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Relationship between physical condition and academic performance in rural Romanian schoolchildren

Relación entre la condición física y el rendimiento académico en escolares de zonas rurales de Rumanía

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Abstract
This study explored the relationship between body mass index (BMI) and motor skills among 5th to 8th-grade boys aged 11-14 in a rural public elementary school. Conducted in a demographically diverse school with a consistent curriculum, the research minimized external variables. BMI was determined according to international guidelines, and motor competencies were assessed using standardized tests (50-meter sprint, 1000-meter run, standing long jump, sit-up test, plank test). Cognitive tests included the Stroop Test and Digital Symbol Test. Results revealed a significant negative correlation between higher BMI and motor skills, indicating that higher BMI scores were associated with lower motor test performance. This finding highlights the detrimental impact of higher BMI on physical performance and emphasizes the importance of preventive measures and early interventions to address adolescent obesity. The study underscores the need to understand the link between physical fitness and body composition to develop effective educational and health programs. Further research is necessary to clarify causal relationships and design tailored interventions to improve motor skills and prevent childhood obesity. In addition, future studies should explore gender differences and their potential effects on academic performance and cognitive development to gain a more comprehensive understanding of the factors influencing physical and cognitive outcomes.

Keywords: body mass index (bmi); motor skills; adolescent obesity; academic performance; motor development.

Resumen
El objetivo de este estudio fue explorar la relación entre el índice de masa corporal (IMC) y las habilidades motoras en niños de 5º a 8º grado, de 11 a 14 años, en una escuela primaria pública rural. Realizado en una escuela demográficamente diversa con un currículo consistente, la investigación minimizó las variables externas. El IMC se determinó según las directrices internacionales, y las competencias motoras se evaluaron mediante pruebas estandarizadas (carrera de 50 metros, carrera de 1000 metros, salto de longitud, prueba de abdominales y prueba de plancha). Las pruebas cognitivas incluyeron la Prueba de Stroop y la Prueba de Símbolos Digitales. Los resultados revelaron una correlación negativa significativa entre un IMC más alto y las habilidades motoras, lo que indica que puntajes más altos de IMC se asociaron con un menor rendimiento en las pruebas motoras. Este hallazgo destaca el impacto perjudicial de un IMC elevado en el rendimiento físico y subraya la importancia de medidas preventivas e intervenciones tempranas para abordar la obesidad en adolescentes. El estudio resalta la necesidad de comprender el vínculo entre la aptitud física y la composición corporal para desarrollar programas educativos y de salud efectivos. Se requieren más investigaciones para aclarar las relaciones causales y diseñar intervenciones personalizadas que mejoren las habilidades motoras y prevengan la obesidad infantil. Además, los estudios futuros deben explorar las diferencias de género y sus posibles efectos sobre el rendimiento académico y el desarrollo cognitivo, para obtener una comprensión más integral de los factores que influyen en los resultados tanto físicos como cognitivos.

Palabras clave: índice de masa corporal (IMC); habilidades motoras; obesidad adolescente; rendimiento académico; desarrollo motor.

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Introduction

Physical activity is a crucial predictor of adolescent health, as highlighted by recent studies (Rollo et al., 2020). According to international guidelines, adolescents should engage in an average of sixty minutes of moderate to vigorous physical activity weekly (World Health Organization, 2020). However, despite these recommendations, more than 80% of adolescents fail to meet these guidelines (World Health Organization, 2022). Adolescents with lower levels of physical activity are at a higher risk of developing mental health issues that can persist into adulthood (Shlack et al., 2021). In addition to physical health benefits, research has shown that physical activity is linked to cognitive and academic improvements across various age groups, including children and older adults (Hillman et al., 2015).

Several physiological mechanisms are believed to underlie the positive effects of physical activity on cognitive outcomes and academic performance. A single session of physical activity (acute physical activity) increases cerebral blood flow and neurotransmitter secretion, which enhances arousal, attention, and effort, thereby improving performance on cognitive tasks (Best, 2010). Regular physical activity (chronic exercise) has been shown to induce angiogenesis, synaptogenesis, and neurogenesis, contributing to long-term improvements in brain function (Hillman et al., 2008).

Physical activity is essential for optimal metabolic processes and the healthy development of bones and muscles (Făgăraș et al., 2015). It also plays a critical role in reducing the risk of obesity, stress, and anxiety (Melanson et al., 2012). In this context, the body mass index (BMI) is a crucial indicator of physical and cognitive development. Previous studies have shown that adolescents with higher BMI levels tend to perform worse in academic subjects, such as reading and mathematics (Hsu et al., 2019). Similarly, Lv et al. (2020) found that higher BMI was associated with lower language and mathematics performance among Chinese students. These findings suggest that BMI is an essential factor influencing academic achievement. While the relationship between BMI, sports performance, and levels of physical education (PE) has been widely studied, there is limited literature specifically addressing the

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relationship between BMI, cognitive abilities, and academic performance in adolescents, which is the focus of this study.

The primary objective of this research was to examine the relationships between children's physical activity, body mass index (BMI), motor skills, cognitive abilities, and academic performance, specifically focusing on students in grades 5 to 8 in rural elementary schools. To achieve this goal, the relationship between BMI and motor skills will be analyzed, particularly in how BMI affects performance in various motor tests such as the 50-meter sprint, 1000-meter run, standing long jump, plank test, mobility test, and abdominal test. These assessments provide insights into how body weight influences children's physical performance. Additionally, the research explores the relationship between athletic status and cognitive abilities by analyzing the results of the Stroop Test and the Digital Symbols Test to determine whether students who regularly participate in sports outperform their non-athletic peers in cognitive tasks.

