Research, Society and Development, v. 13, n. 2, e8213244697, 2024
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v13i2.44697

The impact of sports participation on cognitive functions and academic performance among youth aged 10 to 14 years: A comprehensive investigation

O impacto da participação esportiva nas funções cognitivas e no desempenho acadêmicos dos jovens dos 10 aos 14 anos: Uma investigação abrangente

El impacto de la participación deportiva en las funciones cognitivas y el rendimiento académico entre los jóvenes de 10 a 14 años: Una investigación exhaustiva

Received: 12/20/2023 | Revised: 01/23/2024 | Accepted: 02/15/2024 | Published: 02/19/2024

Nathália Monastirski Ribeiro Campos
ORCID: https://orcid.org/0000-0002-3909-0619
Federal University of Rio Grande do Norte, Brazil
E-mail: nathaliacampos07@hotmail.com
Mateus Freitas de Medeiros
ORCID: https://orcid.org/0000-0003-4017-7997
Federal University of Rio Grande do Norte, Brazil
E-mail: MateusFreitasdeMedeiros1998@hotmail.com
Paulo Francisco de Almeida Neto
ORCID: https://orcid.org/0000-0002-2860-2260
Federal University of Rio Grande do Norte, Brazil
E-mail: paulo.neto.095@ufrn.edu.br
Izabel Augusta Hazin Pires
ORCID: https://orcid.org/0000-0002-4045-8628
Federal University of Rio Grande do Norte, Brazil
E-mail: izabel.hazin@gmail.com
Felipe José Aidar
ORCID: https://orcid.org/0000-0001-7378-4529
Federal University of Sergipe, Brazil
E-mail: fjaidar@gmail.com
Paulo Moreira Silva Dantas
ORCID: https://orcid.org/0000-0002-9217-7107
Federal University of Rio Grande do Norte, Brazil
E-mail: paulo.dantas.1@ufrn.br
Breno Guilherme de Araújo Tinôco Cabral
ORCID: https://orcid.org/0000-0002-9966-9956
Federal University of Rio Grande do Norte, Brazil
E-mail: brenotcabral@gmail.com

Abstract
Sports practice is essential for young people to perform better in the various pillars of their lives. Considering the maturational stage, this study aimed to investigate the effects of practicing sports on cognitive aspects (inhibitory control) and academic performance (report card).Seventy-five young people aged between 10 and 14 of both sexes were analyzed and divided into two groups: group I (Non-sporty), involved only in school physical education, and group II (Sporty), involved in sports initiation in addition to school physical education. Inhibitory control was assessed using the Go/No Go test and the 5-digit test (FDT). Maturation was determined using the bone age equation, and academic performance was assessed on the basis of school report card grades. There were no significant correlations between bone age, performance on cognitive tests and academic performance based on report card grades ($p \geq 0.05$). However, the cognitive tests revealed a significant disparity between the two groups. The sportsmen had significantly fewer errors in all phases of the FDT test ($p < 0.05$) than their non-sporting peers. In addition, the sports group showed superior inhibitory control, as evidenced by better performance in the Go/No Go test [7.58 ± 0.14; $p = 0.001$]. It is concluded that regardless of the correlation between maturational development, cognitive aspects and academic performance, systematized sports practice has a beneficial effect on the cognitive abilities of young people, since sports players showed better cognitive performance than non-sports players.
Keywords: Sports; Adolescent; Students; Cognition; Development.

Resumo
A prática esportiva é essencial para que os jovens tenham um melhor desempenho nos diversos pilares de suas vidas. Considerando o estágio maturacional, este estudo teve como objetivo investigar os efeitos da prática desportiva nos

aspectos cognitivos (controlo inibitório) e no desempenho académico (boletim escolar). Foram analisados setenta e cinco jovens com idade entre 10 e 14 anos, de ambos os sexos, divididos em dois grupos: grupo I (Não esportivo), envolvido apenas na educação física escolar, e grupo II (Esportivo), envolvido na iniciação esportiva além da educação física escolar. O controle inibitório foi avaliado com o teste Go/No Go e o teste de 5 dígitos (FDT). A maturação foi determinada usando a equação da idade óssea e o desempenho acadêmico foi avaliado com base nas notas do boletim escolar. Não houve correlações significativas entre a idade óssea, o desempenho nos testes cognitivos e o desempenho acadêmico com base nas notas do boletim escolar ($p \geq 0,05$). Entretanto, os testes cognitivos revelaram uma disparidade significativa entre os dois grupos. Os esportistas apresentaram significativamente menos erros em todas as fases do teste FDT ($p < 0,05$) do que seus colegas não esportistas. Além disso, o grupo esportivo apresentou controle inibitório superior, conforme evidenciado pelo melhor desempenho no teste Go/No Go [7,58 ± 0,14; p = 0,001]. Conclui-se que independente da correlação entre desenvolvimento maturacional, aspectos cognitivos e desempenho acadêmico, a prática esportiva sistematizada tem relação benéfica sobre habilidades cognitivas de juvenis, visto que os esportistas apresentaram melhor desempenho cognitivo frente aos não esportistas.
Palavras-chave: Esportes; Adolescente; Estudantes; Cognição; Desenvolvimento.

