

Do Girls with Excess Adiposity Perform Poorer Motor Skills than Leaner Peers?

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ABSTRACT

International Journal of Exercise Science 9(3): 318-326, 2016. The main aim of this study was to analyze the joint association of body fat percentage and physical activity levels on motor coordination scores in girls with different adiposity status. Sixty-eight school-aged children between 12 and 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. Children's adiposity status was attributed in according to age-specific cutoff points of a Brazilian database. Analysis of Variance was used to compare motor coordination scores among groups with different status of adiposity and physical activity. Girls with appropriate body fat percentage performed higher motor coordination scores than girls with excess adiposity, regardless of their physical activity levels ($p < 0.05$). Additionally, within groups with the same adiposity status, no differences were found in motor coordination scores ($p > 0.05$). Adiposity status was predominant over physical activity status when joint associations of body fat percentage and physical activity levels on motor coordination scores were analyzed in girls. In addition to metabolic and cardiovascular issues, the acquisition and/or maintenance of appropriate body fat levels in female students should be focused in physical education classes due to its association with motor skills performance.

KEY WORDS: Motor coordination, weight status, body fat, physical exercise, children, adolescents

INTRODUCTION

Bernstein (3) described motor coordination as the capacity to efficiently control the degrees of freedom of the different body segments that are involved in the motion. The inability to efficiently coordinate body segments in motor tasks might be

indicative of a neurodevelopmental disorder (20, 25). In fact, physicians have used motor coordination tests as auxiliary tools in screening for child developmental delays and/or neurological disorder throughout several years. These procedures are commonly used in clinical settings based on the premise that an adequate level

of motor skill performance is associated with children's general motor development (7).

Additionally, scores achieved on motor coordination tests have been associated with others attributes related to health of children, such as levels of adiposity and physical activity (4). In general, previous findings have suggested that the higher the physical activity levels, the higher the motor coordination scores in children (2, 14, 26), despite the fact that some studies do not confirm this relationship (13, 19). Although it seems to be a consensus that motor coordination scores and physical activity levels are positively associated, not all studies have found significant correlations between these variables.

With regard to the level of adiposity, the literature on this topic has suggested that motor coordination scores are negatively related to body mass index and/or body fat percentage (4, 6, 18, 23). Therefore, it is expected that children with higher adiposity levels would demonstrate poorer motor performance than their leaner peers. Indeed, previous findings have reported that overweight/obese children tend to have lower motor coordination scores than those with a normal weight classification (1, 7, 8, 9, 17).

However, it is unclear whether children with excess adiposity perform poorer motor coordination scores than peers with appropriate body fat percentage regardless of their physical activity levels. In other words, little is known about the effect of joint association of body fat percentage and physical activity levels on motor coordination scores in a sample of children

with different adiposity status. Specifically, investigations about the effect of joint association of body fat percentage and physical activity levels on motor coordination scores in children may improve the understanding of interrelationships cited above. In this sense, there is the premise that not all children with higher body fat levels perform poor motor skills and/or are physically inactive (19).

A previous study (19) analyzed the effect of joint association of body fat percentage and physical activity on motor performance in children and found that boys, but not girls, with low adiposity levels showed higher motor performance scores than their peers with elevated adiposity levels, regardless of physical activity levels. However, in that study the cutoff point of body fat percentage adopted for classification of adiposity status in girls was only 15%. Therefore, the relatively low cut-off points adopted for classifying the adiposity status among the participants may have resulted in a bias result, because girls classified as high fat may not necessarily have had excessive body fat in that study (19).

From a neuromechanical point of view, subjects with excess adiposity tend to have greater difficulty performing some skills that require coordination compared to their leaner peers due to the additional mechanical constraints imposed by the increased body mass. This may be true regardless of physical activity levels. Based on this assumption, it seems plausible to consider that adiposity status may predominate over physical activity status when joint associations of body fat percentage and physical activity levels on

motor coordination scores are analyzed, despite of positive associations between levels of physical activity and motor coordination previously reported (2, 14, 26).

The purpose of this study was to analyze the joint association of body fat percentage and physical activity levels on motor coordination scores in girls with different adiposity status. We hypothesized that girls with excess adiposity will demonstrate lower motor coordination scores than their peers with appropriate adiposity, regardless of their physical activity levels.

