

A SINGLE PHYSICAL EDUCATION SESSION IMPROVES SUBSEQUENT ACADEMIC PERFORMANCE IN RURAL SCHOOL STUDENTS



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UMA ÚNICA AULA DE EDUCAÇÃO FÍSICA MELHORA O DESEMPENHO ACADÊMICO SUBSEQUENTE EM ESTUDANTES DE ESCOLA RURAL

UNA ÚNICA CLASE DE EDUCACIÓN FÍSICA MEJORA EL POSTERIOR DESEMPEÑO ACADÉMICO EN ALUMNOS DE ESCUELA RURAL

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ABSTRACT

Introduction: Activity breaks or physical exercise interventions in schools are linked to better cognitive function in adolescents. However, few studies have evaluated the relationship between physical exercise and cognition in rural schools, where drop-out levels tend to be higher and academic achievement lower. **Objective:** To analyze the effects of a physical exercise class (PE) on subsequent academic performance of students, and how they felt during mathematics (MATH) and Portuguese language (PL) tests. **Methods:** Thirty-six students (14.9 ± 1.5 years) randomly carried out 30 min of PE, performed at $74.3 \pm 11.8\%HR_{max}$, while a control group (CON) remained seated watching a movie, prior to the tests (PE-MATH; PE-PL; CON-MATH; CON-PL). **Results:** The PE-MATH group presented higher scores (5.3 ± 2.2) than the CON-MATH group (4.0 ± 2.2). The tests were completed more quickly in PE-PL (7.8 ± 3.3 minutes) than in CON-PL (10.5 ± 4.2 minutes). The number of correct answer per minute was higher in PE-MATH and PE-PL (0.52 ± 0.25 ; 0.64 ± 0.51) than in CON-MATH and CON-PL (0.35 ± 0.19 ; 0.41 ± 0.41). Furthermore, 38.9% of PE-MATH felt more focused during the test, while only 16.7% of CON-MATH felt more focused. During the Portuguese language test, 27.8% of CON-PL complained of greater apprehensiveness, compared to 8.3% for PE-PL. Also, 36.1% reported feeling fatigued during PL after PE, compared to 8.3% in the CON-PL group. **Conclusions:** PE improved the adolescents' academic performance. Despite feeling fatigue, more students who performed physical exercise felt less apprehensive and more focused during the tests after PE. **Level of evidence I; STARD: studies of diagnostic accuracy.**

Keywords: Academic performance; Adolescents; Exercise.

RESUMO

Introdução: Os intervalos com atividade ou as intervenções com programas de exercícios na escola estão relacionados com a melhora da função cognitiva em adolescentes. Contudo, poucos estudos avaliaram a relação entre exercício físico e cognição em escolas de zonas rurais, onde os níveis de evasão são altos e o rendimento acadêmico é baixo. **Objetivo:** Analisar os efeitos de uma aula de exercício físico (EF) sobre o desempenho acadêmico subsequente dos alunos e o que sentem durante os testes de matemática (MAT) e de língua portuguesa (PO). **Métodos:** Trinta e seis estudantes ($14,9 \pm 1,5$ anos) foram divididos randomicamente em dois grupos: um com 30 minutos de EF realizados a $74,3 \pm 11,8\%$ da FC_{max} e um controle (CON), que permaneceram sentados assistindo a um filme antes dos testes (EF-MAT; EF-PO; CON-MAT; CON-PO). **Resultados:** O EF-MAT apresentou maior escore ($5,3 \pm 2,2$) que o CON-MAT ($4,0 \pm 2,2$). Os testes foram concluídos mais rapidamente no EF-PO ($7,8 \pm 3,3$) do que no CON-PO ($10,5 \pm 4,2$). O número de respostas corretas por minuto foi maior no EF-MAT e no EF-PO ($0,52 \pm 0,25$; $0,64 \pm 0,51$) do que no CON-MAT e no CON-PO ($0,35 \pm 0,19$; $0,41 \pm 0,41$). Além disso, 38,9% do EF-MAT sentiram que estavam mais concentrados durante o teste, em comparação com apenas 16,7% do CON-MAT que se sentiram mais concentrados. Durante o teste de português, 27,8% dos CON-PO reclamaram de maior apreensão quando comparados com 8,3% do EF-PO. Ainda, 36,1% relataram cansaço durante o teste de PO depois de EF, comparados com 8,3% do grupo CON-PO. **Conclusão:** A aula de EF melhorou o desempenho acadêmico dos adolescentes. Apesar da sensação de cansaço, mais estudantes sentiram menos apreensão e estavam mais concentrados durante os testes depois de EF. **Nível de evidência I; Estudos de acurácia diagnóstica (STARD).**

