and 3.62 weekly training sessions ($SD = 1.11$). In contrast, padel players reported an average of 4.05 years of practice ($SD = 2.51$) and 2.55 weekly training sessions ($SD = 1.10$). Notably, rugby players recorded a significantly higher average number of concussions ($M = 1.29$, $SD = 1.61$) compared to padel sport players and non-athletes, who reported no concussions.

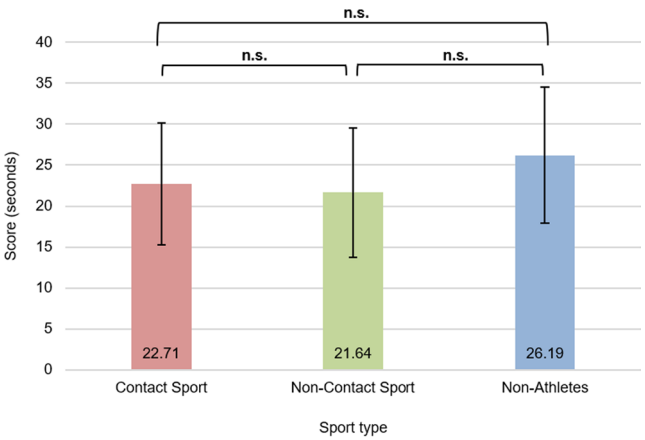
The results of the one-way ANOVA indicated no statistically significant differences among the three groups regarding age [$F(2, 61) = 0.706$, $p = .497$, $\eta^2 = 0.115$], education [$F(2, 61) = 0.071$, $p = .931$, $\eta^2 = 0.032$], or estimated premorbid intelligence [$F(2, 61) = 0.774$, $p = .466$, $\eta^2 = 0.119$]. These findings suggest that the groups are statistically equivalent in these demographic variables, supporting the validity of the subsequent comparisons of cognitive performance across the groups.

Group Differences in Cognitive Performance

The MANOVA revealed a statistically significant effect of sport type (i.e., rugby, padel, and non-athletes) on the dependent variables [Pillai's Trace = 0.295; $F(10, 116) = 2.009$; $p = .038$; $\eta^2p = .148$; $\pi = 0.862$]. A subsequent one-way ANOVA was conducted to determine whether sport type had a significant influence on performance in cognitive tests. No significant effect was found for sport type on performance in the Trail Making Test part A [$F(2, 61) = 1.942$; $p = .152$; $\eta^2p = .060$; $\pi = 0.388$]. Consistent with the analytical approach, the figures present the ANOVA post hoc results, highlighting the specific group comparisons (Fig. 1).

However. a significant effect was observed in the Trail Making Test part B [$F(2, 61) = 3.395$; $p = .040$; $\eta^2p = .100$; $\pi = 0.618$], where rugby players, ($M = 70.81$; $SD = 9,23$) demonstrated longer times, (and poorer performance) compared to padel players, ($M = 60.55$; $SD = 14.71$). In contrast, no significant differences were found between rugby players and non-athletes, ($p = .583$) or between padel players and non-athletes, ($p = .264$), (Fig. 2).

Sport type also had a significant effect on the Processing Speed Index [$F(2, 61) = 6.554$; $p < .05$; $\eta^2p = .177$; $\pi = 0.896$], as shown by performance in the Digit Symbol-Coding and Symbol Search subtests of the WAIS-III. Significant



n.s. indicates no significant differences

Fig. 1 The bar graph illustrates the mean score of Trail Making Test part A for each sport, with SD indicated by error bars

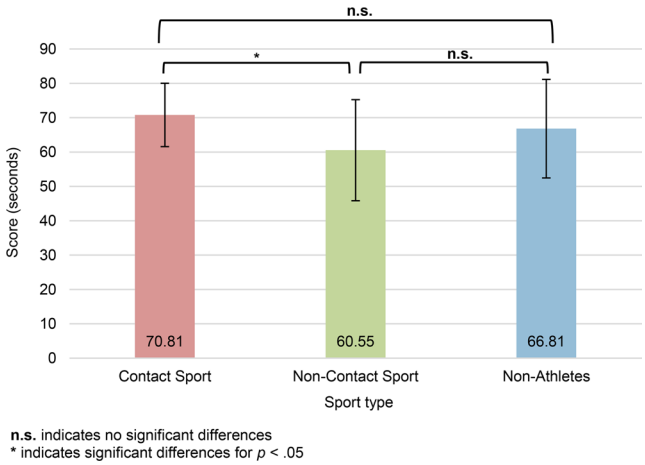


Fig. 2 The bar graph illustrates the mean score of Trail Making Test part B for each sport, with SD indicated by error bars

differences were observed between rugby and padel players (p <.05), as well as between padel players and non-athletes (p <.05). Specifically, rugby players had lower Processing Speed Index scores (M=111.33; SD=8.25) compared to padel players (M=120.82; SD=9.11). Additionally, padel players scored higher on the Processing Speed Index than non-athletes (M=113.86; SD=9.34). No significant differences were found between rugby players and non-athletes (p =.632) (Fig. 3).

