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The relationship of sports practice with motor performance, selective attention, cognitive flexibility and processing speed in children aged 7 to 10 years

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Open acess

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Abstract

Introduction: Sports initiation is usually started during childhood and adolescence, and the beneficial effects of this practice for physical and motor capacities are already known. Recent research has shown the potential of sports to stimulate and modify cognitive development.

Objective: To verify the relationship of sports practice during childhood on cardiorespiratory, motor, attention, cognitive flexibility and cognitive processing speed.

Methods: 130 students aged 7 to 10 years participated in the study, of which 68 were athletes and 62 non-athletes, divided into sports group and control group. The researchers carried out three visits for the application of the research instruments, which were carried out in a randomized manner within the school premises, divided into three blocks: 1) attention test for cancellation and test of tracks A and B (applied collectively); 2) jumping tests; 3) anamnesis, body composition and the Körperkoordination für Kinder (KTK) test.

Results: Children practicing sports obtained lower values in the weight (28 ± 10.08 kg vs 33.9 ± 15.3 kg), waist circumference (57.8 ± 7.7 cm vs 61.7 ± 9.6 cm) and circumference of the hip (69.1 ± 9.5 cm vs 72.8 ± 10.5 cm). In addition, we observed higher values in single-hops scores (96.9 ± 17.3 vs 85.6 ± 14.3) and lateral jumps scores (99.1 ± 18.8 vs 91.2 ± 18.0) compared to children who do not play sports. ($p < 0.05$). The high performance in single-heel jumps, side jumps, motor quotient, B-trails and B-A trails presented as predictors of sports practice (CI > 0.50).

Conclusion: The results indicated a positive relationship between children practicing sports in childhood and interesting benefits in the ability of cognitive flexibility, without expressing differences in motor coordination compared to non-practicing children.

Keywords: sport, motor coordination, cognitive flexibility, speed of cognitive processing.

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Authors summary

Why was this study done?
The initial purpose of this study is related to the empirical knowledge that involves sport, which in turn may have benefits directed to child development globally, however, few studies investigate its effects in the domains of executive functions in childhood. There is currently little research investigating the effect of sport on executive functions in children and thus the authors investigated the behavior of executive functions in children who play sports.

What did the researchers do and find?
The study refers to the comparison of anthropometric variables, body composition, motor coordination, attention and cognitive flexibility between practicing and non-practicing children. The results had very interesting effects, there was no difference in motor coordination values between practicing and non-practicing children. However, children who practice sports had higher domains of cognitive flexibility than non-practicing children, demonstrating that the effect of complexity and motor progression required by the child's insertion in sport are interesting to improve the ability of cognitive flexibility.
What do these findings mean?
Note the ability of sports to act not only on motor domains, but also on the possibility of influencing the domains of cognitive flexibility, as shown by the study results. During sports practice the child acts with various tasks, with motor and cognitive complexities, during sports practice the child will have to interpret and process a set of information before the execution of the motor gesture, requiring from the practitioner not only the motor domain but also the cognitive domain, as in the following tasks: perception of play space, accuracy of movement or play, decision making, selection of information. Thus, attention control is one of the main determinants of sports performance.

INTRODUCTION

Sports practice usually begins during childhood. This period is the most sensitive and interesting to stimulate and develop the child's fine and thick motor skills, a condition that will form and provide increase and improvement of their motor repertory which is a fundamental stimulus for good growth and biological development: aerobic and neuromuscular performance[1-3].

Moreover, in addition to the beneficial stimulusfor children's physical and motor growth and development, sports practice through motor learning is relevant for beneficial cognitive ability. In particular, among the required cognitive functions, executive function is one of the most requested cognitive constructs[4,5]. The executive function is responsible for self-regulation capacity, its function is the control of planning, organization, creativity and self-control actions, which is divided into inhibitory control, cognitive flexibility and working memory, essential elements for good development, performance and cognitive functioning and consequently have a strong contribution to social and academic Capacities[4,5].

Casey *et al.*[6] e Mischel *et al.*[7] observed in 4-year-olds the ability to postpone gratification by means ofa self-control test (marshmallow) and followed them over the years. Children who had the ability to postpone gratification at age[4], when they were 18 years old had better aspects of social cognition and academic performance if compared to the group that could not postpone gratification.

Thus, executive functions are influenced by a number of factors and among them, is sports practice, from which elements evidenced and required in decision-making, precision, strategy, reaction time, concentration, motor dexterity, among other aspects, are derived. The degree of demanding executive function is dependent on the degree of demanding physical, cognitive and motor complexity for each sport[1-3,5,8].

