INTERRELATIONSHIPS AMONG MOTOR COORDINATION, BODY FAT PERCENTAGE, AND PHYSICAL ACTIVITY IN ADOLESCENT GIRLS

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ABSTRACT

Purpose. The aim of this study was to analyze the interrelationships among motor coordination, body fat percentage, and physical activity levels in adolescent girls. **Methods.** Sixty-eight girls aged 12–14 years participated in the study. Skinfold thickness was measured and the Körperkoordinationstest für Kinder test was administered. Participants completed a self-reporting questionnaire on physical activity. Bivariate and partial correlations were used to analyze the interrelationships among the selected variables. **Results.** There were no significant ($p > 0.05$) correlations between any motor coordination scores and physical activity levels with and without controlling for body fat percentage. All motor coordination scores were significantly ($p < 0.05$) associated with body fat with and without controlling for physical activity levels. **Conclusions.** The relationships between motor coordination scores and physical activity levels, as well as between motor coordination scores and body fat percentage, were not influenced by body fat and physical activity levels, respectively. However, the overall low physical activity level in this sample may have biased these results. Additional research involving girls with higher physical activity levels should be pursued.

Key words: motor skills, physical activity, adiposity, children, adolescence, health

Introduction

The usefulness of scores obtained from motor coordination tests are not restricted to solely assessing neurological and/or functional status in infants and children by pediatricians. There is a growing scope of knowledge suggesting significant associations between motor coordination scores and some health-related attributes such as physical fitness, body fat, and physical activity levels in both young males and females. Recent evidences have suggested that motor coordination scores are negatively related to body mass index and body fat percentage [1–5] and positively related to physical activity levels [6–10] in school-aged children.

However, recent findings have also demonstrated that the interrelationships cited above can form a sort of vicious circle in children and adolescents, where children with poor motor coordination may develop a negative engagement with physical activity consequently leading to an unhealthy increase of adipocytes. This negative engagement and adipocyte increase may further hinder motor development [9]. Indeed, this negative feedback effect might place adolescent females at increased risk as this group tends to be less engaged in physical activities, physical education classes, and recreational sports than age-matched boys [11, 12] or their younger peers [12, 13]. Recently, a pilot study [14] stressed this assumption. Therefore, understanding of how these interrelationships are underpinned in adolescent females is a matter of public health.

Although there is an increasing body of research on the subject, there are some specifics points that remain unclear among the interrelationships of motor coordination scores, body fat percentage, and physical activity levels in children. One of these involves study design, where most of the evidence has been based on bivariate analyses between motor coordination scores and adiposity or physical activity levels and may have biased results and interpretations. Little is known whether physical activity levels can influence the relationships between motor coordination scores and body fat percentage as well as whether body fat can influence the relationships between motor coordination scores and physical activity levels. In this sense, Morrison et al. [15] observed that associations between global motor coordination scores and physical activity levels were altered when body fat percentage was included as a covariate in correlational analysis in a sample of primary school girls. However, it is unknown whether their findings could be generalized to adolescent females.

Therefore, the aim of this study was to analyze the interrelationships among motor coordination, body fat percentage, and physical activity levels in adolescent girls so as to determine which relationships between motor coordination scores and body fat percentage, as well as between gross motor coordination scores and physical activity levels, can be influenced by the covariates physical activity and body fat, respectively.

Material and methods

Sixty-eight girls aged 12–14 years enrolled in a public school in the city of Rio de Janeiro, Brazil were recruited

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to participate in the study. Subject demographics are provided in Table 1. Inclusion criteria required female students to be under 15 years old with no history of injury or disease that could affect motor performance. Participant data was excluded if they refused to participate in any task or procedure of study. The study was conducted in association with the Biomechanics and Motor Behavior Laboratory of the State University of Rio de Janeiro, Brazil, which provided technical support for this investigation. Ethical approval for this study was obtained from the University's Ethics Committee and parental consent and child assent were obtained prior to participation.

The study was conducted by experienced personnel following standard measurement procedures for anthropometry [16], physical activity [17], and motor coordination [18], and included fully explaining and familiarizing the participants with all tasks. Anthropometry and motor coordination tests were administered in a school gymnasium during the school day and lasted approximately 25 min per child. Children were assessed according to their classroom group. Each group was assessed (for anthropometry, physical activity, and motor coordination) within a period of one week.

Body mass was measured to the nearest 0.1 kg using an electronic scale with participants wearing their school uniform. Standing height was measured while unshod with a meter wall to the nearest 0.1 cm. BMI (kg/m^2) was then calculated. Triceps and gastrocnemius skinfold thickness were measured using a skin caliper; the mean values were converted to body fat percentage using the Slaughter equation [19].

The Physical Activity Questionnaire for Older Children (PAQ-C), a valid [17] self-administered 7-day recall instrument, was used to assess general levels of physical activity. The PAQ-C is appropriate for public elementary school-aged children approximately 8–14 years old who have recess as a regular component of their school week. The summary score for the PAQ-C is the mean sum of nine items rated on a five-point scale.

