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Relationships Between Motor Coordination and Academic Achievement in Middle School Children

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ABSTRACT

International Journal of Exercise Science 9(5): 616-624, 2016. Although it is recognized that children with a marked impairment in the development of motor coordination may show difficulty in gaining academic achievement, research examining the relationship between gross motor coordination and academic achievement in children without intellectual disabilities is limited. This study aimed to examine whether gross motor coordination is associated with academic achievement among children. Middle school children (n=122) were recruited. Writing, reading, and mathematics performance were used to attribute academic achievement. Gross motor coordination was assessed using the Körperkoordinationstest für Kinder test. Pearson and partial correlations were used to analyze associations between gross motor coordination and academic achievement, controlling for physical activity. Bivariate correlations revealed no significant associations between gross motor coordination and academic achievement scores in both boys and girls. On the other hand, gross motor coordination scores were significantly correlated with writing performance when controlled for physical activity levels, in boys. Our findings question whether motor coordination scores are really associated with academic achievement scores among middle school children.

KEY WORDS: Motor behavior, physical activity, academic performance, students

INTRODUCTION

Motor coordination is described as the capacity to efficiently control the degrees of freedom of the different segments that are involved in the motion (3). From an anatomic point of view, the mechanisms underlying the neural control of voluntary movement is extremely complex. Indeed, it is necessary to activate multiple muscles at the appropriate time and with the proper amount of force, so that a smooth, efficient and accurate motion occurs (25). From a

neuromechanical point of view, motor coordination is not a simple skill, because beyond several degrees of freedom to be constrained during motor performance, there are inherent internal and external forces acting on movement (3).

It is postulated that the capacity to efficiently coordinate the human movement is related to general human development (10). During childhood, for example, pediatricians commonly assess children's development through procedures involving motor tasks. In addition, recently it has been discussed that motor coordination is not just a matter of children's general motor development (4, 6). Among others associations, it has been suggested that motor coordination scores are related with academic achievement in children (5, 22, 29). Theoretically, associations between motor coordination and academic achievement scores can be speculated because some neuronal structures of the brain (e.g., the cerebellum, frontal cortex, basal ganglia) are responsible for motor and cognitive functions (7, 24). The comprehension about how these variables are related is particularly important for educational settings due to pressure for schools to have students perform increasingly higher on academic achievement measures.

It is recognized that children with a marked impairment in the development of fine and gross motor coordination may show difficulty in gaining academic achievement (2). However, research examining the relationship between gross motor coordination scores and academic achievement in children without intellectual disabilities is limited. Lopes and colleagues (20) found that children with insufficient motor coordination or motor coordination disorders exhibited a higher probability of having low academic achievement than their peers with normal and good motor coordination. However, those authors (20) considered academic achievement as a global measure which involved mathematics and Portuguese Language scores and, therefore, they did not determine whether that observed trend changed across academic disciplines. Cheng and colleagues (5) found poorer writing, but not reading, academic achievement in the children with developmental coordination disorder than in the typically developing children. Similarly, Wocadlo and Rieger (30) found poorer academic achievement in spelling and mathematics, but not in reading, in children with developmental coordination disorders. This previous evidence (5, 20, 30) suggests that gross motor coordination tends to be associated with academic achievement scores, but this trend may vary across academic disciplines.

Children's physical activity levels were not considered as a possible confounding factor on relationships between motor coordination and academic achievement scores in these previous studies. This default might have biased those earlier findings, because evidence suggests that physical activity may influence cognitive function in children, leading to enhanced scholastic performance (8, 12, 26). Also, these previous studies (5, 20, 30) analyzed only elementary school children. Considering these factors, the purpose of this study was to examine whether gross motor coordination scores are associated with writing, reading, and mathematics academic achievement among middle school children, considering the level of physical activity as a possible confounding factor.

METHODS

Participants

One-hundred and twenty two (n=122) middle school children between the ages of 12 and 14 years old, 70 girls (13.8±0.7 years, 54.5±15.2 kg, 1.59±0.1 m) and 52 boys (13.8±0.6 years, 49.5±11.9 kg, 1.60±0.1 m), between seventh and ninth grade, were recruited to participate in the current study. A convenience sample extraction was conducted within a population of students from a Brazilian public school located in Rio de Janeiro city.