Materials and Methods

Participants

The research was conducted in Csíkszentdomokos (Sândominic in Romanian), located in Harghita County, Romania, a region inhabited mostly by ethnic Hungarians. The study occurred in a rural elementary school between September 2022 and July 2024. The school's ethics committee approved the study, adhering to the Helsinki Declaration and institutional guidelines. Parental consent was obtained in written form, ensuring that data collection and analysis were conducted following ethical standards.

Our research followed a quantitative approach, relying on objective measurement results and quantifiable data. Participant selection was conducted in the first step, based on questionnaires filled out by all students, 200 students aged between 11 and 15, during physical education classes with assistance from school staff. Each questionnaire took approximately 20 minutes to complete. Based on the responses, we selected students whose physical activity and sports participation met the study's criteria. Girls were excluded from the sample as their preliminary results indicated minimal participation in sports activities. This exclusion allowed the research

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to focus exclusively on boys' sports activities and to provide a more accurate analysis of the relationship between sports participation and other relevant factors. Boys who participated in organized sports at least three times a week, with each session lasting at least two hours, were included in the development group. This allowed for a clearer investigation into the connections between regular sports participation and various outcomes. The selection of non-athlete participants also followed specific criteria. Only boys between the ages of 11 and 14 who did not have chronic illnesses or health conditions that could affect their physical performance or cognitive functions were included.

The selected cohort thus contained 52 adolescent boys aged 11 to 14, divided into two groups: athletes (n=26) and non-athletes (n=26). The athletes were subdivided into judo athletes (n=13) and football players (n=13). Additionally, the non-athletes were divided into two subgroups: typically developing students and students with special educational needs (SEN).

During the two-year longitudinal study, participants' body measurements, including weight and height, were collected and used to calculate body mass index (BMI) using validated equipment. Physical performance was measured using standardized motor tests, including the 50-meter sprint, 1000-meter run, standing long jump, plank test, mobility test, and sit-up test. Previous studies grouped these tests into five fitness elements: endurance, strength, coordination, speed, and flexibility (Masanovic et al., 2020).

The parents of the selected groups were thoroughly informed about the research's further objectives and the data collection, measurement, and testing process, and they provided written consent for their children's participation.

Cognitive Tests

Cognitive functions were assessed using the Stroop Test and the Digital Symbol Test. The Stroop Test measures cognitive flexibility and selective attention by requiring participants to name the ink color of a word that spells out a different color (e.g., the word "red" printed in blue ink). The Digital Symbol Test, part of the Wechsler Adult Intelligence Scale (WAIS), assesses processing speed, attention, and visual-motor coordination by having participants match symbols to numbers within a time limit. Both tests are widely used and validated in

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cognitive research (MacLeod, 1991; Wechsler, 1955), and they have been specifically validated for use in this age group.

Table 1. summarizes key physical and cognitive performance test protocols administered to the study participants. The BMI data highlights the participants' body fat levels, which are classified into standard categories (underweight, normal, overweight, and obese) following WHO guidelines. The standing long jump test reflects lower limb strength, while the 1000-meter run test measures endurance, particularly cardiovascular and respiratory fitness. The 50-meter run assesses speed and agility, and the plank test evaluates core strength. Flexibility is measured using the mobility test, and the sit-rise test (SRT) assesses overall musculoskeletal endurance. For cognitive abilities, the Stroop test measured cognitive control and attentional flexibility, and the Digital Symbol Test assessed visual-motor speed and cognitive processing efficiency. Together, these measurements provide a comprehensive physical and cognitive performance analysis among the study's participants, allowing for a clear comparison between athletes and non-athletes.

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Table 1. Motor and Fitness Tests, Measurement Protocol

Test/Measurement	Description	Measurement Protocol
Body Mass Index (BMI)	BMI calculated using weight (kg) / [height (m)]^2. Classified per WHO guidelines. (WHO.2022)	Weight measured with a digital scale; height with a stadiometer. Barefoot, light clothing.
Standing Long Jump (Strength)	Measures lower limb strength. Best of three jump attempts recorded in cm. (Zhang et al., 2021)	Participants jump from a standing position. Rest between attempts.
1000 Meter Run (Endurance)	Tests endurance and cardiovascular health over a 1000m run, timed in minutes and seconds. (Dong et al., 2021)	Run on a flat, 300-meter track. Steady pace encouraged, timed crossing of finish line.
Mobility Test (Flexibility)	Measures flexibility in trunk, waist, hips. Seated forward bend test, best of two results recorded in cm. (Zhang et al., 2021)	Legs straight, feet flat and spaced 10-15 cm apart. Upper body leans forward. Best result taken.
50 Meter Run (Speed)	Tests speed and agility over 50m, with performance measured in seconds. (Dong et al., 2021)	Single attempt on flat track, sprinting 50 meters as fast as possible.
Plank Test (Core Strength)	Assesses core strength by maintaining a plank position. Time held is recorded. (Lemes et al., 2021)	Participants hold plank position on palms or elbows, keeping body straight.
Sit-Rise Test (Musculoskeletal Endurance)	Measures musculoskeletal endurance based on rising from a seated position without assistance. (Araujo, 1999; Brito et al., 2014)	No hands, knees, or other assistance allowed while rising from the floor.
Stroop Test (Cognitive Control)	Assesses cognitive control and attentional flexibility by naming ink colors of conflicting words. Errors and time recorded. (Stroop, 1935)	Test conducted in a quiet room. Participants name ink colors under timed conditions.
Digital Symbol Test (Cognitive Processing Speed)	Measures visual-motor and cognitive processing speed. Correct and incorrect symbol-number pairings within time limit recorded. (Wechsler, 1955)	Participants match symbols to numbers according to a key in a quiet room under time constraints.
Tracking Academic Performance	Annual academic averages recorded to track performance over two years, allowing for long-term analysis.	Academic performance data recorded annually and analyzed for changes over time.