Motor coordination was assessed using the Körperkoordinationstest für Kinder (KTK) [18]. The KTK is a reliable and valid instrument for elementary school-aged children and consists of four tasks. The first is walking backwards on balance beams (3 m length) of decreasing width (6, 4.5, and 3 cm). Each beam was crossed three times where a maximum of eight steps per trial were allowed (72 steps overall); the sum of steps in all trials determined Motor Quotient 1 (MQ1). The second involved one-legged hopping over an obstacle, formed with an increasing pile of pillows (pillow size 60 cm × 20 cm × 5 cm; the maximum was 12 pillows or a height of 60 cm). Only three trials were allowed for each obstacle and three, two, or one point(s) were/was awarded for successful performance on the first, second, or third try, respectively. Therefore, a maximum of 39 points (including a ground level trial) could be scored for each

leg; the scores were summed to determine Motor Quotient 2 (MQ2). The third task was two-legged sideways jumping across a wooden slat (60 cm × 4 cm × 2 cm) for 15 s as quickly as possible. The number of jumps performed correctly was summed over two trials to determine Motor Quotient 3 (MQ3). The final task involved moving sideways on wooden boards (25 cm × 25 cm × 5.7 cm) as many times as possible in 20 s. One point was awarded for each time the plate was transferred and one more for stepping on it. The number of relocations were counted and summed over two trials to determine Motor Quotient 4 (MQ4). All four scores were age-adjusted and a global motor quotient (MQglobal) for each participant was derived from the sum of MQ1, MQ2, MQ3, and MQ4.

Descriptive statistics were determined for all variables. The Kolmogorov-Smirnov test confirmed acceptable normality of the data distribution. Pearson correlation coefficients were used to examine the bivariate relationships between physical activity levels and motor coordination scores, and between body fat percentage and motor coordination scores. Partial correlations were used to analyze the relationship between physical activity levels and motor coordination scores controlling for body fat, and between body fat and motor coordination scores controlling for physical activity levels. Multivariate analysis of variance (MANOVA) was performed to compare motor coordination scores, physical activity levels, and body fat percentage according to age (12, 13, and 14 years old). A significance level of 5% ($\alpha = 0.05$) was adopted in all statistical tests. Data analysis was executed using Statistical Package for Social Sciences software ver. 22.0 (IBM, USA).

Results

Descriptive statistics of the sample including age, height, body height, body mass index, % body fat, physical activity levels, and motor coordination scores are provided in Table 1. No significant differences between the means for age were found ($F = 0.884$, $p = 0.565$).

Pearson and partial correlations coefficients indicated that all correlations between motor coordination scores and physical activity levels, with and without controlling for body fat percentage, were not significant ($p < 0.05$, coefficient range between –0.028 to 1.71). In turn, all motor coordination scores were significantly associated with body fat percentage with and without controlling for physical activity levels (Table 2). MQ4 scores showed low association with body fat but the correlation coefficients were close to cutoff point (i.e. 0.50) for moderate correlations. Furthermore, all the other motor coordination scores were moderately associated with body fat percentage.

Table 1. Descriptive statistics of the sample including demographic, body fat percentage, physical activity level, and motor coordination scores; data provided as mean ± *SD* with 95% confidence interval (CI)

	12 years (*n* = 11)	13 years (*n* = 23)	14 years (*n* = 34)
Height (m)	1.59 ± 0.03 CI: 1.53, 1.65	1.57 ± 0.03 CI: 1.52, 1.61	1.51 ± 0.01 CI: 1.59, 1.63
Weight (kg)	55.6 ± 4.7 CI: 45.1, 66.0	50.8 ± 2.9 CI: 44.8, 56.8	56.7 ± 2.8 CI: 50.9, 60.4
BMI (kg/m^2)	21.9 ± 1.6 CI: 18.4, 25.3	20.5 ± 0.7 CI: 18.9, 22.0	21.8 ± 1.0 CI: 19.8, 23.7
Body fat percentage	28.6 ± 2.8 CI: 22.3, 34.9	25.5 ± 2.1 CI: 21.1, 29.9	30.2 ± 2.0 CI: 26.2, 34.2
Physical activity level	2.2 ± 0.2 CI: 1.8, 2.6	2.3 ± 0.1 CI: 2.0, 2.5	2.3 ± 0.1 CI: 2.0, 2.6
MQglobal	72.0 ± 5.4 CI: 60.0, 84.0	82.3 ± 5.2 CI: 71.4, 93.1	72.9 ± 3.2 CI: 66.3, 79.5
MQ1	93.4 ± 5.6 CI: 81.0, 105.8	99.6 ± 4.1 CI: 91.2, 108.0	97.2 ± 3.2 CI: 90.7, 103.6
MQ2	70.2 ± 7.4 CI: 53.8, 86.6	79.1 ± 6.1 CI: 66.5, 91.7	67.8 ± 4.6 CI: 58.5, 77.1
MQ3	72.2 ± 5.1 CI: 60.9, 83.5	76.0 ± 4.9 CI: 65.9, 86.3	68.2 ± 3.5 CI: 61.1, 75.3
MQ4	76.2 ± 4.8 CI: 65.5, 86.9	88.6 ± 4.1 CI: 80.2, 97.0	81.4 ± 2.7 CI: 75.9, 86.9