Consequently, sports practice has relevance in acting in the global development of children, as shown in recent research that demonstrated children practicing sports have greater cardiorespiratory, motor, attentional, executive and cognitive ability compared to non-practicing children[5,9-14].

Ishihara *et al.*[15] observed the relationship between tennis sports experience and executive function in children aged 6 to 12 years and found a positive association between higher cardiorespiratory capacity and executive function. Practice time beneficially influenced cognitive flexibility performance only in boys.

Therefore, the importance of sports practice during childhood is observed in the physical, motor and cognitive development of children. However, there are still few studies analyzing the influence of sports practice on executive function in children. These studies are aimed more onadolescents and adults[16-18]. Thus, further investigations into possible changes in executive function capabilities within sport practice during childhood are needed.

Thus, the aim of this study is to analyze the relationship of sports practice during childhood in motor coordination, attention, cognitive flexibility and cognitive processing speed.

METHODS

Sample and ethical criteria

This is an analytical cross-sectional study[19]. The study included 130 students aged 7 to 10 years, 68 practitioners of sports and 62 non-practitioners of sports, divided into group of athletes (GA) and control group (CG). All have Physical Education classes twice a week and are students from schools of the private and public schools of the Federal District. The sports practiced are ballet (1), basketball (1), soccer (11), futsal (2), artistic gymnastics (3), martial art (30) and swimming (14). The selection of the place of performance and recruitment of the study members was done by convenience and all participants had the informed consent and consent signed by their parents or guardians. The study was approved by the Research Ethics Committee of the Catholic University of Brasilia (nº 2071564).

Inclusion criteria

Inclusion criteria were: absence of diagnosis of neurological and/or psychiatric diseases, no physical problem that prevented participation in physical tests, no use of drugs that altered the senses or cognition, no history of school failure.

General procedure

Anamnesis was applied prior to the beginning of the study for parents and children separately, in order to ensure the inclusion criteria of the study, such as history of school disapproval, schooling, medication use and neurological disorders. The researchers made three visits to apply the research instruments, which were conducted randomly within the school premises, divided into three blocks: 1) attention test by cancellation and test of A and B trails (applied collectively); 2) jump tests; 3) body composition and the Körperkoordination für Kinder (KTK) test. All professionals who applied the tests were trained and the children were previously familiar with all research instruments one week before their application.

Test of A and B trails

Trail test A consists of two tasks, one of letters (A-L) and numbers (1-12), both arranged at random. The test consists of connecting the dots in alphabetical order and ascending numerical order. The trail test B consists of the presentation of letters (A to L) and numbers (1 to 12) randomly arranged on a single sheet. The task is to connect the items following an alternation in the sequence of numerical and alphabetical orders[20].

Trail A and B test performance was recorded within one minute20. The performance of the test in part A was measured by the number of hits in sequence and in part B the sequence, connections and sum. The same instructions were given to all subjects and the score was calculated by counting the correct sequences for track A. For track B, the sequences, connections and summation of sequences + connections were computed[21].

Attention Test by Cancelation

Attention test by cancelation (TAC) developed by Montiel and Capovilla[21], aims to evaluate selective and alternate attention in a visual search task, composed of three parts, with different matrices, stimuli and degrees of difficulty, with a maximum duration of one minute each test[20]. In all tests, the participant's task is to mark all stimuli equal to the target stimulus (symbols) previously determined.

In the first part of the test, the target figure was indicated at the top of the sheet, appearing randomly 50 times and arranged in 15 lines for a total of 300 figures. In the second part, the target stimulus was composed of a pair of geometrical figures that appeared randomly 7 times, arranged in 15 lines. In the third part of the test, the target stimulus changed and varied from two to six times in each line. The correctness of the tests was evaluated according to the total number of correct answers, errors and absences[21].

Anthropometric assessment and body composition

Anthropometric and body composition assessment was performed by measuring waist and hip circumference, body mass (electronic scale, Tech 05, China), height (stadiometer, Cardiomed, Brazil) and tricipital and subscapular folds (adipometer, Lange, Skinfold Caliper, USA). Using the results of the anthropometric and body composition evaluations, the body mass index [BMI = Body mass (kg)/Height^2 (m)] was established and the body fat percentage (GoC) was calculated using the calculation proposed by Slaugther *et al.*[22]. The techniques adopted to measure anthropometric variables will follow the procedures described by Petroski *et al.*[23].