Discussion

This study analyzed and compared cognitive performance among rugby players, padel players, and non-athletes, with a specific focus on processing speed, attention, and executive functions.

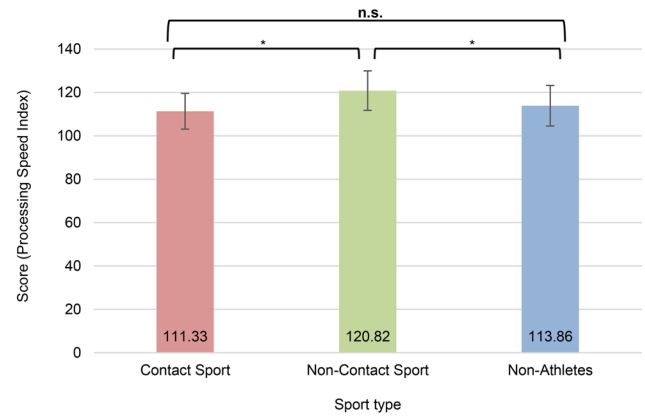


Fig. 3 The bar graph illustrates the mean score of Processing Speed Index for each sport, with SD indicated by error bars

The findings indicate that rugby athletes perform worse on tasks measuring executive functions (Trail Making Test part B) and processing speed (Processing Speed Index) than padel athletes, aligning with prior research (Tsushima et al., 2016, 2019) that reported poorer cognitive performance in contact sports athletes than in their non-contact counterparts. However, the Trail Making Test part A did not significantly differentiate between the groups, contrary to findings by Shuttleworth-Edwards and Radloff (Shuttleworth-Edwards & Radloff, 2008), who employed a larger sample size. Moreover, studies utilizing computerized neuropsychological assessments (Hume et al., 2017; Zoccola et al., 2019) further support the idea of impaired cognitive performance, particularly in processing speed and executive functions, among rugby players relative to non-contact athletes. This has been attributed in the literature to the higher frequency of concussions reported in rugby players, leading to increased cognitive vulnerability and deficits in neuropsychological tasks targeting these areas (Shuttleworth-Edwards et al., 2014; Zoccola et al., 2019). In the present study, rugby athletes reported an average of 1.29 (±1.61) concussions during their sporting careers, whereas padel athletes reported no concussions. This discrepancy may help explain the lower cognitive performance observed in rugby players (Guskiewicz et al., 2005), a finding widely discussed in the literature. Despite the potential impact of concussions on cognitive functioning, it is essential to examine and critically evaluate the differences between specific sports, as these distinctions may influence the observed cognitive outcomes.

Rugby and padel are sports that require physical attributes such as strength, speed, and endurance, although the intensity at which these qualities are demanded varies between the two sports (Guijarro-Herencia et al., 2023; Millard et al., 2023). Both require efficiency in processing speed, attention, and executive functions, with padel potentially associated with decision-making, inhibitory control (Díaz-García et al., 2023), fast interceptive actions, and visuomotor coordination, as commonly observed in racket sports like tennis and table tennis (Haryanto et al., 2024; Pacesova et al., 2018; Wang et al., 2013). Similarly, rugby is linked to anticipation and visual skills such as speed of recognition, hand–eye coordination, and saccadic eye movement (Millard et al., 2021, 2023). Although padel and rugby are distinct in their practical execution, they share similar cognitive demands, including decision-making, anticipation, and attentional control, which can be mobilized with varying frequency and intensity. The observed differences, specifically the lower performance of rugby athletes on executive function (TMT-B) and processing speed (PSI) tasks, are consistent with these sport-specific cognitive

profiles, suggesting that padel may place more frequent or more intense demands on certain executive processes.