Statistical Analyses

To analyze the data, we used linear models where the measured parameters (50-meter run, 1000-meter run, jump, plank) were explained by BMI as a continuous variable and group or subgroup as categorical variables, except for academic average, where only group or subgroup was used as a variable, excluding BMI. Two measurements were taken for the plank test and academic average (before-after and two-year end averages), so the measurement time was also used as an explanatory variable. When significant effects were observed, we compared the groups using linear hypothesis testing to determine the significance levels of the differences. The fit of the linear models was assessed by examining the distribution of the residuals: if the residuals were normally distributed, the model fit was considered good.

For linear models, we used the lm() function in the R statistical environment (version 4.2.2; Aslam & Ullah, 2023), and for linear hypothesis testing, we used the means package, R package

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version 1.8.5., available at https://rvlenth.github.io/emmeans/. Figures were created using the ggplot2 package (Wickham, 2016). For model fit diagnostics, we used the DHARMa package (Hartig, 2022).

Results

The study collected data from 52 boys, aged 11 to 14, who were participants from a rural elementary school. The participants were divided into two groups: athletes (n=26), with two subgroups formed by judo and football practicing students, and non-athletes (n=26). During the longitudinal study, spanning two years, we collected participants' body measurements, including weight and height, from which we calculated the body mass index (BMI), a standard indicator of body fat and health status worldwide (CDC, 2022). Physical performance was measured using motor tests such as the 50-meter sprint, 1000-meter run, standing long jump, plank test, mobility test, and sit-up test. Previous studies categorized these tests into five fitness elements: endurance, strength, coordination, speed, and flexibility (Masanovic et al., 2020). The standing long jump test was applied to assess the strength of the lower limbs (Zhang et al., 2021), while the students' endurance level, particularly cardiovascular and respiratory system function, and muscle endurance were assessed using the 1000-meter run test (Agrawal, Gunjal, 2023). The mobility test aimed to measure the static range of motion of the students' trunk, waist, hips, and other joints, thus assessing the level of physical flexibility development in students (Zhang et al., 2021). The 50-meter run tested the students' speed, agility, and neurological flexibility (Agrawal, Gunjal, 2023). Core strength is particularly important among various fitness components as it relates to overall physical performance and injury prevention (Faigenbaum et al., 2010), while the sit-rise test (SRT) test was particularly useful for assessing overall mobility and endurance, as it is simple to perform and quickly evaluated. By requiring participants to use their bodies to perform the task, the SRT provides a comprehensive view of their musculoskeletal endurance and functional fitness level (Barbosa Barreto de Brito et al., 2014).

A significant difference was also found between the groups in the 1000-meter run (Table 1, Figure 1b). Athletes ran the 1000 meters faster than the control group (mean_control = 5.57, SD_control = 1.49; mean_athlete = 4.45, SD_athlete = 0.6; p = 0.014). There was no significant effect at the subgroup level (Df_subgroup = 3, Df_residual = 47, F = 2.23, p = 0.096).

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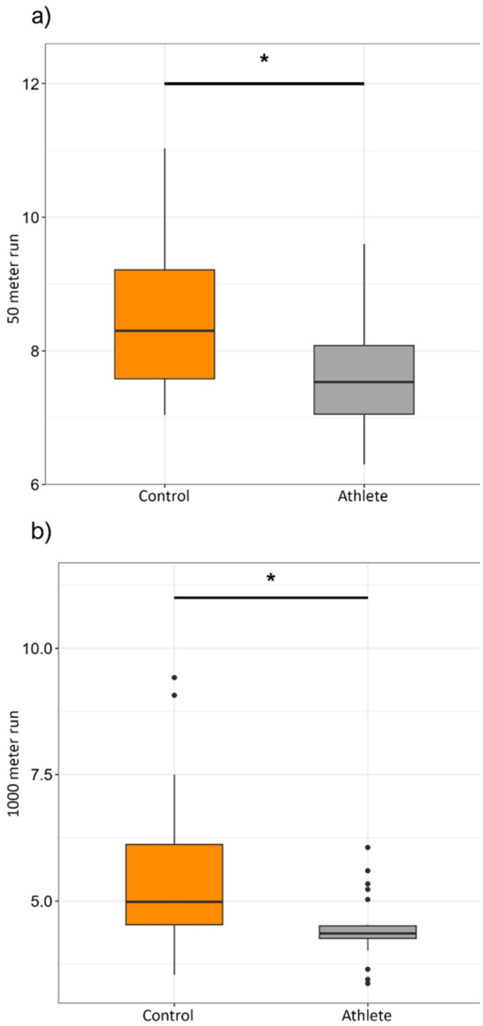

Figure 1. a) 50-meter run results by groups. The athlete group average running time was significantly lower than the control (*p < 0.05). b) 1000-meter run results with the same difference.

Generally, participants with regular weights perform better physically than their overweight peers. For example, a study on Chinese adolescents found that boys with average weight achieved significantly better results in the 50-meter sprint (Liu et al., 2023). Similarly, Swiss primary school participants showed improved motor performance over time, with BMI increases not significantly affecting performance (Nebiker, 2023).

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There is a strong correlation between BMI and long-distance running performance. Research among Chinese youths showed that those with normal weight performed better in the 1000-meter run than their overweight peers (Agrawal, Gunjal, 2023).