Körperkoordinationstest für Kinder (KTK) test

The KTK consists of four tasks: 1) Balance beam: walking backwards along three decreasing width beams; 2) single jump: jump over obstacles of increasing height; 3) transfer on platforms: move laterally on wooden planks (20 s) and; 4) side jumps: jump with both legs from side to side (15 s)[24].

The evaluation of the coordinative capacity was performed by the motor quotient (QM), derived from the gross values obtained in each KTK task and its sum results in the total QM. It can be classified into five levels of motor coordination: high overall motor coordination; good overall motor coordination; normal overall motor coordination; inadequate overall motor coordination and; disturbance in overall motor coordination[24].

Statistical analysis

Descriptive statistics were calculated as means and standard deviations. Data normality was tested using the Shapiro-Wilk test. To compare anthropometric, physical, motor and cognitive variables between genders, Student's t-test was used. To analyze the cutoff points of anthropometric indicators and the performance of the motor test, attention, cognitive flexibility and processing speed that could identify the action of sports practice, the ROC curve technique was adopted (Receiver Operating Characteristic). The criteria used to obtain the cutoff points were the highest and closest sensitivity and specificity values, not less than 60%. The statistical significance of each analysis was verified by the area under the ROC curve and the 95% confidence interval (95% CI), so it was considered the discriminatory ability significant when the area under the ROC curve was between 1.00 and 0.60 and the lower limit of the 95% CI not less than 0.50. Bivariate and multivariate regression models were used to calculate the odds ratio (OR). The significance level of the study was $p \leq 0.05$ and the software used was the Statistical Package for the Social Sciences (SPSS), version 23.0.

RESULTS

Table 1 presents the separate anthropometric, jumping and motor coordination variables based on the children practicing and not practicing sports.

Table 1 shows that the children who practiced sports had lower values of body mass and higher values in single-legged and side jumps compared to non-sports ($p < 0.05$).

Figure 1 shows the test performance, total TAC and trails A, B and B-A according to the sport practice. It was found that children who practiced sports performed better on the B trail test than those who did not practice (P<0,05).

Table 1: Characterization of anthropometric, physical, motor, attention and executive function variables according to sports practice.

Variables	Sports practice	Does not play sports	P value
Body mass (kg)	28.9±10.08	33.9±15.3	0.03
Height (m)	1.2±0.1	1.3±0.1	0.75
BMI (kg.m²(-1))	16.7±3.2	16.9±3.04	0.85
Waist circumference (cm)	57.8±7.7	61.7±9.6	0.1
Hip circumference (cm)	69.1±9.5	72.8±10.5	0.32
Sum of skinfolds	11.01±6.9	9.72±5.9	0.34
Body fat (%)	21.6±7.8	23±8.3	0.3
Balance beam (score)	86±9.7	82.9±13.7	0.15
Single-legged jumps (score)	96.9±17.3	85.6±14.3	0.01
Side jumps (Score)	99.1±18.8	91.2±18.0	0.01
Platform transfer (score)	72.4±15.6	71.5±13.7	0.72
Motor quotient (sum of KTK scores)	335.3±41.9	331.8±82.5	0.75
Motor quotient (score)	93.9±10.1	95.7±23.7	0.57

*p< 0,05 difference between the group of practitioners and non-practitioners of sports.

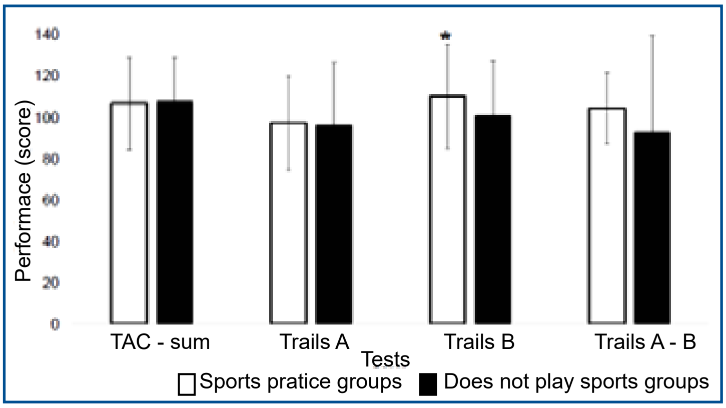

Figure 1: Shows performance on attention tests and executive function according to sports practice* Significant difference between groups.

Table 2 shows the areas under the ROC curve with the respective confidence intervals (CI) for anthropometric, motor, attention and executive function indicators in sports predisposition.

The variables that presented discriminatory power (CI> 0.50) of performance of the sports practice were the side jumps, single-legged jumps and QM score (Table 2). However, none of the variables indicated a significant odds ratio.