Resumen
La práctica deportiva es esencial para que los jóvenes obtengan mejores resultados en los diversos pilares de su vida. Considerando la etapa madurativa, el objetivo de este estudio fue investigar los efectos de la práctica deportiva sobre aspectos cognitivos (control inhibitorio) y el rendimiento académico (boletín de notas). Se analizaron setenta y cinco jóvenes de entre 10 y 14 años de ambos sexos, divididos en dos grupos: grupo I (No deportistas), implicados sólo en la educación física escolar, y grupo II (Deportistas), implicados en la iniciación deportiva además de la educación física escolar. El control inhibitorio se evaluó mediante el test Go/No Go y el test de los 5 dígitos (FDT). La maduración se determinó mediante la ecuación de la edad ósea, y el rendimiento académico se evaluó a partir de las notas del boletín escolar. No hubo correlaciones significativas entre la edad ósea, el rendimiento en las pruebas cognitivas y el rendimiento académico basado en las notas del boletín de notas ($p \geq 0,05$). Sin embargo, las pruebas cognitivas revelaron una disparidad significativa entre los dos grupos. Los deportistas tuvieron significativamente menos errores en todas las fases de la prueba FDT ($p < 0,05$) que sus compañeros no deportistas. Además, el grupo de deportistas mostró un control inhibitorio superior, como lo demuestra el mejor rendimiento en la prueba Go/No Go [7,58 ± 0,14; p = 0,001]. Se concluye que, independientemente de la correlación entre el desarrollo madurativo, los aspectos cognitivos y el rendimiento académico, la práctica deportiva sistematizada tiene un efecto beneficioso sobre las capacidades cognitivas de los jóvenes, ya que los deportistas mostraron un mejor rendimiento cognitivo que los no deportistas.
Palabras clave: Deportes; Adolescentes; Estudiantes; Cognición; Desarrollo.

1. Introduction

The modern lifestyle of children and adolescents is increasingly marked by sedentary behavior and poor living habits, which can harm their physical and cognitive development (Wu et al., 2017). Scientific evidence has shown that physical activity levels tend to decrease as children and adolescents age chronologically and biologically (Katzmarzyk et al., 2016; Bacil et al., 2016). In response to this concerning trend, it becomes crucial to implement physical activity programs within school environments, encouraging young individuals to adopt active habits. Early exposure to movement experiences and the development of appropriate motor skills during the school years have been associated with improved motor abilities, enhanced cognitive development, and a greater inclination toward a healthier and more active lifestyle (De Marco et al., 2015).

Engaging in sports has been linked to several mental health benefits (Rodrigues-Ayllon et al., 2019), and regular physical activity positively influences brain function and cognition (Alvarez-Bueno et al., 2017). Some studies have also demonstrated a positive relationship between the time spent on physical activity and improved school performance (de Greeff et al., 2018; Haapala et al., 2017). Additionally, research supports a positive association between motor development and cognitive functions in children and adolescentes (de Almeida-Neto et al., 2021; Savina et al., 2016). However, there are varying perspectives on the relationship between sports participation and academic performance, with Pestana et al., (2018) suggesting that sports involvement outside the school setting may positively influence overall education and human development, without necessarily impacting school performance.

Among the cognitive skills relevant to task performance, inhibitory control holds particular significance (Fuentes et al., 2014). This skill involves voluntarily suppressing responses, filtering out distractions, and maintaining a defined response

(Bjorklund & Harnishfeger, 1995). Improvements in inhibitory control correspond with the maturation of brain regions responsible for working memory and meta-cognitive abilities (Carver et al., 2001).

Furthermore, it is evident from the literature that an individual's learning capacity can significantly influence their cognitive development and academic performance (Oberer et al., 2018). Hence, it becomes essential to investigate whether engaging in physical activities may influence cognition, potentially promoting positive academic outcomes, especially considering the diverse learning processes experienced by children and adolescents. Based on this premise, our hypothesis posits that sports practice may be correlated with cognitive aspects among young individuals, thus potentially contributing to improved school performance. Consequently, the present study aims to examine the relationship between cognitive and maturational variables with school performance in children who participate in sports and those who do not. Through this investigation, we seek to shed light on the potential benefits of sports practice on cognitive development and academic achievement, providing valuable insights for educational and sports-related interventions.

2. Methodology

The study comprised 75 volunteers, including 36 males and 39 females, aged between 10 to 14 years. The participants were divided into two groups: group I (Non-Sport) consisted of 37 young individuals who were not involved in sports activities, while group II (Sport) comprised 38 young individuals engaged in initiation sports practice in addition to school physical education. All subjects were enrolled in public schools.

Data collection involved two visits to the respective sites. During the first visit, the research objectives and methodological procedures were explained to the volunteers and their guardians. On the second visit, after obtaining signed Informed Consent Forms from the parents/guardians, anthropometric measurements and cognitive tests were conducted. The cognitive assessments were administered by a qualified psychologist, adhering to the guidelines set forth by the Federal Council of Psychology (Brazil). The present study was evaluated and approved a priori by the Research Ethics Committee of the Federal University of Rio Grande do Norte (#98795318.3.0000.5537), in accordance with the requirements of the international declaration of Helsinki.

The inclusion criteria adopted for both groups were: taking part in school physical education classes, being male or female and being within the age range for the research (10 to 14 years old). For the group considered to be sports, in addition to practicing physical education at school, the subjects had to be enrolled in sports initiation clubs and train every week in the specific sport. The exclusion criteria encompassed participants who did not provide signed consent forms, lacked school report cards from the previous year, exhibited physical or cognitive limitations that could potentially impact the tests, and, in the case of the sports group, individuals who had discontinued sports practice.

