Relationships among motor coordination, body mass index and physical activity in adolescents with different weight status

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Summary

Purpose: To analyze the influence of physical activity level on associations between motor coordination and body mass index (BMI) in normal weight, overweight and obese adolescents.
Method: Thirty nine adolescents (13 normal weight, 13 overweight and 13 obese) aged 12-14 years old, participated in this study. The Physical Activity Questionnaire for Older Children (PAQ-C) and Körperkoordinationtest für kinder (KTK) tools were used in order to assess the levels of physical activity and motor coordination, respectively. Bivariate and partial correlations were used to analyze the interrelationships among motor coordination, BMI and physical activity. The analysis of covariance test was used in order to compare the levels of motor coordination among normal weight, overweight and obese adolescents, considering the physical activity level as a covariate.
Results: Moderate negative correlations ($p<0.05$) were found between motor coordination and BMI in the sample as a whole, normal weight and obese groups. However, when controlled for physical activity levels, it was not observed a significant correlation in the normal weight group. Motor coordination and BMI were not significantly correlated in overweight adolescents with and without controlling for physical activity levels. Furthermore, motor coordination level demonstrated a trend to be lower in overweight and obese adolescents.
Conclusion: Physical activity level influenced the association between motor coordination and BMI in normal weight adolescents, but not in overweight and obese. The negative effect of excess body mass on motor coordination level may overlap the possible influence that physical activity level exerts on the association between motor coordination and BMI in overweight and obese adolescents.

Key words:
Motor coordination. Obesity. Overweight. Adolescents. Biomechanics.

Relaciones entre la coordinación motora, índice de masa corporal y la actividad física en adolescentes con diferentes estados de peso corporal

Resumen

Objetivo: Analizar la influencia del nivel de actividad física en las asociaciones entre la coordinación motora y el índice de masa corporal (IMC) en adolescentes de peso normal, con sobrepeso y obesos.
Método: Treinta y nueve adolescentes (13 con peso normal, 13 con sobrepeso y 13 obesos) con edades comprendidas entre 12 y 14 años participaron en este estudio. Las herramientas Physical Activity Questionnaire for Older Children (PAQ-C) y Körperkoordinationtest für kinder (KTK) se usaron para evaluar los niveles de actividad física y coordinación motriz, respectivamente. Se usaron correlaciones bivariadas y parciales para analizar las interrelaciones entre la coordinación motora, el IMC y la actividad física. El análisis de covarianza se utilizó para comparar los niveles de coordinación motora entre los adolescentes de peso normal, con sobrepeso y obesos, considerando el nivel de actividad física como una covariable.
Resultados: se encontraron correlaciones negativas y moderadas ($p <0.05$) entre la coordinación motora y el IMC en la muestra como un todo, en los adolescentes con peso normal y obesos. Sin embargo, cuando se controlan los niveles de actividad física, no se observó una correlación significativa en el grupo de peso normal. La coordinación motora y el IMC no se correlacionaron significativamente en adolescentes con sobrepeso con y sin control de los niveles de actividad física. Además, el nivel de coordinación motora demostró una tendencia a ser menor en adolescentes con sobrepeso y obesos.
Conclusión: El nivel de actividad física influyó en la asociación entre la coordinación motora y el IMC en adolescentes de peso normal, pero no en adolescentes con sobrepeso y obesos. El efecto negativo del exceso de masa corporal en el nivel de coordinación motora puede superponerse a la posible influencia que ejerce el nivel de actividad física en la asociación entre la coordinación motora y el IMC en los adolescentes con sobrepeso y obesos.

Palabras clave:
Coordinación motora. Obesidad. Sobrepeso. Adolescentes. Biomecánica.

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Introduction

Pediatric obesity has become a global epidemic[1], being recognized as one of the most serious public health concerns in the 21st century[2]. In Brazil, more than 8 million children and adolescents are estimated to be obese[3]. This high prevalence is a concern due its associated health risks such as hypertension, hyperinsulinemia, glucose intolerance, type II diabetes and dyslipidemia[2].

Obesity seems also to be associated with poor motor coordination in children and adolescents[4-6]. Although few studies[7,8] have not found significant associations between motor coordination level and body mass index (BMI), most evidence suggests these variables are negatively associated[9-14]. Overall, these previous studies suggest obese children tend to have lower motor coordination level than their normal weight peers.

A plausible explanation for a negative association between BMI and motor coordination level in children and adolescents is based on biomechanical issues. That is, the higher the amount of body mass, the higher the mechanical work required to performing motor tasks, especially those which demand body weight-bearing. Evidence[10,15,16] has confirmed, at least partially, this weight-bearing hypothesis. However, the reported negative relationship between motor coordination level and BMI can be mediated by several alternative mechanisms[17].