Descritores: Desempenho acadêmico; Adolescentes; Exercício físico

RESUMEN

Introducción: Los intervalos con actividad o las intervenciones con programas de ejercicios en la escuela están relacionados con la mejora de la función cognitiva en adolescentes. Sin embargo, pocos estudios evaluaron la relación entre ejercicio físico y cognición en escuelas de zonas rurales, en donde los niveles de evasión son altos y el rendimiento académico es bajo. **Objetivo:** Analizar los efectos de una clase de ejercicio físico (EF) sobre el desempeño académico subsiguiente de los alumnos y lo que sienten durante los tests de matemática (MAT) y de idioma portugués

(PO). Métodos: Treinta y seis estudiantes ($14,9 \pm 1,5$ años) fueron divididos aleatoriamente en dos grupos: uno con 30 minutos de EF realizados a $74,3 \pm 11,8\%$ de la $FC_{\text{máx}}$ y un control (CON), que permanecieron sentados viendo una película antes de los tests (EF-MAT; EF-PO; CON-MAT; CON-PO). Resultados: El EF-MAT presentó mayor puntuación ($5,3 \pm 2,2$) que el CON-MAT ($4,0 \pm 2,2$). Los tests fueron concluidos más rápidamente en el EF-PO ($7,8 \pm 3,3$) que en el CON-PO ($10,5 \pm 4,2$). El número de respuestas correctas por minuto fue mayor en el EF-MAT y en el EF-PO ($0,52 \pm 0,25$, $0,64 \pm 0,51$) que en el CON-MAT y en el CON-PO ($0,35 \pm 0,19$, $0,41 \pm 0,41$). Además, 38,9% del EF-MAT sintió que estaba más concentrado durante el test, en comparación con sólo 16,7% del CON-MAT que se sintió más concentrado. Durante la prueba de portugués, 27,8% de los CON-PO reclamó de mayor aprehensión cuando comparado con 8,3% del EF-PO. Además, 36,1% relató cansancio durante el test de PO después del EF, comparado con el 8,3% del grupo CON-PO. Conclusión: La clase de EF mejoró el desempeño académico de los adolescentes. A pesar de la sensación de cansancio, más estudiantes sintieron menos aprehensión y estaban más concentrados durante los tests después de EF. **Nivel de evidencia I; Estudios de precisión diagnóstica (STARD).**

Descriptor: Rendimiento académico; Adolescentes; Ejercicio físico.

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INTRODUCTION

In the countryside of Brazil, the number of schools and teachers is sometimes insufficient to meet the demand of students. Because of that, children are usually not segregated by age group, so a mix of students of different grades within the same class occurs. This may affect the teaching and learning process and thus the cognitive development of children. This education gap may be a major cause of school dropout and reflects the low level of education and the high rate of functional illiteracy in Brazilian rural zones.¹

Several strategies have been implemented to improve the teaching and learning process. Improvements in cognitive function² and academic performance³ are among several benefits of participation in a physical exercise program and/or maintaining a higher level of physical fitness.