2.1 Protocols and instruments

Anthropometric

For anthropometric assessments: body mass was measured using a Filizola® digital scale with capacity up to 150 kg and variation of 0.10 kg; For height, the Sanny® stadiometer accurate to 0.1 mm will be used; skin folds through a Sanny®adpometer; perimeter through the Sanny® anthropometric tape; and Sanny® caliper for bone diameters. The protocol followed ISAK (Marfell-Jones et al., 2012).

2.2 Chronological age

The chronological age was determined by the sum of the individual's months of life, from their date of birth to the date of collection, divided by 12 (Malina et al., 2009).

2.3 Bone age

The bone age protocol described by Cabral et al., (2013) was used, where bone age is defined from the following equation:

$$\text{Bone age}_{\text{(years)}} = -11.620 + 7.004 \times (\text{Height}_{\text{(m)}}) + 1.226 \times (\text{Dsex}) + 0.749 \times (\text{Age}_{\text{(years)}}) - 0.068 \times (\text{Triceps Skinfold}_{\text{(mm)}}) + 0.214 \times (\text{Corrected Arm Circumference}_{\text{(cm)}}) - 0.588 \times (\text{Humerus Diameter}_{\text{(cm)}}) + 0.388 \times (\text{Femoral Diameter}_{\text{(cm)}})$$

Dsex: For male sex = 0; for female sex = 1. (m): meters. (mm): millimeters. (cm) centimeters.

It is noteworthy that to find the correct value of the corrected arm perimeter in the equation of Cabral et al., (2013) just use the following equation:

$$\text{Corrected Arm Circumference}_{\text{(cm)}} = \text{Contracted biceps circumference}_{\text{(cm)}} - (\text{Triceps Skinfold}_{\text{(mm)}} / 10)$$

(mm): millimeters. (cm) centimeters.

Maturation stage determination

From this, the maturation component classified the individuals in delayed, normal, or accelerated maturational state, and this classification is determined by subtracting the bone age of the individual in months, by their chronological age in months. Performed the calculation, when the individual is between +1 and − 1 in relation to the sum of months of chronological age is considered normal, above + 1 is considered accelerated and below − 1 is considered late in relation to his chronological age (Malina & Bouchard, 2002).

2.4 Cognitive aspects

Go/No Go Test: It is a subtest of the NEUPSILIN-Inf Battery (Brief Infant Neuropsychological Assessment Instrument). An audio recording of 60 random numbers was presented to the child. She was told to say "yes" to every number she heard except to number 8 when she was supposed to be silent. Go/No Go is a paradigm that allows one to observe errors of omission (when the participant does not respond when expected to do so) and commission (when the patient responds when expected not to respond) (Gonçalves et al., 2017).

Five Digit Test (FDT): The FDT has four steps: read, count, choose, and toggle. The Reading phase is the simplest and has digits in quantities that exactly correspond to their values (i.e., one 1, two 2, three 3 ...), and in it the individual must recognize and name one of the numbers. The Counting phase has groups of one to five asterisks, and the individual must recognize the "set" and count the number of existing asterisks. In the Choice phase, the subject should inhibit the reading of the numbers presented and say how many numbers there are in each stimulus, presented this time incongruously (when the subject meets 2-2-2, must say "three," or when he finds 1-1-1-1, should say "four"). Finally, in the toggle phase, one in five-digit groups is delimited by a thicker border. In these stimuli, the individual is ordered to alternate between two operations, counting 80% of the items (as in choice), but breaking this routine in stimuli with the thicker edge, and he should only read one of the numbers (as in reading) (Campos et al., 2016).

2.5 School performance

School performance was assessed by analyzing each student's report card grades, and the overall average of all subjects was made (Pestana et al., 2018).

2.6 Statistics

Data were normalized by the Kolmogorov-Smirnov statistical test. The data indicated nonparametric distribution for the Go/No Go test data. Thus, the data were transformed parametrically using the log technique at the base of 10. Correlations were performed by Pearson's test. The magnitude of the results of each correlation was determined by the scale proposed by Hopkins et al., (2009): Trivial: r <0.1, small: r = 0.1-0.3, moderate: r = 0.3-0.5, large: r = 0.5-0.7, very large: r = 0, 7-0.9 and almost perfect: r> 0.9. Comparative analyzes between groups were performed using Student's independent "T" test. The Effect Size was calculated by Cohen's test (d). The magnitude of the Effect Size followed the classification described by Espírito Santo & Daniel (2017): insignificant <0.19; small 0.20-0.49; average 0.50-0.79; large 0.80-1.29; very large <1.30). All analyzes were performed using the open source statistical software R (version 3.3.5), and the significance level of p <0.05 was considered for all analyzes.

3. Results

Table 1 presents the characterization of the sample, indicating that the subjects in the Sport group had a slightly higher chronological age than those in the non-sport group (p = 0.04). However, the biological maturation assessment based on bone age demonstrated similar results in both groups (p = 0.7).

Table 1 - Sample characterization.

Variables	Total Sample	Sport	Non-Sport
N° (%)	75 (100%)	38 (50.5%)	37 (49.5%)
Male (n / %)	36 (47.9%)	16 (43%)	20 (54%)
Female (n / %)	39 (52.1%)	22(57%)	17 (46%)
Chronological Age (Yrs)	11.7±1.24	12.5±1.18	10.9±0.66
Bone Age (Yrs)	9.4±1.81	10.3±1.69	8.50±1.40
Biological Maturation	-2.28±1.16	-2.13±1.15	-2.43±1.17
Height (Cm)	147.7±17.87	153.5±8.34	141.7±22.6

CA = chronological age, BA = bone age, BM = biological maturation (%): Percentage. (n / %): Absolut number and percentage. (Cm): Centimeter. Source: Authors.