Table 3 shows the indicators of attention and executive function tests as influenced by sports practice (CI> 0.50). Thus, only the test of trails B and trails B-A were presented as indicators of sports practice. Sports have shown a 5.44-fold chance of higher B-track performance and 2.59-times higher B-A-track performance.

Table 2: Area under the ROC and 95% CI curve, cutoff point, sensitivity and specificity and odds ratio, between anthropometric and motor indicators with the sports practice indicator.

	Variables	Area under the curve	Cutoff point	Sensitivity / Specificity	Odds Ratio
Sports practice	BMI	0.47 (0.36;0.58)		NP	
	Waist circumference	0.46 (0.36; 0.58)		NP	
	Body fat (%)	0.51 (0.4; 0.62)		NP	
	Balance beam	0.44 (0.34; 0.54)		NP	
	Single-legged jumps	0.69 (0.60;0.79)	>68.5	(0.93-0.85)	1.25 (0.46-3.39)
	Side jumps	0.62 (0.53;0.72)	>71.5	(0.96-0.92)	0.96 (0.26-3.51)
	Motor quotient (score)	0.60 (0.50;0.71)	>73.5	(0.93-0.94)	0.52 (0.14-1.89)

Table 3: Areas under the ROC curve with the respective confidence intervals (CI) for attention and executive function indicators in sports predisposition.

	Variables	Area under the curve	Cutoff point	Sensitivity / Specificity	Odds Ratio
Sports practice	TAC- sum	0.54 (0.44;0.64)		NP	
	Trails A- sum	0.53 (0.44;0.63)		NP	
	Trails B- sum	0.67 (0.58;0.76)	>6.5	(0.96-0.80)	5.44 (1.48-19.95)*
	Trails B-A	0.70 (0.61;0.79)	>-19.5	(0.90-0.80)	2.59 (0.93-7.22)

*p<0,05 Odds Ratio.

DISCUSSION

The main results of the present study highlighted that there was no difference in the sum and motor coordination score values between the groups. They only presented differences in the tasks of lateral and single-legged jump with greater capacity in these tests for children who practice sports.

In addition, children who practiced sports had a higher ability to test cognitive flexibility compared to children who did not practice sports. These results were reaffirmed when it was observed that sports showed a predictive capacity for cognitive flexibility and cognitive processing speed, representing a 5.44 and 2.9 times Greater chance of its practitioners achieving better performance in the respective variables.

These findings reaffirm what Huijgen *et al.*[25] observed in 13- to 17-year-old adolescents, where there was a higher performance of sustained attention and cognitive flexibility in elite players compared to amateur soccer players. Accordingly, Verburgh *et al.*[26] observed that elite and amateur soccer athletes aged 8-12 years showed greater inhibitory control ability, shorter reaction time, and lower error rate in executive function tests in elite athletes compared to amateur athletes.

With reference to the above studies, it is noteworthy that sports practice is able to influence the capabilities of executive functions in its practitioners, however, the studies mentioned were performed on adolescent samples and used professional athletes, a different condition from the population of the present study that approached children who practice sports initiation. But it is interesting to note that even in children who do the sport initiation, the sport was able to provide improvements in cognitive flexibility[13,27,28].

Moreover, it is interesting to note that the performance of motor coordination did not differ between the groups, but there was a difference in cognitive flexibility, an element that contrasts recent research with children, since they bring motor coordination and cardiorespiratory fitness as determining factors to change executive function performance. The present result demonstrates that there are other components directly related to the influence on executive function, such as the cognitive demand required by the motor task, an act constantly applied during the initiation of sports with the objective of technical learning[5,13,29,30]. The possible explanation of no differences in motor coordination and body composition between the groups may be due to the group of non-practicing children and sports practitioners taking Physical Education classes twice a week, minimizing the differences between the groups.

The practice of sports is applicable to act beneficially on the development of cognitive flexibility and cognitive processing speed in children, an action directly related to the cognitive demand for sports performance. During sports practice, children face the complexity of motor and cognitive tasks, that is, when performing sports movements, they will have to interpret process and choose their motor gesture against a set of information, such as: spatial perception accuracy, movement accuracy, decision making, information selection, focus, attentional control, anticipation, among other elements. The process of issuing responses to this information will determine sports performance and therefore cognitive performance.