METHODS

Participants

Sixty-eight girls aged 12-14 years old enrolled in a public school in the city of Rio de Janeiro, Brazil were recruited to participate in the study. Subject demographics are provided in Table 1. Inclusion criteria consisted of female students under 15 years old with no history of injury or disease that could affect motor performance. Ethical approval for this study was obtained from the University's Ethics Committee and parental consent and child assent was obtained prior to participation in the research.

Protocol

Body weight 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. Body mass index (kg/m²) was then calculated. Triceps (TR) and gastrocnemius (GAS) skinfold thickness were measured using a skin caliper; the mean values were converted to body fat percentage using the

Slaughter equation (21): body fat percentage = 0.61*(TR + GAS) + 5.1. Based on these measures, low, appropriate or excessive body fat classification was attributed to adiposity status of girls in accordance with age-specific cutoff points of a Brazilian database (5), with the following values for 12- and 13-14 years old, respectively: low body fat = < 9.5% and < 11.4%; appropriate body fat = ≥ 9.5% to < 28.1%, and ≥ 11.4% to < 29.2%, and excessive body fat = ≥ 28.1% and ≥ 29.2%.

The Physical Activity Questionnaire for Older Children (PAQ-C), a valid (16) self-administered 7-day recall instrument, was used to assess general levels of physical activity of participants. The PAQ-C is appropriate for elementary 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 from the PAQ-C is the average of the sum of the nine items questions, each scored on a 5-point scale. As adopted in a previous study (19), the PAQ scores (z-scores) were dichotomized, by median split, in order to classify the physical activity status of children as lower or higher physical activity levels.

Motor coordination was assessed using the Körperkoordinationstest für Kinder (KTK). The KTK is a reliable and valid (15) instrument for elementary school-aged children which consists of four test items: 1) walking backwards along balance beams of decreasing width; each beam was explored three times, and a maximum of eight steps per trial were computed; sum of steps over the trials formed the Motor Quotient 1 (MQ1); 2) one-legged hopping over an

obstacle, formed for an increasing pile of pillows; a maximum of 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 trial, respectively; a maximum of 39 points could be scored for each leg; sum of scores obtained from each leg formed the Motor Quotient 2 (MQ2); 3) two-legged jumping sideways across a wooden slat (60 x 4 x 2 cm) vertically positioned in the middle of one platform (100 x 60 cm) for 15s as quickly as possible; the number of jumps well succeeded, i.e. landed simultaneously with both feet on the platform without touching the slat, was summed over two trials and formed the Motor Quotient 3 (MQ3); 4) moving sideways on wooden boards lasting 20s as many times as possible; one point was attributed to each lateral plate transference, and one more for stepping on it; relocations were counted and summed over two trials, forming the Motor Quotient 4 (MQ4). All the four test items were age-adjusted scores, and a motor coordination score for each participant was derived from the sum of the MQ1, MQ2, MQ3, and MQ4.

Four groups were created in according to the status of adiposity and physical activity in order to analyze the joint association of body fat percentage and physical activity on motor coordination scores: group 1 (G1) - excess adiposity and lower physical activity levels; group 2 (G2) - excess

adiposity and higher physical activity levels; group 3 (G3) appropriate adiposity and lower physical activity levels; group 4 (G4) appropriate adiposity and higher physical activity levels.

Statistical Analysis

Descriptive statistics were determined for all variables. The Kolmogorov-Smirnov test confirmed acceptable normality of the data distribution. One-way Analysis of Variance (ANOVA) was used to identify differences in motor coordination scores among groups (G1-G4). Post hoc comparisons were performed using the Tukey test. Two-way ANOVA was used to compare motor coordination scores between girls with appropriate and elevated adiposity levels, as well as between girls with higher and lower physical activity levels. Levene's Test confirmed homogeneity of variance across groups. A significance level of 5% ($p \leq 0.05$) was adopted for all statistical tests. Data analysis was executed using Statistical Package for Social Sciences (SPSS ver. 22.0 software, IBM, USA).

RESULTS

From 68 girls, 29 (42.7%) were classified as having excessive body fat. No participant was classified as having low body fat. Descriptive statistics of both whole sample and groups of joint association are provided in Table 1.

MOTOR COORDINATION IN OVERWEIGHT GIRLS

Table 1. Descriptive statistics of both whole sample and groups of joint association including demographic, body fat percentage, physical activity levels, and motor coordination scores: mean \pm SD and 95% confidence interval (CI).