Studies have demonstrated a positive association between physical activity and the cognitive function in children.^{4,5} In addition, cognitive improvement after physical activity appear to be dependent on the level of physical fitness⁶ on the socioeconomic and cultural aspects of individuals.⁷ The possible mechanisms associated with physical activity in the cognitive response can be explained by increased cerebral blood flow, nutrient availability and increased activity of neurotransmitters. In addition, studies have show that circulation levels of brain-derived neurotrophic factor are increased with more intense exercise.⁸

Participation in a long term physical activity program does not only contribute to improved cognition during specific tests, but also results in better academic performance. Although it has been observed⁹ that children living in Brazil's countryside are more active than those living in urban areas, those who have PE classes exhibit better motor development. Many countryside kids, however, often perform farm work and have little free time and fewer opportunities to participate in sports. Thus, although the higher aerobic fitness and the practice of physical activity are associated with better academic performance^{10,11} no study has investigated this relationship in rural schools.

Studies involving the assessment of cognitive performance after exercise have generally been conducted in laboratories, with the participation of children from urban areas and after a long-term period of intervention. The contribution of acute exercise on cognitive performance of students from a rural zone has not yet been investigated. Thus, this study aimed to evaluate the effects of a moderate-intensity PE class on subsequent academic performance in Mathematics and Portuguese tests in children from rural schools and to determine the perceptions and feelings of these participants while performing the tests after 30 minutes of PE class.

MATERIALS AND METHODS

Subjects

Thirty-six adolescents (n=17 boys and n=19 girls), aged between 14 and 16 years, enrolled in the 8th and 9th grade of a high school in a rural public school participated in this study. The exclusion criteria were having any health problem or locomotor limitations that could impair participation in the study. Participation in the study took place after the guardian of each adolescent signed the informed consent form.

Procedures

This study was approved by the Research Ethics Committee of Human Research at University (CAAE 11624312.8.0000.0029). Participants underwent four experimental sessions in random order, a minimum of 48 hours apart. Two sessions, consisting of a 30-minute PE class and two control sessions (CON) without PE class, were followed by Math or Portuguese tests.

The Math and Portuguese tests were similar to those usually administered to adolescents from the 8th and 9th grades in Brazil. The Math and Portuguese tests had the same level of difficulty and were developed and corrected by the students' teachers. The time necessary to complete the tests was between 5 and 15 minutes. After the completion of each intervention (PE or CON), the students went to the bathroom to wash their hands and face and returned to the classroom to start the tests. At 10 minutes after PE class or CON, the tests were started. The individual time to complete each test was recorded, and then the students answered a questionnaire about their feelings and perceptions while doing the tests.

Physical Education (PE) Class

The PE class lasted 30 minutes and consisted of several games and activities. The activities and duration were: Dodge ball – 10 minutes; Tag play – 10 minutes of tag; Recreational soccer – 5 minutes; and Circuit training – 5 minutes (2 times: 20 m sprint / 5 sit-ups / 20 m sprint / 5 burpee / 20 m running from side to side doing jumping jacks / 200 m running). The intensity of the session was determined from the heart rate (HR) measurement through radial artery palpation at the end of the session. This measurement was practiced successively until the subjects performed the count properly as supervised by researchers. The maximum heart rate ($HR_{\text{máx}}$) was calculated using the equation $208 - (0.7 \times \text{age})$.¹² The intensity of PE class was set between 70 and 85% $HR_{\text{máx}}$, which corresponds to moderate intensity.¹³ At the end of the PE session, the subjects were taken to the bathroom to wash their hands and face and then were conducted to a classroom to perform the Math and Portuguese tests, which started 10 minutes after the end of intervention.

Control Session (CON)

The subjects remained seated in the classroom watching the movie *Nanny McPhee: Full Cast & Crew* with 95 minutes of duration, but only 30 minutes were watched. Each part of movie with 30 minutes was presented in order in each experimental session. Heart rate was recorded 30 minutes after the start of the movie as was done at the end of the 30-minute interventional PE session. Afterwards, the students were taken to the bathroom to wash their hands and face and into the classroom to perform the Math or Portuguese test for both PE and CON sessions.