A similar pattern was observed in the standing long jump (table 1). Athletes jumped a greater distance than the control group (mean_control = 1.7, SD_control = 0.266; mean_athlete = 1.94, SD_athlete = 0.224; p = 0.008), but no significant differences were found at the subgroup level (Df_subgroup = 3, Df_residual = 47, F = 2.67, p = 0.058).

The standing long jump performance is significantly better for children with normal weight than their overweight or obese peers (Tomkinson et al., 2021). However, a study on Chinese university students confirmed that those with higher BMI performed worse in the standing long jump (Pi et al., 2024).

There was a significant difference between the groups in the plank test (table 2, Figure 3). Athletes could hold the plank position longer than the control group, although there was no significant change between the initial and final states (p = 0.12). Among the subgroups, the Judo subgroup could hold the plank significantly longer than the normal (p < 0.001) or SNI subgroup (p < 0.001). At the same time, there were no significant differences among the other subgroups (table 2, Figure 4).

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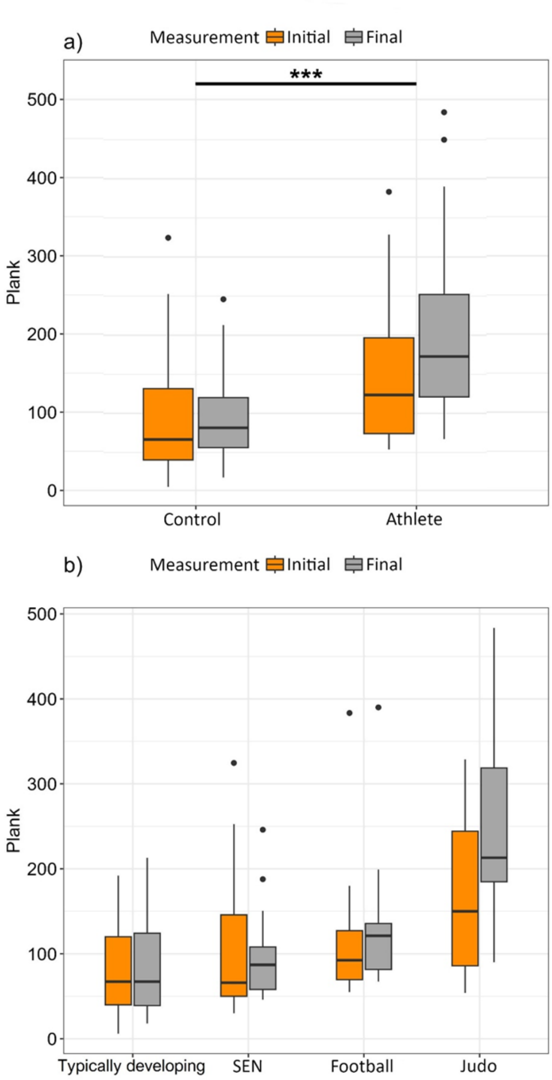

Figure 2. Plank Results by Groups (a) and Subgroups (b) (*** p < 0.001).

Similar results have been observed in other studies examining the relationship between the plank test and BMI. Guseman et al. (2020) found that normal-weight children performed significantly better in the plank test than their overweight or obese peers. Additionally, there is a close relationship between plank performance and fundamental motor skills (FMS), with children with higher FMS levels achieving better plank results, indicating that developing motor skills can improve plank performance (Pitchford et al., 2022).

Analysis of academic averages showed that athletes achieved higher results at the end of both school years compared to the control group (table 3, Figure 4). Among the subgroups, the

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academic average of the special education needs (SEN) group was significantly lower compared to the other groups ($p < 0.001$).

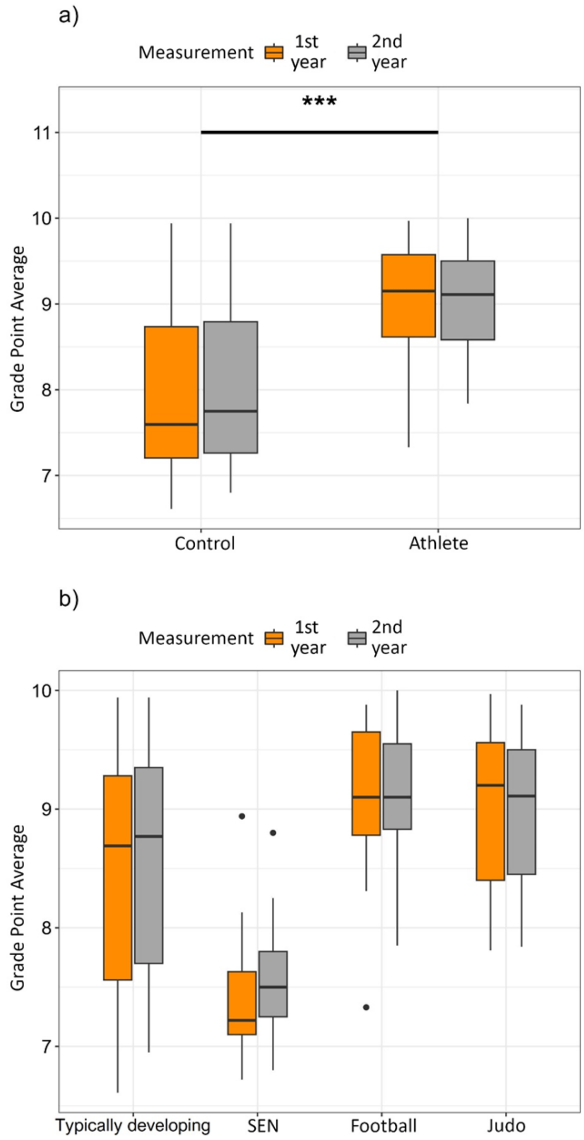

Figure 3. Academic Averages by Groups (a) and Subgroups (b) (*** $p < 0.001$).