	Whole sample (n=68)	G1 (n=15)	G2 (n=13)	G3 (n=19)	G4 (n=21)
Age (years)	13.8 \pm 0.7 CI:13.6-13.9	14.0 \pm 0.2 CI:13.6-14.4	13.8 \pm 0.2 CI:13.3-14.2	13.8 \pm 0.1 CI:13.5-14.0	13.6 \pm 0.2 CI:13.3 -14.0
Weight (kg)	54.6 \pm 15.5 CI:50.8-58.3	67.5 \pm 4.5 CI:57.9-77.1	65.9 \pm 4.1 CI:57.1-74.7	45.1 \pm 1.4 CI:42.3-47.9	46.7 \pm 1.9 CI:42.8-50.6
Height (m)	1.59 \pm 0.08 CI:1.57-1.61	1.61 \pm 0.02 CI:1.57-1.64	1.64 \pm 0.02 CI:1.59-1.68	1.57 \pm 0.02 CI:1.52-1.61	1.57 \pm 0.02 CI:1.53-1.60
Body Mass Index (kg/m ²)	21.4 \pm 0.6 CI:20.2-22.5	25.9 \pm 1.5 CI:22.7-29.0	24.4 \pm 1.3 CI:21.6-27.1	18.4 \pm 0.4 CI:17.5-19.2	18.9 \pm 0.5 CI:17.9-20.0
Body fat percentage	28.7 \pm 10.8 CI:25.8-31.0	37.0 \pm 2.5 CI:31.7-42.3	39.2 \pm 2.7 CI:33.2-45.1	22.0 \pm 1.1 CI:19.7-24.2	21.3 \pm 1.0 CI:19.2-23.4
Physical Activity levels	2.3 \pm 0.7 CI:2.1-2.4	1.8 \pm 0.1 CI:1.6-1.9	2.8 \pm 0.2 CI:2.4 -3.2	1.7 \pm 0.0 CI:1.6-1.8	2.8 \pm 0.1 CI:2.6-3.0
Motor coordination scores	75.9 \pm 21.2 CI:70.8-81.1	63.0 \pm 4.2 CI:54.0-72.0	64.9 \pm 5.3 CI:53.3-76.6	79.3 \pm 4.3 CI:70.4-88.2	88.9 \pm 4.4 CI:79.7-98.0

Girls with excess adiposity performed lower motor coordination scores than those with appropriate adiposity ($F_{(1,66)} = 19.915$, $p < 0.001$). On the other hand, there were no significant differences in motor coordination scores between girls with lower and higher levels of physical activity ($p = 0.254$).

Joint associations of body fat percentage and physical activity levels on motor coordination scores are depicted in Figure 1, which indicates that girls with appropriate adiposity have higher motor performance than girls with excess adiposity, regardless of physical activity status. One-way ANOVA test identified significant differences among group means ($F = 7.440$), and Tukey's post-hoc test confirmed the trend depicted in Figure 1. Significant differences were found between the following groups: G1 vs. G3 ($p = 0.014$), G1 vs. G4 ($p = 0.0001$), G2 vs. G3 ($p = 0.036$), and G2 vs. G4 ($p = 0.001$). On the other hand, significant differences were not found among girls with the same adiposity

status (G1 vs. G2, $p = 0.787$; and G3 vs. G4, $p = 0.112$).

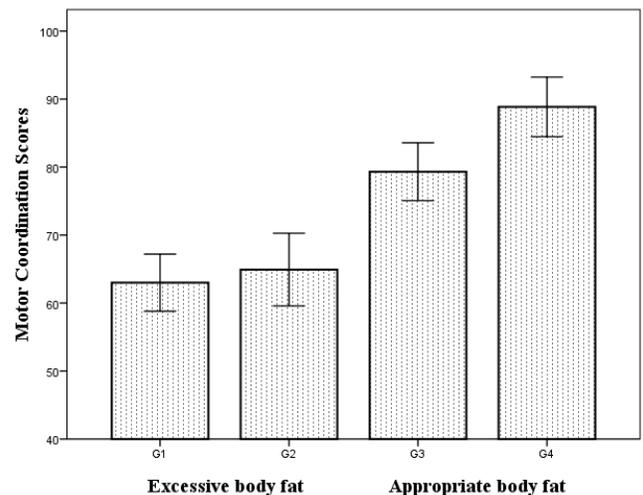


Figure 1. Motor coordination scores (means and standard deviation) among four groups: there were significant differences between girls with excessive (G1-G2) versus appropriate (G3-G4) body fat.