One of mechanisms that can mediate, or influence, the relationship between motor coordination level and BMI in pediatric population is the physical activity level[4,18]. This assumption is based on evidence that physical activity level is positively associated with motor coordination level[19,20]. Also, it is important to recognize that not all obese children and adolescents have poor motor coordination or are physically inactive[21]. Therefore, the hypothesis that physical activity level may influence the association between motor coordination level and BMI in children and adolescents seems to be plausible.

Chagas and Batista[22] found physical activity level influences the association between motor coordination level and BMI in normal weight, but not in their overweight/obese peers. However, the comparisons realized in that study involved overweight and obese adolescents in the same group. Therefore, it remains unknown if physical activity level can influence the associations between motor coordination level and BMI in obese adolescents.

The purpose of this study was to analyze the influence of physical activity level on associations between motor coordination and BMI in normal weight, overweight and obese adolescents.

Material and method

One hundred and fifty five adolescents (69 boys and 86 girls) between seventh and ninth grade of elementary school (age ranged between 12 and 15 years old) from a Brazilian public school were initially recruited to participate in the study. Inclusion criteria required students to be under 15 years old with no history of injury or disease that could affect motor performance. Exclusion criteria consisted of subject's weight status classified as underweight. Ethical approval for this study was obtained from the University's Ethics Committee and parental consent and child assent were obtained prior to participation.

After initial recruitment (N=155), eight subjects were excluded from the study due to their being underweight. Further, thirteen obese adolescents were detected (n=13). Thus, among the 134 remaining subjects (28 overweight and 106 normal weight), 13 overweight and 13 normal weight adolescents were randomly selected to compose the final sample of 39 participants (17 boys and 22 girls). There was not missing data.

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 stadiometer wall to the nearest 0.1 cm. BMI (kg/m^2) was then calculated. World Health Organization[23] age-specific cut-off points for BMI were used in order to determine the weight status of participants (underweight, normal weight, overweight and obesity) according to gender.

The Physical Activity Questionnaire for Older Children (PAQ-C), a valid[24] self-applied 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 item questions, each scored on a 5-point scale, with 1 being the lower level of physical activity and 5 the higher level.

Motor coordination level was assessed using the Körperkoordinationstest für Kinder (KTK). The KTK is appropriated to assess motor coordination level of participants because it is a reliable and valid instrument, with a teste-retest reliability coefficient of 0.97[25]. KTK is one of most used tools for assessing children's motor coordination[26] and it consists of four test items. The first is walking backwards along balance beams (3m 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 score 1. The second involved one-legged hopping over an obstacle, formed by 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 points were summed to determine score 2. 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 score 3. 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 was counted and summed over two trials to determine score 4. KTK takes into account motor coordination level is gender and age-related. Thus, the four scores acquired in each item test were gender and age-adjusted in according to KTK normative database. Finally, the motor coordination level for each participant was derived from the sum of the four adjusted scores obtained in the tests.

Descriptive statistics were determined for all variables. The Kolmogorov–Smirnov test confirmed acceptable normality of the data distribution. Pearson's correlation coefficients were used to examine the bivariate relationships between levels of motor coordination, BMI and physical activity. Partial correlations were used to analyse the relationship between motor coordination level and BMI, controlling for physical activity levels. Analysis of covariance (ANCOVA) was used to compare the motor coordination levels between normal weight, overweight and obese adolescents, considering the physical activity level as a covariate. 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 (SPSS ver. 22.0, IBM, USA).

Results

The total sample (N=39) presented the following values for age, body weight, height, BMI, motor coordination and physical activity levels, respectively: 13.7y (±0.6), 63.2kg (±17.5), 1.61m (±0.8), 24.1kg/m^2 (±5.9), 78.6 (±22.0) and 2.7 (±0.9). Descriptive statistics of group 1 (normal weight), group 2 (overweight) and group 3 (obese) are provided in Table 1.

As shown in Figure 1, motor coordination levels decline as weight status worsens, that is, as higher BMI, the lower motor coordination levels. However, results of ANCOVA test confirmed significant differences in motor coordination levels only between normal weight and obese groups (F=4.123, p=0.025).

Pearson and partial correlations coefficients are displayed in Table 2. Moderate negative correlations were found between BMI and motor coordination levels in the group as a whole, as well as in the normal weight and obese groups. However, when statistically controlled for physical activity levels, significant correlations were only observed in the group as a whole and obese group.

Table 1. Descriptive statistics (mean ± standard deviation) of age, body weight, height, BMI, motor coordination levels (MC) and physical activity levels (PA) of normal weight (group 1), overweight (group 2) and obese (group 3) adolescents.