Table 2. Pearson and partial correlation coefficients between motor coordination scores and body fat percentage controlling for physical activity levels

	Bivariate correlations	Partial correlations
MQglobal and % body fat	–0.639**	–0.642‡**
MQ1 and % body fat	–0.587**	–0.587‡**
MQ2 and % body fat	–0.635**	–0.638‡**
MQ3 and % body fat	–0.520**	–0.526‡**
MQ4 and % body fat	–0.473**	–0.475‡**

** Correlation significant at the 0.01 level (two-tailed test)
‡ Partial correlations controlling for physical activity levels

Discussion

The main aim of this study was to analyze the inter-relationships among motor coordination, body fat percentage, and physical activity levels in adolescent girls aged 12 to 14 years. For this, the degree of association between physical activity levels and body fat percentage with motor coordination scores were analyzed in two ways: separately, through Pearson correlation analysis, and jointly, through partial correlation analysis. Descriptive statistics showed low general levels of physical activity among the sample. In addition, the results indicated that the relationships of motor coordination scores with body fat percentage and physical activity levels were not influenced by physical activity and body fat, respectively.

The correlation analyses performed in this study were not age-specific due to a lack of significant differences in the levels of motor coordination, physical activity, and body fat according to age.

In general, the low magnitude and positive direction of bivariate associations between physical activity levels and motor coordination scores in our sample were similar to the findings of previous studies [1, 7–9, 15, 20, 21], regardless of the measurement procedures used across the cited investigations. In addition, the non-significant correlations observed between physical activity levels and all motor coordination scores, even when controlled for body fat percentage, reinforce the arguments posited by Fisher et al. [20], who questioned whether these variables are truly associated in the general child and adolescent populations. Indeed, there is no consensus regarding the statistical significance of correlations between physical activity levels and motor coordination scores in children. Specifically, with respect to females, two other studies [15, 21] indicated non-significant associations between physical activity levels and motor coordination scores. These findings suggest there is no influence of body fat percentage on the relationships between motor coordination scores and physical activity levels in adolescent females.

Motor coordination scores and body fat percentage were inversely and significantly associated in this study's sample. These results are in line with previous findings [1–5]. Furthermore, the direction, magnitude, strength, and significance of correlations between body fat per-

centage and motor coordination scores were not altered when controlled for physical activity levels in partial correlations analyses. Thus, physical activity levels were not a confounding influence on the relationships between motor coordination scores and body fat percentage. These results are in line with a previous finding, where physical activity status did not influence the relationships between motor coordination scores and body mass index [14]. Contrary to this, Morrison et al. [15] reported that besides being significantly correlated with motor coordination scores when controlled for body fat, physical activity status influenced the relationships between body fat percentage and motor coordination scores in primary school girls. Based on these findings, Morrison et al. [15] defended the premise that not all children with higher levels of body fat display poor motor skills. Could this be generalized to adolescent females? In this sense, it is important to mention that physical activity levels tend to decline as children get older [12, 13], particularly during adolescence [22] and above all among females [23]. Furthermore, there is a worldwide prevalence of low physical activity levels in adolescents, also mainly among females [24]. In Brazilian girls, for example, prevalence rates of physical inactivity may be over 90% among adolescents [25]. Therefore, it seems plausible that the general low physical activity levels observed in our sample might have been insufficient not only to be significantly associated with motor coordination scores but also to influence the relationships between body fat and motor coordination. Additional research including females with both low and high levels of physical activity should be pursued in order to examine whether the relationships between motor coordination scores and body fat percentage, as well as between motor coordination scores and physical activity levels, can be influenced by covariates such as physical activity and body fat, respectively, in adolescent females.

It is important to emphasize that comparisons between studies is difficult and may sometimes be inappropriate due to differences in measurement tools used and experimental design. Although the present study design is not appropriate in determining the direction of the measured effects, our results suggest that the higher the adiposity level, the lower motor coordination scores in adolescent girls with low levels of physical activity.

Conclusions

The results did not corroborate the hypothesis that the relationships between motor coordination scores and body fat percentage, as well as between motor coordination scores and physical activity levels, could be influenced by the covariates physical activity and body fat, respectively, in adolescent females. However, the low physical activity levels in this sample may have biased these results. Additional research should involve young females with higher physical activity levels. Moreover, the low physical activity levels observed in this sample as well as the negative associations between body fat percentage and motor coordination scores reinforce the hypothesis that adolescent females are at increased risk of experiencing a negative feedback effect intertwining motor skills, body fatness, and physical activity levels. Therefore, research on the complex interrelationships among these variables in children and adolescents should focus on developing public health initiatives in order to promote not only positive engagement in physical activities but also adequate development of motor skills, with special attention paid to adolescent females.

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