Table 2 displays the outcomes concerning the relationship between biological maturation, bone age, and average school grades, revealing no significant correlations among these variables (p > 0.05). The table also presents the correlation between the FDT cognitive test and the average scores of sports practitioners and non-sports participants. Although a weak correlation was observed between these variables, it is noteworthy that young individuals engaged in sports exhibited shorter response times in the FDT test, indicating potential enhancements in cognitive functions related to automatic attention, processing speed, controlled attention, and executive attention. However, it is essential to highlight that this positive cognitive performance did not manifest in corresponding academic achievements.

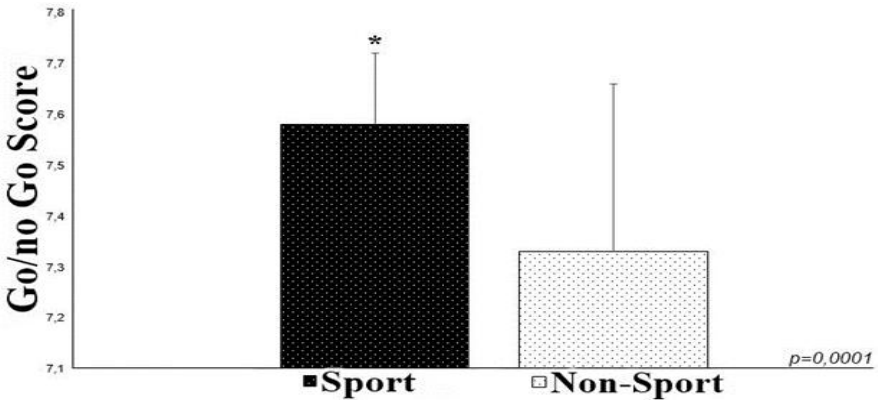
Table 2 - Correlation of maturational variables and FDT test with average of school grades among young practitioners and non-practitioners of sports.

	Non-sport (r)	p	Sport (r)	p
	Average of school grades			
Bone Age	-0.30	0.06	-0.23	0.1
Maturation	-0.15	0.3	-0.05	0.7
FDT: Reading Errors	0.007	0.9	0.13	0.4
FDT: Count Time	0.31	0.05	-0.01	0.9
FDT: Error Count	0.05	0.7	0.11	0.4
FDT: Choose Time	0.24	0.1	-0.15	0.3
FDT: Choose Errors	0.23	0.1	0.18	0.2
FDT: Alternation Time	0.22	0.1	-0.05	0.7
FDT: SwitchoverErrors	0.13	0.4	0.19	0.2

FDT = Five Digit Test. Source: Authors.

Figure 1 shows the results of comparing the Go / No Go cognitive test with the two groups measured above. There is also a significant result (Effect Size: 0.93; 95% CI: [0.45] [1.42]; p = 0.0001) for the sports group, showing that this group had better control inhibitory.

Figure 1 - Comparison of the Go/No Go test with the Sport and Non-Sport groups.



* *Highest score.* Source: Authors.

Table 3 compares the FDT cognitive test results between the two evaluated groups. Notably, the Sport group exhibited fewer errors across all phases of the test, along with superior performance in measures of automatic attention and processing speed, leading to a statistically significant difference (p < 0.05).

Table 3 - Comparison of the FDT test with the Sport and Non-Sport groups.

FDT Phases	Sports	Non-Sport	ES	95% CI	P
RT	0.54 ± 0.05*	0.59 ± 0.10	-0.54	[-1.02] [0.07]	0.02
RE	0.027 ±0.16*	0.26 ± 0.53	-0.60	[-1.07] [-0.12]	0.01
CT	0.61 ± 0.05	0.64 ± 0.07	-0.45	[-0.91] [0.01]	0.05
CE	0.27 ± 0.73*	1.05 ± 1.98	-0.52	[-0.99] [-0.05]	0.02
CT	0.79 ± 0.08	0.82 ± 0.12	-0.25	[-0.72] [0.20]	0.2
CE	1.32 ± 0.70*	2.01 ± 0.82	0.90	[-1.38] [-0.41]	0.0002
TT	0.84 ± 0.09	0.88 ± 0.13	-0.36	[-0.83] [0.09]	0.1
ET	3.56 ± 2.29*	5.43 ± 3.34	-0.65	[-1.12] [0.17]	0.006

*FDT= Five Digit Test, RT = Reading Time, RE = Reading Errors, CT = Count Time, CE = Count Errors, CT = Choose Time, CE = Choose Errors, TT = Time Toggle, ET = Error Toggle. ES = Effect Size, 95% CI = 95% Confidence Interval. * = Less time and fewer errors.* Source: Authors.

3. Results

Table 4 presents the characterization of the sample, indicating that the subjects in the Sport group had a slightly higher chronological age than those in the non-sport group (p = 0.04). However, the biological maturation assessment based on bone age demonstrated similar results in both groups (p = 0.7).

Table 4 - Sample characterization.