Mathematics Test

The mathematics tests consisted of seven operation questions involving addition, subtraction, and multiplication. Each correct answer was given 1.43 points for a possible 10 points if all seven questions were answered correctly. Both math tests were similar in content and level of difficulty at each math session. The students' teacher was responsible for the adjustments of the questions and level of difficulty of both Math tests.

Portuguese Language Test

The Portuguese language test consisted of 10 lines of text and four questions for reading comprehension evaluation. Each correct answer was given 2.5 points for a possible 10 points if all four questions were answered correctly. Both tests were similar in content and level of difficulty at sessions. The students' teacher was responsible for the adjustments of the questions and level of difficulty of both Portuguese language test.

Feelings and Perceptions Questionnaire

The students answered a questionnaire about their feelings and perceptions while doing the tests. The questions contained options about the possible feelings and perceptions of the students. These options included: feeling disperse, hot, fearful, anxious, fatigued, focused, concentrated, confident, unfocused and preoccupied.

Statistical analysis

Descriptive statistics were used to summarize the general characteristics of the sample. Data normality was verified by the Shapiro-Wilk test. The paired t-test was used to analyze and compare the number of correct answers on the Math and Portuguese tests and the total time needed to complete the test and HR measured between sessions. The frequency of the perception's assessment was expressed in percentages and analyzed with the chi-square test for proportions. IBM SPSS Statistics 20 for Windows, GraphPad Prism 6.0, and Microsoft Excel® 2010 were used to analyze, graph, and collect the data, respectively. The significance level was set at $p < 0.05$.

RESULTS

The comparison between genders was performed, but the only difference observed was in their height, which does not affect cognitive performance. Therefore, the data are presented without distinction between genders. Table 1 presents the anthropometric characteristics of the sample.

The Table 2 presents the HR values obtained at the end of the sessions, the number of correct answers and the time spent to complete each test (Math and Portuguese). The %HR_{max} during PE sessions classified them at moderate intensity. HR was higher at the end of 30 minutes of PE when compared to the CON session. When compared to the CON session, prior PE tests resulted in a greater number of correct answers on the Math test and less time spent to complete the Portuguese test, which was performed 2.6 minutes faster.

No significant correlation was observed between number of correct answers and time to complete the tests with body mass and BMI. (Table 2)

The Figure 1 shows the correct answers per minute (CA/min) obtained during the tests. A greater number of CA/min was found when previous PE sessions were performed (PE-MATH: 0.52 ± 0.25 vs. CON-MATH: 0.35 ± 0.19 CA/min, $p = 0.0005$; and PE-PL: 0.64 ± 0.51 vs. CON-PL 0.41 ± 0.41 CA/min, $p = 0.03$).

The Table 3 shows the perceptions and feelings recorded by the participants during the Math and Portuguese tests.

The tests performed after PE resulted in a higher percentage of participants considering themselves "more focused" (PE-MATH) and "suffering from fatigue" (PE-PL), but a smaller percentage considered "apprehensive" while performing the Portuguese language test. (Table 3)

Table 1. Mean values (\pm SD) of characteristics of study participants (n=36).

	Sample (n=17 M / 19 F)
Age (years)	14.9 \pm 1.5
Body weight (kg)	51.1 \pm 8.4
Height (cm)	161.28 \pm 9.73
BMI (kg/m ²)	19.7 \pm 2.8

BMI - Body Mass Index; M - male; F - female.

Table 2. Mean values (\pm SD) of heart rate (HR), percentage of maximum heart rate (%HR_{max}), correct answers per minute (CA/min), and time to complete the math test (MATH) and Portuguese language test (PL) (n=36).