These findings are consistent with the notion that athletes generally achieve better academic results than their non-athlete peers. A comprehensive systematic review by Latino and Tafuri (2023) demonstrated that sports positively impact academic performance, especially during school hours. The review emphasized that sports and physical activity can directly and indirectly contribute to improved academic outcomes, particularly in mathematics and science subjects.

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Moreover, participation in sports enhances school performance, particularly by improving immediate attention and task-solving abilities (Owen, 2022). Research by Trudeau and Shephard (2008) in the United States found that athletes achieved higher GPAs than non-athletes, even when controlling for socioeconomic status.

The mobility test results indicated that athletes had higher mobility than the control group (table 1, see Appendix; Figure 5a). However, there was no significant difference between the initial and final measurements. The Judo subgroup showed significantly greater mobility at the subgroup level than the typically developing or SEN subgroup (Figure 5b, $p < 0.01$).

According to the SRT results, athletes scored higher than the control group (table 1, see Appendix; Figure 5c). There was no significant difference between the initial and final measurements. At the subgroup level, athlete subgroups produced significantly better results than the normal or SEN groups ($p < 0.001$). There was no significant difference between the football and Judo subgroups (Figure 5d), nor was there a significant difference between the SEN and tye typically developing groups.

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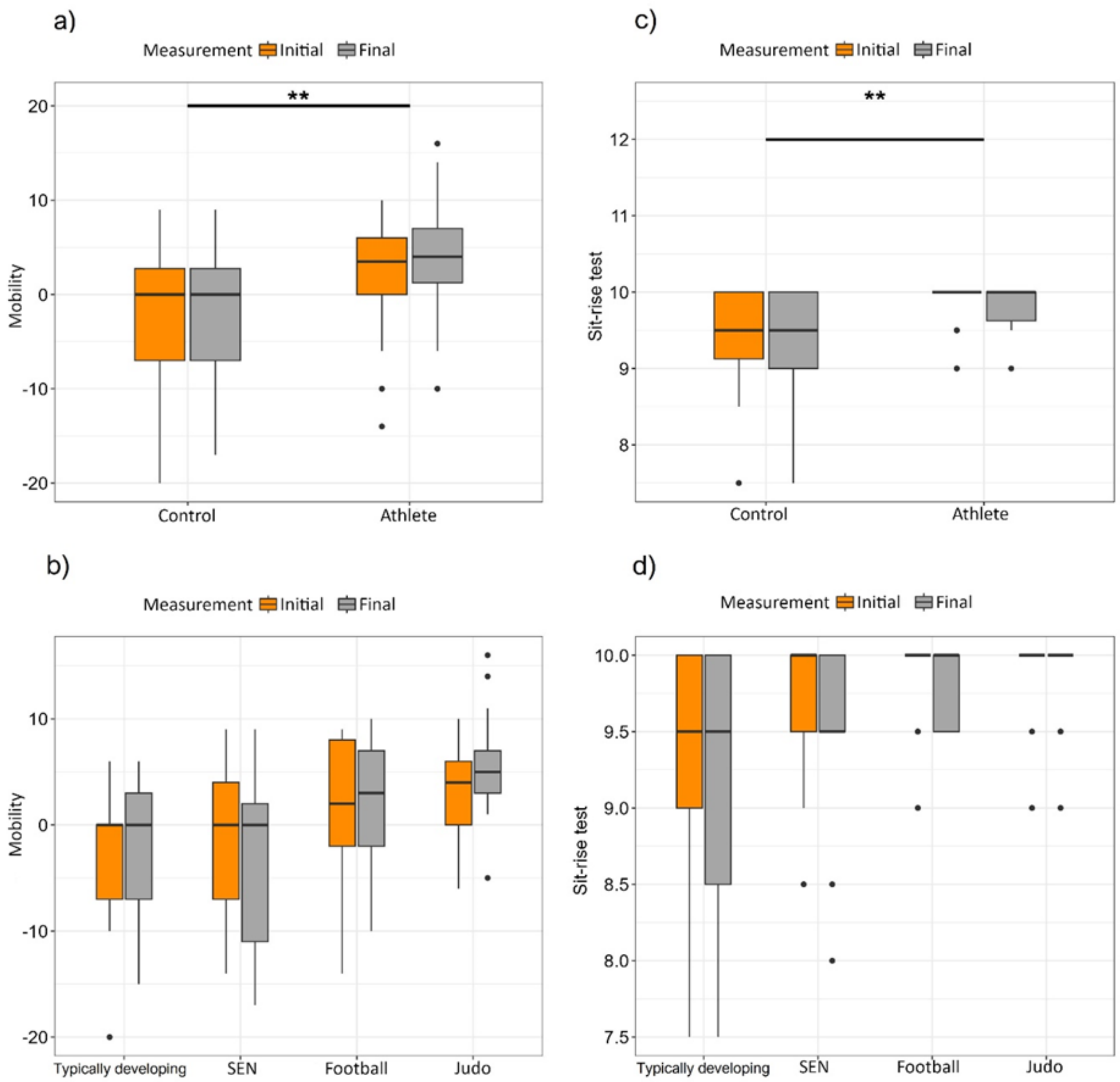

Figure 4. Results of the mobility test at a) group level and b) subgroup level; and the results of the sit-rise test also at c) group and d) subgroup level. Significant differences were found at group levels.