Inclusion criteria consisted of students under 15 years old enrolled in school without intellectual disabilities (i.e. children without record of learning disorders) and any history of injury that could affect motor performance. Ethical approval for this study was obtained from the University Ethics Committee and parental consent and child assent was obtained prior to participation in the study.

Protocol

All the measures were collected in the school gymnasium during the school year by personnel systematically trained by the coordinator of the current study, following standard procedures for anthropometry (1), self-reported physical activity (16) and motor coordination (15) tests. Data collection occurred the during school year, between October and November.

Body mass was measured to the nearest 0.1 kg using an electronic scale, with participants wearing their school uniform. Standing height was measured in a bare feet by a wall stadiometer to the nearest 0.1 cm.

The Physical Activity Questionnaire for Older Children (PAQ-C; 16), a valid self-administered 7-day recall instrument, was used to assess general levels of physical activity of participants. The PAQ-C is appropriate for elementary and middle school-aged children approximately between 8-14-years old who are currently in the school system and have recess as a regular part of their school week. The summary score for the PAQ-C is the average of the sum of the nine items questions, each scored on a 5-point ordinal scale, with the lowest activity response (i.e. “no activity”) being a 1 and the highest activity response being a 5. Thus, the max score for the PAQ-C was 5 points.

Gross motor coordination was assessed using the Körperkoordinationstest für Kinder (KTK; 15). The KTK is a reliable and valid instrument for middle school-aged children and consists of four test items: 1) walking backwards along balance beams of decreasing width; 2) one-legged hopping over an obstacle, formed by an increasing pile of pillows; 3) two-legged jumping sideways across a wooden slat for 15s as quickly as possible; and 4) moving sideways on wooden boards lasting 20s as many times as possible. All four test items were age-adjusted scores, and a global motor quotient, representing the gross motor coordination scores, for each participant was derived from the sum of the scores obtained in the tests. The max age-adjusted score for the KTK was 150 points.

Writing, reading, and mathematics grades of students on Portuguese Language and Mathematics standardized regional test were used to attribute academic achievement scores among participants. These tests are administrated periodically in the referred school system, and the grades used in data analysis were those obtained from children at the same period of data collection. Academic achievement scores could vary from 0 to 10, with an interval of 0.1. In that school system, the minimum passing score is 5.0 points.

Statistical Analysis

Descriptive statistics were calculated for all variables. The Kolmogorov-Smirnov test confirmed acceptable normality of the data distribution. Analysis of Variance (ANOVA *one-way*) was used to test differences between genders in gross motor coordination and physical activity levels. Pearson correlations were used to analyze the associations between gross motor coordination and academic achievement (writing, reading, and mathematics performances), while partial correlations were used to analyze these same associations controlling for physical activity levels. All the analyses were gender-specific. A significance level of 5% ($\alpha = 0.05$) was adopted for all statistical tests. Data analysis was executed using Statistical Package for Social Sciences (SPSS ver. 22.0 software, IBM, USA).

RESULTS

Descriptive statistics including motor coordination, academic achievement, and physical activity levels among participants are provided in Table 1. Boys and girls showed significant differences ($p<0.05$) between gross motor coordination scores, physical activity levels, and academic achievement scores (Table 1). The average academic achievement scores for boys and girls in writing, reading, and mathematics were above passing rate (i.e. ≥ 5.0 points). Also, percentiles of the motor coordination scores, physical activity levels, and academic achievement scores are provided in Table 2.

Table 1. Descriptive statistics (mean ± standard deviation) in boys and girls: gross motor coordination scores (MC), academic achievement scores (AA), and physical activity levels (PA).

	Boys	Girls
MC*	95.4 ± 15.9	76.3 ± 21
PA*	3 ± 0.8	2.3 ± 0.7
AA		
Writing*	6.2 ± 2	6.8 ± 1.6
Reading*	6.2 ± 2.1	7.0 ± 1.7
Mathematics	5.8 ± 2.2	5.8 ± 2.1

*Significant differences between genders at level $p<0.05$.

All the correlations were weak (i.e. <0.30). Bivariate correlations revealed no significant associations between gross motor coordination and academic achievement scores in both boys and girls.

Gross motor coordination scores were significantly correlated with writing performance when controlled for physical activity levels ($p=0.043$) in boys. Bivariate and partial correlations

between gross motor coordination and academic achievement scores, with and without controlling for physical activity levels, are shown in Table 3.

Table 2. Percentiles of the academic achievement scores, motor coordination scores (MC), and physical activity levels (PA).