	CON-MATH	PE-MATH	P	CON-PL	PE-PL	p
HR (bpm)	76.30 \pm 7.29	150.39 \pm 20.29*	<0.0001	76.83 \pm 7.64	144.72 \pm 26.28*	<0.0001
%HR _{max}	38.63 \pm 3.69	74.14 \pm 10.27*	<0.0001	38.90 \pm 3.86	73.27 \pm 13.30*	<0.0001
Score test	4.01 \pm 2.18	5.27 \pm 2.22*	0.0020	3.47 \pm 2.48	4.23 \pm 2.59	0.2394
Time (min)	11.96 \pm 4.10	11.52 \pm 5.09	0.2768	10.51 \pm 4.23	7.85 \pm 3.28*	0.0003

CON-MATH: 30 min of control session followed by math test; PE-MATH: 30 min of physical education followed by math test; CON-PL: 30 min of control session followed by Portuguese language test; PE-PL: 30 min of physical education followed by Portuguese language test. * $p < 0.05$ in relation to CON for the same test.

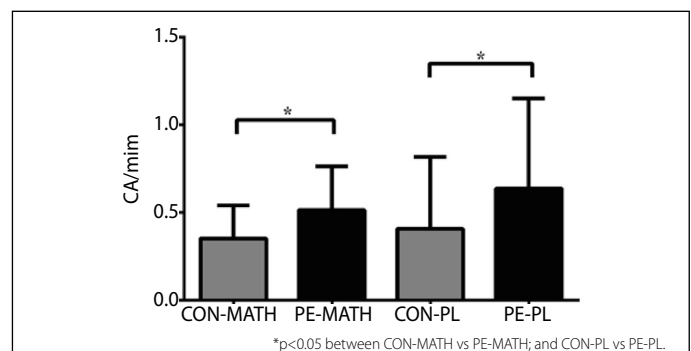


Figure 1. Correct answers per minute (CA/min) in the math and Portuguese language tests after 30 minutes of control session (CON-MATH; CON-PL) and after 30 minutes of physical education session (PE-MATH; PE-PL).

Table 3. Percentage of feelings and perceptions by participants while performing math and portuguese tests after control and physical education sessions (n=36).

	CON-MATH	PE-MATH			CON-PL	PE-PL		
	%	%	X ²	p	%	%	X ²	p
Flushed	36.11	36.11	0.01	1.00	16.67	33.33	2.70	0.10
Anxious	19.44	33.33	1.79	0.18	22.22	13.89	0.84	0.36
Fatigued	25.00	25.00	0.01	1.00	8.33	36.11*	8.04	0.00
Focused	16.68	38.89*	4.43	0.03	8.33	19.44	1.86	0.17
Confident	33.33	44.44	0.93	0.33	27.78	27.78	0.01	1.00
Apprehensive	27.78	30.00	0.07	0.79	27.78	8.33*	4.60	0.03

CON-MATH: 30 min of control session followed by math test; PE-MATH: 30 min of physical education followed by math test; CON-PL: 30 min of control session followed by Portuguese language test; PE-PL: 30 min of physical education followed by Portuguese language test. * $p < 0.05$ between CON-MATH vs PE-MATH; and CON-PL vs PE-PL.

DISCUSSION

This study sought to compare the effects of 30 minutes of PE class at moderate intensity on performance on Math and Portuguese tests in adolescents from a rural school. Also, the students' feelings and perceptions while performing the tests were analyzed. The main findings were that the PE classes induced a higher performance on the Math and Portuguese tests. After a single PE class, the students felt more focused during the math test and less apprehensive, though more tired, while performing the Portuguese test.

The PE class used in this study was similar to the common PE class in Brazil containing some play and physical exercises lasting 30 minutes at moderate intensity (~74% of HR_{max}). It is important to note that the weather was similar in all experimental sessions, considering that the region shows temperatures and humidity between 25-30°C and 45-75%. The HR_{max} equation used is considered most adequate for adolescents.¹⁴ The current study shows that 30 minutes of moderate intensity PE promoted higher score ratios on math (>47%) and Portuguese (>56%) when compared to the respective control sessions. Thus, PE improved the cognitive function of the participants. To the best of our knowledge, the improvement obtained by the adolescents at 10 minutes after a short and acute PE class has not been studied before.