These findings align with other studies that analyze the relationship between sports participation and physical performance. Research by Rodrigues Pestana et al. (2018) indicated that regular physical activity and sports positively affect children's mobility and overall physical performance. Similarly, higher physical activity levels improve adolescent mobility and motor skills (Farias Júnior et al., 2012).

The SRT scores were significantly better among athletes compared to non-athletes. SRT scores are closely linked to overall physical fitness, balance, and flexibility (The Training Room PT, 2023).

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No difference was found between the groups in the time required to complete the Stroop test task (table 1, see Appendix; Figure 6a). However, at the subgroup level, the SEN subgroup required marginally more time ($p = 0.0481$; table 2, see Appendix; Figure 6b). Analysis of Stroop test errors showed that athletes made significantly fewer errors than the control group (table 1, see Appendix; Figure 6c). However, this pattern was not detectable at the subgroup level (table 2, see Appendix; Figure 6d).

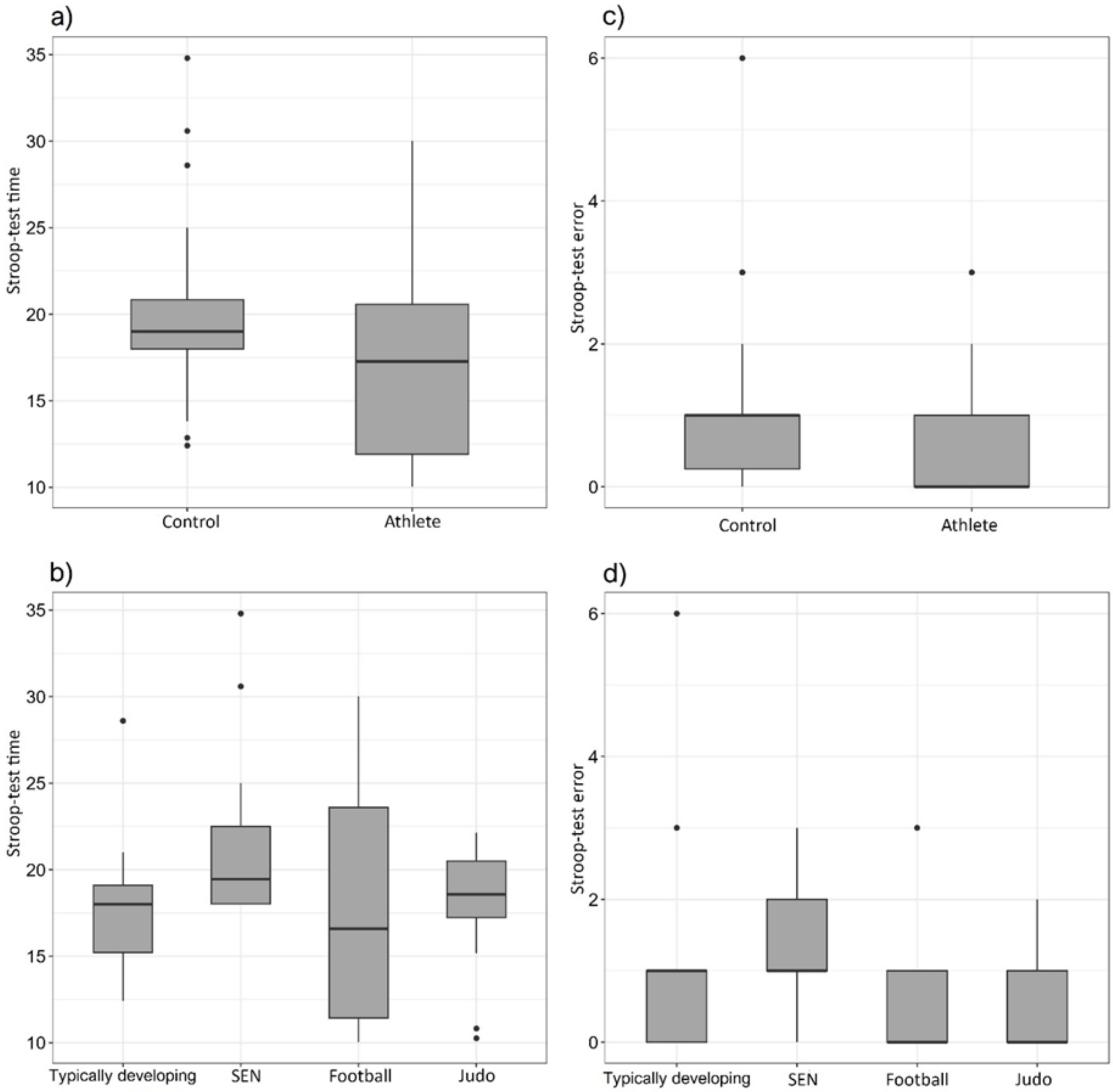

Figure 5. Results of the Stoop test time at a) group level and b) subgroup level; and the Stroop test error point also at c) group and d) subgroup level.

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A study showed that table tennis athletes have better cognitive inhibition abilities than non-athletes, reflected in smaller incongruent-related negative potential amplitudes during the color-word Stroop task (Huang et al., 2024). This cognitive efficiency is particularly important in sports requiring quick reactions, such as table tennis. Chang et al. (2012) found that athletes performed better on the Stroop test regarding reaction times and error rates, suggesting that athletes generally have better cognitive control and faster information-processing abilities. Analysis of the Digit Symbol Substitution Test (DSST) results showed that athletes generally performed better than the control group (table 1, see Appendix). However, this pattern was not detectable at the subgroup level (table 2, see Appendix).