Variables	Total Sample	Sport	Non-Sport
N° (%)	75 (100%)	38 (50.5%)	37 (49.5%)
Male (n / %)	36 (47.9%)	16 (43%)	20 (54%)
Female (n / %)	39 (52.1%)	22(57%)	17 (46%)
Chronological Age (Yrs)	11.7±1.24	12.5±1.18	10.9±0.66
Bone Age (Yrs)	9.4±1.81	10.3±1.69	8.50±1.40
Biological Maturation	-2.28±1.16	-2.13±1.15	-2.43±1.17
Height (Cm)	147.7±17.87	153.5±8.34	141.7±22.6

CA = chronological age, BA = bone age, BM = biological maturation (%): Percentage. (n / %): Absolut number and percentage. (Cm): Centimeter. Source: Authors.

Table 5 displays the outcomes concerning the relationship between biological maturation, bone age, and average school grades, revealing no significant correlations among these variables (p > 0.05). The table also presents the correlation between the FDT cognitive test and the average scores of sports practitioners and non-sports participants. Although a weak correlation was observed between these variables, it is noteworthy that young individuals engaged in sports exhibited shorter response times in the FDT test, indicating potential enhancements in cognitive functions related to automatic attention, processing speed, controlled attention, and executive attention. However, it is essential to highlight that this positive cognitive performance did not manifest in corresponding academic achievements.

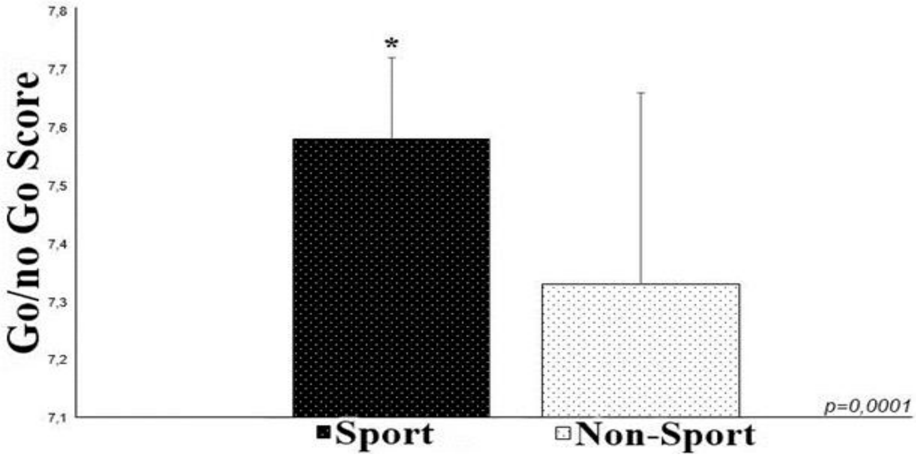
Table 5 - Correlation of maturational variables and FDT test with average of school grades among young practitioners and non-practitioners of sports.

	Non-sport (r)	p	Sport (r)	p
	Average of school grades			
Bone Age	-0.30	0.06	-0.23	0.1
Maturation	-0.15	0.3	-0.05	0.7
FDT: Reading Errors	0.007	0.9	0.13	0.4
FDT: Count Time	0.31	0.05	-0.01	0.9
FDT: Error Count	0.05	0.7	0.11	0.4
FDT: Choose Time	0.24	0.1	-0.15	0.3
FDT: Choose Errors	0.23	0.1	0.18	0.2
FDT: Alternation Time	0.22	0.1	-0.05	0.7
FDT: SwitchoverErrors	0.13	0.4	0.19	0.2

FDT = Five Digit Test. Source: Authors.

Figure 2 shows the results of comparing the Go / No Go cognitive test with the two groups measured above. There is also a significant result (Effect Size: 0.93; 95% CI: [0.45] [1.42]; p = 0.0001) for the sports group, showing that this group had better control inhibitory.

Figure 2 - Comparison of the Go/No Go test with the Sport and Non-Sport groups.



** Highest score.* Source: Authors.

Table 6 compares the FDT cognitive test results between the two evaluated groups. Notably, the Sport group exhibited fewer errors across all phases of the test, along with superior performance in measures of automatic attention and processing speed, leading to a statistically significant difference (p < 0.05).

Table 6 - Comparison of the FDT test with the Sport and Non-Sport groups.

FDT Phases	Sports	Non-Sport	ES	95% CI	P
RT	0.54 ± 0.05*	0.59 ± 0.10	-0.54	[-1.02] [0.07]	0.02
RE	0.027 ±0.16*	0.26 ± 0.53	-0.60	[-1.07] [-0.12]	0.01
CT	0.61 ± 0.05	0.64 ± 0.07	-0.45	[-0.91] [0.01]	0.05
CE	0.27 ± 0.73*	1.05 ± 1.98	-0.52	[-0.99] [-0.05]	0.02
CT	0.79 ± 0.08	0.82 ± 0.12	-0.25	[-0.72] [0.20]	0.2
CE	1.32 ± 0.70*	2.01 ± 0.82	0.90	[-1.38] [-0.41]	0.0002
TT	0.84 ± 0.09	0.88 ± 0.13	-0.36	[-0.83] [0.09]	0.1
ET	3.56 ± 2.29*	5.43 ± 3.34	-0.65	[-1.12] [0.17]	0.006

*FDT= Five Digit Test, RT = Reading Time, RE = Reading Errors, CT = Count Time, CE = Count Errors, CT = Choose Time, CE = Choose Errors, TT = Time Toggle, ET = Error Toggle. ES = Effect Size, 95% CI = 95% Confidence Interval. * = Less time and fewer errors.* Source: Authors.