	Math	Writing	Reading	MC	PA
Boys					
Percentiles					
25	4.0	5.0	4.2	89	2.6
50	6.0	6.0	6.7	99	3.0
75	7.0	7.4	8.0	105	3.6
Girls					
Percentiles					
25	4.7	6.0	6.0	60.8	1.7
50	5.3	6.5	7.0	77	2.1
75	7.3	7.6	8.0	93	2.8

Table 3. Correlations between gross motor coordination (MC) and academic achievement (AA) scores, with and without controlling for physical activity levels.

	A	B
Boys		
MC and writing	.236	.284*
MC and reading	.091	.202
MC and mathematics		
	.078	.107
Girls		
MC and writing	.197	.196
MC and reading	.053	.061
MC and mathematics	.104	.101

*Correlation is significant at the 0.05 level (2-tailed). A. Bivariate correlations (Pearson's r). B. Partial correlations controlling for physical activity levels.

DISCUSSION

This study investigated whether motor coordination scores are associated with academic achievement scores, considering the level of physical activity as a potential confounding factor among middle school children. In general, results indicated weak and insignificant associations between gross motor coordination and academic achievement scores. Furthermore, our results suggested that the associations between motor coordination and academic achievement scores may be influenced for physical activity levels in boys.

It is known that performance ceiling effects occur when a substantial proportion of individuals obtain either maximum or near-maximum scores (28). Our descriptive data showed that there

were not ceiling effects on the scores analyzed in the current study. It means that, concerning to our data distributions, the skills of participants of this research were not masked by the assessment tools.

Significant differences were found between genders in gross motor coordination and physical activity levels. Boys had higher gross motor coordination scores and physical activity levels than girls. Considering that motor development also depends on opportunities for practice (10), and it seems to be associated with physical activity levels (18), these findings may be explained by the fact that girls at this age tend to not only decline in their physical activity levels (9, 21), but also tend to have less engagement in physical activity than boys (19). Due to these behavioral differences between genders, we suggest that researches about the topic enrolling middle school children are gender-specific.

To the best of our knowledge, this was the first correlational study to analyze the associations between gross motor coordination and academic achievement scores, controlling for physical activity levels, among middle school children without intellectual disabilities. The low and insignificant correlations of gross motor coordination scores with writing, reading, and mathematics performance among boys and girls did not confirm the speculated association between motor coordination and academic achievement scores. Gross motor coordination scores were associated with writing performance when controlled for physical activity levels among boys. These findings suggest that physical activity levels may influence the relationships between gross motor coordination and academic achievement scores, at least among middle school boys. One plausible explanation for this influence of physical activity levels lies in the fact that some previous papers have indicated a positive effect of physical activity on academic achievement among children (11, 13, 17). However, there is no consensus whether physical activity influences positively or has no influence on academic achievement among children (13, 23, 27). Further, we must highlight that only writing performance, among boys, was associated with gross motor coordination scores when controlled for physical activity levels. Although evidence suggests that some neuronal structures of the brain are responsible for motor and cognitive functions (7, 24), our findings suggest which this fact does not ensure that motor coordination scores are significantly associated with academic achievement. Despite the academic achievement scores are often used by researchers who desire to study cognitive functions among children, not always the grades achieved by students on standardized exams reflect their cognition or intelligence. Future researches with different designs should examine whether motor coordination and academic achievement scores are, or not, really associated among children.

Research on inter-relationships among motor skills, physical activity levels, and academic performance in children seem to be a fertile field of investigation with relevant applicability in the school settings. While physical activity in public schools has steadily declined since the 1970s (8), the rates of children and adolescents who are overweight and/or with metabolic disorders, among others health problems, have increased considerably. Although our findings have indicated overall insignificant associations between motor coordination and academic achievement scores among middle school children, this does not mean that there is a negative

association between these variables. Therefore, the time spent in physical education classes, which are important not only to increase children's physical activity levels but also to improve their motor coordination, should not be reduced in order to have students perform increasingly higher on academic achievement measures. At best, as argued previously for Tomporowski and colleagues (27), the time spent in physical activities does not have a negative impact on children's academic performance.

Gross motor coordination scores were not significantly associated with academic achievement scores in middle school children. When controlled for physical activity levels, only writing performance, among boys, was associated with gross motor coordination scores. Our findings question whether motor coordination scores are really associated with academic achievement scores among middle school children.

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