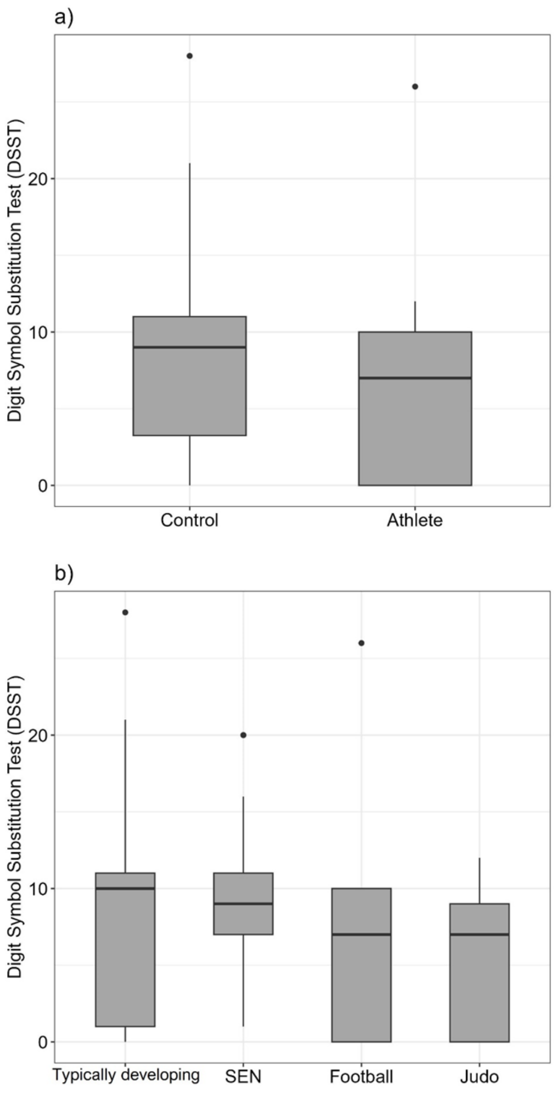

Figure 6. Digit Symbol Test by groups (a) and subgroups (b).

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Based on the Digit Symbol Substitution Test (DSST) results, athletes generally performed better than the control group. However, when examining different subgroups (normal, SEN, football, judo), no significant differences in DSST scores were found according to ANOVA results. Although the boxplots indicate some differences, they were not statistically significant, with the judo group showing better results than the other groups. This suggests that while trends indicate physical activity may positively impact cognitive performance, these differences are not always statistically significant.

Other studies have shown that athletes perform better on neuropsychological tests, including the DSST than non-athletes. Athletes' superior performance in processing speed and visuomotor coordination indicates that regular physical activity enhances cognitive functions (Swanwick et al., 2018).

Discussion

The results of this study provide valuable insights into the relationship between BMI, motor skills, athletic status, and cognitive abilities among 5th to 8th-grade boys from a rural elementary school. One of the key findings is the significant negative correlation between higher BMI and physical performance, which aligns with previous studies. For example, the 1000-meter run and standing long jump tests demonstrated that athletes outperformed their non-athlete and overweight peers, particularly those with a normal BMI. This highlights the detrimental impact of a higher BMI on physical fitness, emphasizing the importance of maintaining a healthy body weight for optimal physical development. Similar trends have been observed in other research, such as studies by Liu et al. (2023) and (Agrawal, Gunjal, 2023), reinforcing that body composition plays a critical role in motor skill proficiency.

The results also underscore the beneficial effects of sports participation on physical and cognitive abilities. Athletes consistently outperformed non-athletes in motor tests, including the plank and mobility tests. In particular, judo athletes excelled in the plank and mobility tests, likely due to the specific demands of the sport on core strength and flexibility. These findings suggest that participation in structured sports, such as judo and football, can enhance key motor skills and physical performance. This is supported by research from Pitchford et al. (2022),

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highlighting the role of core strength and fundamental motor skills in overall physical fitness and injury prevention.

Furthermore, the study observed that athletes achieved higher academic performance than non-athletes. This result is consistent with existing literature suggesting a positive relationship between physical activity and cognitive outcomes. The better academic performance of athletes may be attributed to improved cognitive functions, such as attention, memory, and executive control, which are enhanced through regular physical activity. The Stroop test results, where athletes made fewer errors than non-athletes, provide further evidence of the cognitive benefits of sports participation. These findings align with studies by Latino and Tafuri (2023), which suggest that sports participation fosters improved academic achievement, particularly in subjects requiring higher cognitive engagement, like mathematics and science.

Regarding cognitive abilities, the Stroop test and DSST revealed no significant difference in completion time between athletes and non-athletes. However, athletes made fewer errors on the Stroop test. This suggests that while the cognitive benefits of sports participation may not always be evident in processing speed, athletes exhibit better cognitive control and accuracy. The DSST results, though not statistically significant at the subgroup level, showed trends suggesting that regular physical activity could positively, albeit subtly, impact cognitive performance, such as visuomotor coordination and processing speed. This supports the notion that physical activity contributes to cognitive development, even if the effects are not always measurable through standard neuropsychological tests (Swanwick et al., 2018).

Finally, the findings emphasize the importance of early interventions and preventive measures to address childhood obesity and promote physical activity. The negative impact of higher BMI on motor performance and the academic benefits associated with sports participation highlight the need for programs that encourage physical fitness and healthy lifestyles from an early age. These interventions could improve physical health and positively influence cognitive development and academic success, as indicated by our results and supported by other studies (Araujo et al., 2020; Latino & Tafuri, 2023).