4. Discussion

The primary objective of this research was to investigate the relationship between sports practice, cognitive aspects, and school performance, with particular consideration for the maturational stage of young individuals. Upon analyzing the results, it becomes evident that biological maturation and bone age did not significantly correlate with school performance, as measured by the grades on the report cards.

These findings suggest that greater maturity in young individuals may not necessarily lead to improved academic performance compared to their less mature peers. This observation aligns with a study by Barrigas & Fragoso (2012), which found no significant differences in overall academic performance between individuals with normal or advanced maturity and those with delayed maturity, however, this study reported other cognitive assessment methods, like maturation the test used and the deepening of the socioeconomic levels found in the sample.

As for the correlation between cognitive aspects and school performance, no significant correlation was found between these variables in the sports-practicing and non-sports groups (p > 0.05). However, when examining the FDT cognitive test in the Sports group, an intriguing inverse relationship was observed, indicating that shorter test times were associated with higher school grades. A study by Pestana et al., (2018), despite having a different sample from the current research, also supported these results, revealing no significant differences in academic performance between athletes and non-athletes (p = 0.626). Interestingly, the study did find positive results (Odds Ratio = 6.53; p = 0.046) for high school students engaging in regular physical activity and possessing good motor conditioning, which might be attributed to the immaturity of the prefrontal cortex in the age groups studied, which influences metacognitive abilities (Carver et al., 2001; Zelazo et al., 1996).

Upon comparing the two groups based on cognitive aspects, significantly inhibitory control, it was evident that the Sports group achieved better scores and fewer errors in both tests, indicating superior performance in measures of automatic attention, processing speed, controlled attention, and executive attention ($p < 0.05$). These findings are in line with the research by Pestana et al., (2018) which found that sports practitioners were 2.15 times more likely to achieve better classroom performance compared to inactive individuals (p = 0.028). Moreover, Haapala et al., (2017) also reported the influence of physical activity on reading ability. attributing theses benefits to various cognitives mechanisms, such as improved neuroelectric processes, enhanced blood flow to the brain (especially the hippocampus), and the development of attention span and memory capacity (Donnelly et al., 2016). This may be due to the fact that physical activity by intense human body movement implicates on the formation of new blood vessels that increases the levels of oxygen and delivery of glucose in the body, improving blood flow to the brain and helping to form new neurotransmitters and acting directly on brain neuroplasticity (Diamond, 2015).

In support of our findings, Simões (2017) observed that sports activity practitioners demonstrated superior inhibitory control compared to non-practitioners, characterized by lower response times and fewer errors. Sports that involve high demands on cognitive ability may develop better inhibitory control, taking into account the training environment, which is consistent, predictable and self-learning for practitioner (Formenti et al., 2021). Supporting this thought, Sakamoto et al., (2018) found in his study that developing subjects who continuously practiced sports showed superior performance in cognitive domains such as inhibition, short-term memory and working memory compared to sedentary subjects, attributing great power to sport in mental aspects.

From this, it is noted that students who play sports have higher cognitive abilities, however, do not get good academic performance when they are assessed due to other factors that were not measured in this research. This may be due to the fact that the academic performance is much more than a neurophysiological process and it can be related to experiences that the person have that can impact the interest in studying, like socioeconomic status, relationship with family members, teachers and friends and the intrinsic desire of dedicating it self to the academic responsibilities (Keeley & Fox, 2009).

Consequently, it is evident that students engaged in sports exhibit higher cognitive abilities, mainly inhibitory control. However, their academic performance does not necessarily reflect these cognitive advantages, potentially due to other unmeasured factors. Despite being a commonly used criterion to assess school performance, report card grades alone may not sufficiently capture an individual's cognitive aspects. As pointed out by Menezes-Filho (2007), variations in grades represent only a fraction (10 to 30%) of an individual's intellectual competence, with other factors within the school environment and personal characteristics playing significant roles. Future studies may consider alternative forms of evaluating school performance to comprehensively assess cognitive skills such as inhibitory control, which may enable students to filter distractions and concentrate better in the classroom (Chaddock-Heyman et al., 2016; Scudder et al., 2016).

5. Perspectives

Through our study, we have shed light on the positive impact of sports practice on cognitive abilities. The findings of this research hold significance for professionals working in the education of young individuals, as they provide valuable insights and contribute to a deeper understanding of the role of sports in cognitive development.

We emphasize the potential benefits of incorporating physical activities into educational settings by demonstrating the association between sports participation and improved cognitive functions. This understanding can help educators and practitioners design more effective and holistic approaches to support the cognitive growth of young learners.

Furthermore, our research adds to the growing body of knowledge in sports science, reinforcing the importance of considering physical activity to enhance cognitive capabilities among the youth. Such insights have practical implications for the development of tailored interventions and strategies that promote both physical and cognitive well-being in young individuals.

6. Conclusion

Our study reveals that the maturation observed through bone age and cognitive aspects did not exhibit significant correlations with school performance in the studied population. Nevertheless, a noteworthy disparity emerged when comparing the two groups. Young individuals engaged in sports demonstrated superior cognitive performance in various aspects, particularly in measures such as inhibitory control.

Despite their enhanced cognitive abilities, the sports practitioners school performance mirrored that of their non-practicing counterparts. This observation suggests that additional factors beyond cognitive skills may influence the academic achievements of young individuals in this age group.