In a longitudinal study, Hollar et al.¹⁵ demonstrated that two years of intervention (physical activity promotion and diet modification) in children aged approximately eight years in six elementary schools had significant impact on their Florida Comprehensive Achievement Test Math scores, with a greater number of children achieving level 2 and 3 when compared to control children. However, the same effect was not observed on reading.¹⁵ It may be inferred that physical exercise performed before a school test or even school class can induce better scores and learning for children. Nevertheless, this needs further investigation. In an elegant acute study, Ellemberg and St-Louis-Deschênes¹⁶ found a positive effect of 40 minutes of prior aerobic cycling exercise (63% HR_{max}) in children (7-10 years of age) on computerized reaction time performance compared to passively watching television. This improvement in sensory-motor function was associated with an improvement in visual and motor functions of the cortex.

In this study, our participants took common Math and Portuguese tests used in schools in Brazil. The greater number of correct answers per minute in Math and the lower time spent completing the Portuguese language test indicated that PE at moderate intensity resulted in better performance on cognitive function. The benefits of exercise on cognitive function appear to be related to the intensity and duration of exercise. An optimal duration and intensity of physical exercise before academic activities can help children's learning process in school. Loprinzi and Kane¹⁷ showed an improvement in cognitive performance concentration (Match test score) and visual attention test (Trail Making Test) in young men after only 30 minutes of aerobic exercise at mild-to-moderate intensity (51-70% HR_{max}) when compared to light and vigorous exercise.

Another concern is what period of time after physical exercise would be the best before administering cognitive tests. The present study showed that the positive effect from PE on math and Portuguese test performance occurred at 10 minutes after the PE class. Children commonly spend ten minutes returning to the classroom after PE class, and that amount of time was shown to be sufficient to promote positive

effects in those students' cognitive functioning. This duration was relatively short considering the benefits that PE can bring both to the adolescent's physical health and school performance. However, whether cognitive functioning benefits from this type of intervention is something that deserves further investigation.

The possible physiological mechanisms underlying this improvement in cognitive function after PE class were not investigated in our study. However, it was speculated that maintenance of heart rate above resting values during the Math and Portuguese tests may have increased blood flow, brain oxygenation, and brain derived neurotrophic factor (BDNF),¹⁸ a molecular mediator of structural and functional plasticity of the brain,¹⁹ which may have also contributed to these results.

It is reasonable to infer that increased BDNF may have contributed to the perception of "increased focus" while performing the Math test, but this variable was not investigated in our study. However, the possible mechanisms that might explain why a single session of PE resulted in better Math and Portuguese school test performance are potential areas of investigation for future research. Besides BDNF, physical activity and cardiorespiratory levels are also positively correlated with academic achievement,^{20,21} but these areas were also not the aim of our study.

Regarding perceptions and feelings during the math and Portuguese tests, it was observed that more students considered themselves "more focused" and "less apprehensive" after the PE session. However, despite a higher percentage of students indicating "fatigue" in the PE-PL compared to CON-PL, they completed the PL test in a significantly lower time and at a greater number of correct answers per minute after PE. A PE class before regular school classes precipitated those gains without risk of impairment of cognitive control processes (i.e., inhibition and working memory) and demonstrated that it can increase children's academic achievement.

This study has limitations, such as not measuring oxygen consumption during sessions, which would tell us the real intensity of the exercise and the number of calories burned during PE class. Also, BDNF and beta-endorphins were not assessed in this study. In addition, the school tests were developed specifically according to adolescents' current school programs, which complicates comparisons to other studies. However, this kind of study has external validity and possible application, and its methods can help to promote mental and physical health in youth at schools.

CONCLUSION

We conclude that a previous acute PE session of 30 minutes at moderate intensity resulted in significant improvements in performance on Math and Portuguese tests in students from a rural school. Also, after PE class, a high percentage of the students felt fatigued, but were less apprehensive while taking the Portuguese test, and reported being more focused during the Math test.

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