DISCUSSION

The main aim of this study was to analyze the joint associations of body fat percentage and physical activity levels on motor

coordination scores in 12- to 14-year old girls. Results indicated that girls with appropriate adiposity demonstrate higher motor coordination scores than girls with excess adiposity, regardless of physical activity levels. Additionally, comparisons performed within groups with the same adiposity status showed there were no significant differences in motor coordination scores in girls with different physical activity status.

Our findings add to the growing body of literature which have suggested that children who are with excess adiposity and/or are overweight/obese tend to have poorer motor skill performance than their peers with normal weight/adiposity (1, 7, 8, 9, 17). A plausible explaining for this phenomenon is the mechanical overload that increased body mass places on children who are overweight, especially during weight-bearing tasks. In line with this point of view, D'Hondt and colleagues (6) argued that excessive body weight affects body geometry and increases the mass of different body segments, and consequently may hinder motor skill performance of these children. Thus, it was expected that girls with excess adiposity would have lower motor coordination scores than their leaner peers. Additional studies containing motor tasks which do not include a replacement of the body are necessary.

Although some previous studies have examined associations between motor skills performance and physical activity levels in female students (4, 13, 19), there is a scarcity of researches which have compared motor coordination scores between girls with different physical activity status. In this sense, Morrison and colleagues (19)

observed that primary school girls with higher physical activity levels had significantly higher motor skill performance than their peers with lower physical activity levels. Contrary to this, our results suggest there are no significant differences in motor coordination scores between girls with different physical activity status. First, it is important to highlight which those authors (19) analyzed a sample with younger children and with different ethnicity than ours. Second, to date there is no consensus regarding the statistical significance of positive associations between physical activity levels and motor coordination scores in children (4). In this sense, our evidence reinforces the arguments posited by Fisher and colleagues (10), who questioned whether these variables are truly associated in the general child and adolescent populations. Indeed, solely the fact of having higher levels of physical activity does not ensure an adequate development of motor coordination in children, because the constraints contained within the requirements of the movement task, the biology of the individual, and the conditions of the learning environment have profound effects on the motor development (12). This assumption is regardless of tools used for assessing physical activity levels. Additional studies enrolling a larger sample are necessary in order to verify whether girls with higher physical activity levels not necessarily tend to perform higher motor coordination scores than their peers with lower physical activity levels.

The central issue in this investigation was the analysis of joint associations between body fat percentage and physical activity

levels on motor coordination scores in girls. It was expected that girls with excess adiposity would perform lower motor coordination scores regardless of physical activity levels due the added difficulty to perform weight-bearing tasks in relation to peers with appropriate adiposity. Our findings corroborated the hypothesis established in this study, i.e. girls with excess adiposity performed lower motor coordination scores than leaner peers regardless of their physical activity levels. Additionally, comparisons performed within groups with the same adiposity status showed there are no significant differences in motor coordination scores in girls with different physical activity status. Therefore, these findings indicate that adiposity status predominates over physical activity when joint associations of these variables on motor coordination scores are analyzed in girls. Similarly, Morrison and colleagues (19) found girls with higher body fat and low levels of physical activity had significantly lower motor performance than girls with lower body fat with high as well as low levels of physical activity. On the other hand, those authors (19) observed that not all girls with higher body fat had lower motor performance scores than girls with lower body fat, because their results varied in according to physical activity levels of children. However, whereas in the present study the adiposity status of children was attributed in according to age-specific cutoff points of Brazilian database (5), Morrison and colleagues (19) admitted their high fat group was lean compared with cutoff points used for children with excess adiposity. Thus, different criteria used for classification of adiposity status between studies besides distinct ages and ethnicity

of study's samples may have led to different results about joint associations between body fat percentage and physical activity levels on motor coordination scores in girls.

In this study it was observed that girls with excess adiposity tend to have poorer motor skills performance than their peers with appropriate adiposity levels, regardless of their physical activity levels. A possible future direction is to determinate whether these trends are observed in males of similar ages. Based on findings of this study, we consider that adiposity status of girls should also be looked in the planning of motor tasks in the physical education classes. In addition, it is important to note that children with poorer motor performance are subject to a negative vicious circle due their trends to have lower sports participation (24, 11), lower engagement in physical education classes (22), as well as to have worse weight status (7). Although a cause and effect relationship between aforementioned variables is not still established, it is important to highlight the role of physical educators in helping to avoid that negative vicious circle. In physical education classes is possible to stimulate a healthy weight status as well as to promote an adequate motor development in children and adolescents. In addition to metabolic and cardiovascular issues, therefore, the acquisition and/or maintenance of an appropriate adiposity in female students should be focused in physical education classes.

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