Therefore, while sports practice appears to positively impact cognitive test results, it is essential to consider other variables that contribute to academic performance. Our findings underscore the complexity of factors influencing educational outcomes and highlight the need for a comprehensive approach in understanding and promoting the overall development of young learners.

Given the findings of this study, there are some limitations which are opportunities for the development of new relevant studies in the field of physical exercise and psychology. As the study is cross-sectional, we were only able to establish a relationship, opening up possibilities for longitudinal studies that will be able to see over time the influence of sport on inhibitory control (attention and response time), as well as analyzing whether there is an increase in cognitive performance over time. New studies could also compare different sports and their potential on cognitive performance, because the question arises, do basketball players (a sport with a lot of unpredictability) have the same attention and reaction time as players in more predictable sports? Another possibility is to take subjects at different maturational stages (delayed, synchronized and advanced) and the same chronological age to see if there is also a relationship between physiological and psychological aspects.

Acknowledgments

For your support and encouragement for the development of this academic article, we thank the Federal University of Rio Grande do Norte (UFRN), the Physical Activity and Health (AFISA) research base, the Child and Adolescent Maturation Research Group (GEPMAC). The National Council for Scientific Development (CNPQ) and the Higher Education Personnel Improvement Coordination (CAPES).

References

Alvarez-Bueno, C., Pesce, C., Cavero-Redondo, I., Sanchez-Lopez, M., Martínez-Hortelano, J. A., & Martinez-Vizcaino, V. (2017). The effect of physical activity interventions on children’s cognition and metacognition: A systematic review and meta-analysis. *Journal of the American Academy of Child & Adolescent Psychiatry*, *56*(9), 729-738. https://doi.org/10.1016/j.jaac.2017.06.012

Bacil, E. D. A., Piola, T. S., Watanabe, P. I., Silva, M. P. D., Legnani, R. F. S., & Campos, W. D. (2016). Biological maturation and sedentary behavior in children and adolescents: a systematic review. *Journal of Physical Education*, *27*. https://doi.org/10.4025/jphyseduc.v27i1.2730

Barrigas, C., & Fragoso, I. (2012). Maturidade, desempenho académico, capacidade de raciocínio e estatuto socioeconómico em crianças de Lisboa entre os 6 e os 13 anos de idade. *Revista Portuguesa de Educação*, *25*(1), 193-215. https://doi.org/10.21814/rpe.3021

Bjorklund, D. F., & Harnishfeger, K. K. (1995). The evolution of inhibition mechanisms and their role in human cognition and behavior. In *Interference and inhibition in cognition* (pp. 141-173). Academic Press. https://doi.org/10.1016/B978-012208930-5/50006-4

Cabral, B. G. D. A. T., Cabral, S. D. A. T., Vital, R., Lima, K. C. D., Alcantara, T., Reis, V. M., & Dantas, P. M. S. (2013). Prediction equation of bone age in sports initiation through anthropometric variables. *Revista Brasileira de Medicina do Esporte*, 19(2), 99-103. https://doi.org/10.1590/S1517-86922013000200005

Campos, M. C., Silva, M. L. D., Florêncio, N. C., & Paula, J. J. D. (2016). Confiabilidade do Teste dos Cinco Dígitos em adultos brasileiros. *Jornal brasileiro de psiquiatria*, *65*, 135-139. https://doi.org/10.1590/0047-2085000000114

Carver, A. C., Livesey, D. J., & Charles, M. (2001). Age related changes in inhibitory control as measured by stop signal task performance. *International Journal of Neuroscience*, *107*(1-2), 43-61. https://doi.org/10.3109/00207450109149756

Chaddock-Heyman, L., Erickson, K. I., Chappell, M. A., Johnson, C. L., Kienzler, C., Knecht, A., & Kramer, A. F. (2016). Aerobic fitness is associated with greater hippocampal cerebral blood flow in children. *Developmental Cognitive Neuroscience*, *20*, 52-58. https://doi.org/10.1016/j.dcn.2016.07.001

de Almeida-Neto, P. F., Campos, N. M. R., de Matos, D. G., Baxter-Jones, A. D., do Carmo Silva, B. R., Bulhões-Correia, A., ... & de Cabral, B. G. A. T. (2021). Higher levels of inhibitory control are associated with superior neuromuscular performance in adolescent athletes. Sport Sciences for Health, 1-8. https://doi.org/10.1007/s11332-021-00858-0

de Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2018). Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of science and medicine in sport*, *21*(5), 501-507. https://doi.org/10.1016/j.jsams.2017.09.595

De Marco, A. C., Zeisel, S., & Odom, S. L. (2015). An evaluation of a program to increase physical activity for young children in child care. *Early Education and Development*, *26*(1), 1-21. https://doi.org/10.1080/10409289.2014.932237

Diamond, A. B. (2015). The cognitive benefits of exercise in youth. *Current sports medicine reports*, *14*(4), 320-326. https://doi.org/10.1249/jsr.0000000000000169

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., ... & Szabo-Reed, A. N. (2016). Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Medicine and science in sports and exercise*, *48*(6), 1197. https://doi.org/10.1249/MSS.0000000000000901

Espírito Santo, H., & Daniel, F. (2017). Calcular e apresentar tamanhos do efeito em trabalhos científicos (1): as limitações do P< 0, 05 na análise de diferenças de médias de dois grupos (Calculating and Reporting Effect Sizes on Scientific Papers (1): P< 0.05 Limitations in the Analysis of Mean Differences of Two Groups). *Revista Portuguesa de Investigação Comportamental e Social*, *1*(1), 3-16. https://doi.org/10.7342/ismt.rpics.2015.1.1.14