In rugby, decision-making can be more unpredictable. The constant assessment of opponents' movements, tactical decisions made under pressure, and the physical resilience required in high-contact situations contribute to a distinct cognitive load. As previously mentioned, the repetitive exposure to head impacts common in contact sports may be associated with neurocognitive alterations, particularly affecting processing speed and executive functions (Shuttleworth-Edwards et al., 2014). This could explain why rugby players performed similarly to non-athletes in these areas, while padel players excelled compared to both groups. In contrast, padel occurs in a more controlled environment, where spatial constraints influence strategic decisions. Decision-making in padel is affected by the continuous tracking of the ball's trajectory, strategic shot placement, and opponent positioning, all within a confined playing area (Díaz-García et al., 2023; García-Giménez et al., 2022). Unlike rugby, where split-second decisions often entail physical engagement, padel relies on cognitive-motor integration without external physical contact interfering. In summary, while both sports engage similar cognitive mechanisms, the application of these processes varies according to the specific demands of each sport. Combined with sport-specific training, these processes may stimulate specific cognitive domains, potentially contributing to the distinct cognitive profiles observed in rugby and padel athletes.

Regarding non-athletes, they exhibited significantly lower Processing Speed Index scores compared to padel players. However, no significant differences were found when compared to rugby players. Although physical exercise is generally associated with physiological adaptations, such as increased brain volume and the modulation of neurotrophic factors (Mandolesi et al., 2018), these mechanisms were not evident in rugby players, which may reflect the higher risk of concussion in this group and its potential impact on cognitive functioning.

Research on the cognitive effects of padel is still limited. Nevertheless, this sport can be categorized alongside racket sports, such as tennis and table tennis, which have been demonstrated to provide cognitive benefits, especially in areas like processing speed, attention, and inhibitory control (Haryanto et al., 2024; Pacesova et al., 2018; Wang et al., 2013). Within this broader literature, the present findings are consistent with the possibility that, in this sample, padel athletes performed better than rugby players in tasks assessing processing speed (e.g., Symbol Search, Coding) and aspects of executive functioning (e.g., Trail Making Test B) that heavily rely on visual attention and precision under time constraints. While rugby players engage in more complex decision-making scenarios, the physical intensity, frequent collisions, and intermittent game flow may diminish or differentially affect the development of specific cognitive components. Thus, rather than assuming a uniform cognitive benefit of sport participation, this study highlights how the type and context of sport participation may be associated with distinct cognitive profiles. These insights may help refine theoretical models of domain-specific versus domain-general cognitive adaptations in athletes.

Several limitations must be considered when interpreting these findings. First, data collection relied on convenience sampling within a limited geographic area, which may restrict the generalizability of the results to other populations. Second, the small sample size and variability in testing conditions (e.g., some participants were evaluated after training or work) could have introduced fatigue, potentially influencing cognitive performance. In addition, concussion history was self-reported, which may have led to reporting biases and inaccuracies in detecting concussive events during rugby training or matches. Although weekly training load and years of education were measured and found to be similar across groups, other contextual factors (e.g., lifestyle habits, sleep quality, academic or occupational demands) were not controlled and may have influenced cognitive outcomes. Furthermore, all participants completed the cognitive tasks in a fixed order. Despite the inclusion of brief rest periods, the absence of test randomization introduces the possibility of order effects influencing performance.

Future studies should investigate cognitive discrepancies among rugby players based on their playing positions (e.g., forwards versus backs) and assess their cognitive performance both pre- and post-season. While head impacts are inherent in rugby, specific positions may experience varying frequencies and intensities of collisions, which can potentially affect cognitive outcomes differently. Additionally, the mandatory implementation of context-specific concussion assessment tools, such as the Sport Concussion Assessment Tool (Echemendia et al., 2017), should be considered before the season and after any suspected concussions to ensure a more accurate understanding of concussion history. Concerning padel, future investigations should extend the assessment of cognitive domains to provide a more comprehensive characterization of its cognitive demands. In addition to processing speed, attention, and executive functions, studies should examine visuospatial abilities, reaction time, and visuomotor coordination to delineate better the range and specificity of potential cognitive benefits associated with this sport. Furthermore, it can be hypothesized that sports with varying cognitive demands may naturally attract athletes with distinct skill sets. For example, padel potentially appeals to athletes with higher processing speeds, while rugby may attract those with attributes such as strength and endurance. However, given that padel is a

popular sport practiced by athletes of diverse physical conditions and ages, it may be challenging to establish that it systematically attracts individuals with superior processing speed and/or executive function efficiency. Methodologically, future research would benefit from larger, more representative samples and greater standardization of assessment procedures to enhance the validity and reliability of comparisons across sport types. The systematic use of comprehensive concussion assessment protocols and careful control of testing conditions are also recommended to ensure more accurate and methodologically robust evaluations.

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Data Availability Data are openly available on OSF at https://osf.io/zcwyg?view_only=71fad05cb32f7497e84c14b50ec5e80f8 (DOI: https://doi.org/10.17605/OSF.IO/ZCWYG).

Declarations

Competing interests The authors declare no competing interests.

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