The great contribution of sport to the development of executive and attentional capacity is due to the brain organization for the accomplishment, learning and control of the motor task. This relationship is explained by the connection between the areas of the cerebellum, motor cortex and prefrontal cortex. The efficiency of this connection or stimuli between brain regions is entirely dependent on the motor task required of the individual by activating the prefrontal cortex which is the region responsible for controlling executive functions. The action will only be effective when performing new and/or complex motor tasks, which will require the child to cognitively process information. The motor learning of movement happens in three stages: the cognitive, associative and autonomous stages. Initially, there will be a great demand for executive and attentive processes and as learning progresses this cognitive recruitment decreases. For this reason, there is a need to act with the progression of complexity and/or novelty of movement to enable executive function stimuli, an activity commonly used in the context of sports initiation[4,5,30,31].

In addition, the sport has its relevance for the application not only for motor development but also for the cognitive development of the child, and may extrapolate the effects of sports practice to the domains of executive function in children, benefiting them in their social and educational learning process, a inherent condition in today's world. Therefore, it is suggested that the production of new experimental studies may justify the increase in motor and sports activities offered by parents and educational centers, in order to benefit children's learning and cognitive development.

Thus, it is essential to provide the child with sports experience, acting on the improvement of aerobic, motor and cognitive performances, fundamental for the maintenance of inherent health aspects and emphasizing the importance of stimulating and improving the motor gesture with the purpose of improving on executive function performance[5,32]. Although the study has some limitations regarding the impossibility of defining the neurophysiological mechanisms responsible for the results and the cause and effect relationship, since it is a cross-sectional study, it allows a greater understanding of the relationship of sports practice as an instrument that can improve children's health. Finally, further longitudinal studies are suggested, to verify whether there is a cause-effect relationship between motor improvement and increased attention and executive function, as well as indicate the possible inherent neurophysiological mechanisms of this relationship between physical and cognitive aspects.

CONCLUSION

Children practicing sports did not show differences in motor coordination and body composition results compared to children not practicing sports. Moreover, sports proved to be relevant in providing greater capacity for cognitive flexibility compared to non-practicing children, and also presented a predictor of cognitive flexibility and processing speed in children.

Finally, the results indicate a positive relationship between children practicing sports in childhood and the ability of cognitive flexibility, without expressing differences in motor coordination compared to children who only attend school physical education. This outcome is interesting for the school because it facilitates the Student's learning, in order to present a new perspective to Physical Education professionals to act through sports initiation of children, adapting the lesson planning not only to the physical, but also cognitive aspects.

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Resumo

Introdução: A iniciação esportiva é geralmente iniciada durante a infância e adolescência. Já é conhecido os efeitos benéficos desta prática para as capacidades físicas e motoras. Pesquisas recentes vêm demonstrando o potencial da prática esportiva em estimular e modificar o desenvolvimento cognitivo.

Objetivo: Analisar a relação da prática esportiva durante a infância na coordenação motora, atenção, flexibilidade cognitiva e velocidade de processamento cognitivo.

Método: Participaram do estudo 130 estudantes com idades entre 7 a 10 anos, sendo 68 praticantes de modalidades esportivas e 62 não praticantes de modalidades esportivas, divididos em grupo de esportistas (GE) e grupo controle (GC). Os pesquisadores realizaram três visitas para aplicação dos instrumentos de pesquisa, os quais foram realizados de forma aleatorizada dentro das dependências da escola, divididos em três blocos: 1) teste de atenção por cancelamento e teste de trilhas A e B (aplicados de forma coletiva); 2) testes de saltos; 3) anamnese, composição corporal e o teste Körperkoordination für Kinder (KTK).

Resultados: Crianças que praticam esporte obtiveram menores valores nas variáveis massa corporal (28 ± 10,08 kg vs 33,9 ± 15,3 kg), circunferência da cintura (57,8 ± 7,7 cm vs 61,7 ± 9,6 cm) e circunferência do quadril (69,1 ± 9,5 cm vs 72,8 ± 10,5 cm). Ademais, observam-se maiores valores nos dos saltos monopedais (96,9 ± 17,3 vs 85,6 ± 14,3) e saltos laterais (99,1 ± 18,8 vs 91,2 ± 18,0) em comparação às crianças que não praticam esporte ($p < 0,05$). O alto desempenho nos saltos monopedais, saltos laterais, quociente motor, trilhas B e Trilhas B-A apresentaram-se como preditores da prática esportiva (IC > 0,50).

Conclusão: Os resultados indicaram relação positiva entre crianças praticantes de modalidades esportivas na infância e benefícios interessantes na capacidade da flexibilidade cognitiva, sem expressar diferenças na coordenação motora em comparação às crianças não praticantes.

Palavras-chave: esporte, coordenação motora, flexibilidade cognitiva, velocidade de processamento cognitivo.