Formenti, D., Trecroci, A., Duca, M., Cavaggioni, L., D'Angelo, F., Passi, A., & Alberti, G. (2021). Differences in inhibitory control and motor fitness in children practicing open and closed skill sports. *Scientific Reports*, *11*(1), 1-9. https://doi.org/10.1038/s41598-021-82698-z

Fuentes, D., Malloy-Diniz, L. F., de Camargo, C. H. P., & Cosenza, R. M. (2014). *Neuropsicologia-: Teoria e Prática*. Artmed Editora. https://doi.org/10.1590/S1516-44462008000300028

Gonçalves, H. A., Viapiana, V. F., Sartori, M. S., Giacomoni, C. H., Stein, L. M., & Fonseca, R. P. (2017). Funções executivas predizem o processamento de habilidades básicas de leitura, escrita e matemática? *Neuropsicologia Latinoamericana*, *9*(3). https://doi.org/10.5579/rnl.2016.0393

Haapala, E. A., Väistö, J., Lintu, N., Westgate, K., Ekelund, U., Poikkeus, A. M., & Lakka, T. A. (2017). Physical activity and sedentary time in relation to academic achievement in children. *Journal of science and medicine in sport*, *20*(6), 583-589. https://doi.org/10.1016/j.jsams.2016.11.003

Hopkins, W., Marshall, S., Batterham, A., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine+ Science in Sports+ Exercise*, *41*(1), 3-13. https://doi.org/10.1249/MSS.0b013e31818cb278

Katzmarzyk, P. T., Denstel, K. D., Beals, K., Bolling, C., Wright, C., Crouter, S. E., & Sisson, S. B. (2016). Results from the United States of America's 2016 report card on physical activity for children and youth. *Journal of physical activity and health*, *13*(s2), S307-S313. https://doi.org/10.1123/jpah.2016-0321

Keeley, T. J., & Fox, K. R. (2009). The impact of physical activity and fitness on academic achievement and cognitive performance in children. *International review of sport and exercise psychology*, *2*(2), 198-214. https://doi.org/10.1080/17509840903233822

Malina, R. M., & Bouchard, C. (2002). *Atividade física do atleta jovem: do crescimento à maturação*. Editora Roca.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2009). *Crescimento, maturação e atividade física* (Vol. 784). São Paulo: Phorte.

Marfell-Jones, M. J., Stewart, A. D., & De Ridder, J. H. (2012). *International standards for anthropometric assessment*. http://hdl.handle.net/11072/1510

Menezes-Filho, N. (2007). Os Determinantes do Desempenho Escolar do Brasil. Mimeo, Instituto Futuro Brasil.

Oberer, N., Gashaj, V., & Roebers, C. M. (2018). Executive functions, visual-motor coordination, physical fitness and academic achievement: Longitudinal relations in typically developing children. *Human movement science*, *58*, 69-79. https://doi.org/10.1016/j.humov.2018.01.003

Pestana, E. R., de Carvalho, W. R. G., de Menezes Nunes, L. A., Almeida Junior, F. D. A. D. S., & Salvador, E. P. (2018). Sports practice and factors associated with school performance in grade and high school: comparison between athletes and non-athletes. *Sport Sciences for Health*, *14*(3), 639-644. https://doi.org/10.1007/s11332-018-0478-6

Rodriguez-Ayllon, M., Cadenas-Sánchez, C., Estévez-López, F., Muñoz, N. E., Mora-Gonzalez, J., Migueles, J. H., ... & Esteban-Cornejo, I. (2019). Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: a systematic review and meta-analysis. *Sports medicine*, *49*(9), 1383-1410. https://doi.org/10.1007/s40279-019-01099-5

Sakamoto, S., Takeuchi, H., Ihara, N., Ligao, B., & Suzukawa, K. (2018). Possible requirement of executive functions for high performance in soccer. *PloS one*, *13*(8), e0201871. https://doi.org/10.1371/journal.pone.0251168

Savina, E., Garrity, K., Kenny, P., & Doerr, C. (2016). The benefits of movement for youth: A whole child approach. Contemporary School Psychology, 20 (3), 282–292. https://doi.org/10.1007/s40688-016-0084-z

Scudder, M. R., Drollette, E. S., Szabo-Reed, A. N., Lambourne, K., Fenton, C. I., Donnelly, J. E., & Hillman, C. H. (2016). Tracking the relationship between children's aerobic fitness and cognitive control. *Health Psychology*, *35*(9), 967. https://doi.org/10.1037/hea0000343

Simões, T. B. D. S. (2017). *Marcadores cognitivos e prática esportiva em jovens de 10 a 13 anos nos diferentes estágios maturacionais* (Master's thesis, Brasil). https://repositorio.ufrn.br/handle/123456789/23614

Wu, X. Y., Han, L. H., Zhang, J. H., Luo, S., Hu, J. W., & Sun, K. (2017). The influence of physical activity, sedentary behavior on health-related quality of life among the general population of children and adolescents: A systematic review. *PloS one*, *12*(11), e0187668. https://doi.org/10.1371/journal.pone.0187668

Zelazo, P. D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive development*, *11*(1), 37-63. https://doi.org/10.1016/S0885-2014(96)90027-1