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Conclusions

This study highlights the significant impact of regular physical activity and a healthy Body Mass Index (BMI) on children's motor skills, cognitive abilities, and academic performance. Higher BMI is linked to lower physical test scores, reinforcing the need for weight management and promoting a healthier lifestyle from an early age. Additionally, children who regularly participated in sports performed better in both physical and cognitive tests, demonstrating the positive influence of sports on overall development.

The implications are clear: schools should prioritize physical activity and sports programs to enhance students' motor and cognitive development and academic success. Integrating physical education into academic curricula and encouraging healthy habits can significantly benefit children's well-being. However, the study had some limitations, such as a relatively small sample size and the exclusion of girls, which could affect the generalizability of the results. Future research should include larger, more diverse populations and examine the long-term effects of physical activity on cognitive and academic outcomes.

In conclusion, physical activity is vital in promoting children's physical health and academic achievement. By incorporating regular sports and exercise into school routines, educators can foster healthier, more successful students, paving the way for improved long-term outcomes.

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Appendix

Appendix 1. Linear model estimates for various variables by group and measurement time. Significance codes: * p<0.05, ** p < 0.01, *** p < 0.001.

		β estimate	SE	t-value	p-value
50-meter run	Intercept	6.466	0.66	9.776	<0.001 ***
	BMI	0.089	0.0279	3.188	0.0025 **
	Group (Athlete)	-0.597	0.257	-2.319	0.0246 *
1000-meter run	Intercept	2	0.678	2.953	0.005 **
	BMI	0.156	0.028	5.463	<0.001 ***
	Group (Athlete)	-0.671	0.264	-2.541	0.014 *
Long jump	Intercept	2.193	0.171	12.793	<0.001 ***
	BMI	-0.0215	0.007	-2.972	0.005 **
	Group (Athlete)	0.183	0.066	2.743	0.008 **
Plank	Intercept	168.039	46.731	3.596	0.0005 ***
	BMI	-3.376	1.931	-1.748	0.083
	Group (Athlete)	44.016	24.984	1.762	0.081
	Measurement (Final)	4.822	24.45	0.197	0.844
	Group (Athlete): Measurement (Final)	49.817	34.565	1.441	0.152
Academic average	Intercept	7.953	0.14	56.674	<0.001 ***
	Group (Athlete)	1	0.162	6.203	<0.001 ***
	Year (Second)	0.077	0.162	0.478	0.634

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Mobility	Intercept	5.004	3.341	1.498	0.137 *
	BMI	-0.33	0.14	-2.375	0.0194 *
	Group (Athlete)	4.070	1.314	3.099	<0.003 **
	Year (Second)	0.8	1.25	0.712	0.47
Sit-rise test	Intercept	11.097	0.22	50.441	<0.001 ***
	BMI	-0.073	0.009	-7.910	<0.001 ***
	Group (Athlete)	0.239	0.086	2.772	<0.006 **
	Year (Second)	-0.057	0.083	-0.694	0.489
Stroop-test time	Intercept	19.903	1.026	19.390	<0.001 ***
	Group (Athlete)	-2.493	1.452	-1.717	0.0921
Stroop-test error	Intercept	1.1923	0.2	5.719	<0.001 ***
	Group (Athlete)	-0.7308	0.294	-2.479	0.016 *
Digital Symbol Substitution Test	Intercept	9.462	1.347	7.027	<0.001 ***
	Group (Athlete)	-3.346	1.904	-1.757	0.085

Appendix 2. Anova type II table for normal, Special Educational Needs, Football and Judo subgroups.

Significance codes: * p<0.05, ** p < 0.01, *** p < 0.001. The model summary can be found in Appendix 1.

	Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
50 meter run	BMI	1	13.192	13.1921	16.2566	<0.001 ***
	Subgroup	3	4.365	1.4551	1.7931	0.1613869
	Residuals	47	38.14	0.8115		
1000 meter run	BMI	1	35.491	35.491	41.8538	<0.001 ***
	Subgroup	3	5.689	1.896	2.2362	0.09635
	Residuals	47	39.854	0.848		
Long jump	BMI	1	0.84908	0.84908	15.7291	<0.001 ***
	Subgroup	3	0.43266	0.14422	2.6717	0.0581379
	Residuals	47	2.53714	0.05398		
Plank	Measurement	1	21606	21606	3.1904	0.08
	Subgroup	3	263017	87672	12.9461	<0.001 ***
	BMI	1	28287	28287	4.0945	0.04575
	Residuals	95	677031	6908		
Grade Point Average	Semester	1	0.157	0.1569	0.278	0.5986
	Subgroup	3	40.085	13.3617	23.749	<0.001 ***
	Residuals	99	55.698	0.5626		
Mobility	BMI	1	482.2	482.15	12.0755	<0.001 ***
	Measurement	1	22.3	22.33	0.5594	0.4563016
	Subgroup	3	577.6	192.53	4.822	0.0036 **
	Residuals	98	3912.9	39.93		
Sit-rise test	BMI	1	14.9096	14.9096	83.1293	<0.001 ***
	Measurement	1	0.0796	0.0796	0.4438	0.50684
	Subgroup	3	1.5496	0.5165	2.8799	0.04 *
	Residuals	98	17.5767	0.1794		
Stroop-test time	Subgroup	3	185.58	61.861	2.3473	0.08438
	Residuals	48	1265.01	26.354		
Stroop-test error	Subgroup	3	6.981	2.3269	1.9782	0.1298
	Residuals	48	56.462	1.1763		
Digital Symbol Substitution Test	Subgroup	3	168.37	56.122	1.154	0.337
	Residuals	48	2334.31	48.631		