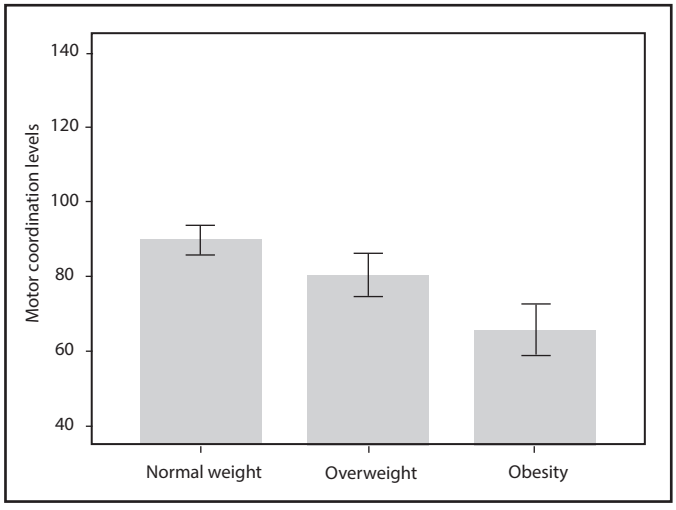
	Group 1 (n=13)	Group 2 (n=13)	Group 3 (n=13)
Age (years)	13.7 (±0.7)	13.6 (±0.6)	13.9 (±0.6)
Body Weight (kg)	45.0 (±8.2)	63.8 (±6.6)	80.8 (±13.1)
Height (m)	1.58 (±0.1)	1.64 (±0.1)	1.62 (±0.1)
BMI (kg/m^2)	18.0 (±1.9)	23.6 (±1.4)	30.8 (±4.1)
MC	89.9 (±13.5)	80.3 (±21.7)	65.6 (±23.5)
PA	2.9 (±0.9)	2.7 (±0.9)	2.5 (±0.8)

Table 2. Pearson and partial correlation coefficients between BMI and motor coordination levels (two-tailed test).

	Bivariate correlations	Partial correlations‡
Total sample	- 0.640**	- 0.622**
Group 1	- 0.569*	- 0.565†
Group 2	- 0.464†	- 0.465†
Group 3	- 0.691**	- 0.643*

‡Controlled for physical activity levels.
*Correlation significant at the 0.05 level.
**Correlation significant at the 0.01 level.
†Correlation non-significant (p>0.05).

Figure 1. Mean and standard error of motor coordination levels across three groups.



Discussion

The main aim of this study was to analyze the influence of physical activity level on associations between motor coordination and BMI in adolescents with different weight status. Our findings suggested motor coordination level and BMI are negatively associated in normal weight and obese adolescents. However, the association between these variables was not significant when controlled for physical activity level in normal weight adolescents. On the other hand, motor coordination level and BMI were significantly negatively correlated in obese adolescents regardless of physical activity level. These results suggest physical activity level can influence the association between motor coordination and BMI in normal weight adolescents. Furthermore, motor coordination level demonstrated a trend to be decline as weight status worsens.

Moderate negative correlations between motor coordination level and BMI were observed in the group as a whole, normal weight and obese adolescents. These findings are in line with previous studies[9-14]. Considering BMI as an indicator of body fat, it seems plausible to expect that individuals with higher BMI, i.e. higher adiposity, have higher difficulty to perform some motor tasks due to increased biomechanical

demands. That is, the higher BMI, higher physical difficulties experienced by individuals, such as increased moments of inertia and mechanical work, especially in weight-bearing tasks.

Nevertheless, our findings showed that motor coordination and BMI were not significantly correlated in overweight adolescents. Few previous studies[7,8] have also not found significant associations between motor coordination level and BMI. These findings can be explained by the fact that individuals with the same weight status, or even with the same BMI, may have considerable differences in body composition. That is, overweight individuals with relatively high levels of lean mass and low levels of body fat may have no increased difficulty to perform motor tasks due their BMI status.

Negative correlations between motor coordination levels and BMI remained weak to moderate when controlled for physical activity level in all groups. However, motor coordination level and BMI were not significantly correlated in normal weight adolescents when controlled for physical activity level. This evidence suggests physical activity level can influence the association between motor coordination and BMI in normal weight adolescents, but not in overweight and obese. These findings are in line with a previous study[22], corroborating the assumption that, in obese adolescents, motor coordination level and BMI are negatively associated regardless of physical activity levels. These results can be explained by negative effect of excess body mass on motor coordination level; it may overlap the possible influence that physical activity level exerts on the association between motor coordination and BMI in overweight and obese adolescents.

In line with previous findings[5,10,17], our results showed motor coordination level tend to decline as weight status worsens. These results add to the body of evidence suggesting obese adolescents tend to have poorer motor coordination level than their normal weight peers. These findings were expected due to increased biomechanical demands in some motor tasks experienced by individuals with higher BMI. However, significant differences in motor coordination level were observed only between normal weight and obese groups. That is, there were no significant differences in motor coordination level when overweight adolescents were compared with normal weight and obese peers. These findings can also be explained by possible differences in body composition, especially with regard to body fat, among participants whose weight status was classified as overweight.

In this study was hypothesized that the physical activity level, as a mediator mechanism, could influence the associations between motor coordination and BMI in adolescents with different weight status. Our findings corroborated only partially this hypothesis, because physical activity level influenced only the associations among normal weight adolescents. Besides the increased negative effect of body fat in overweight and obese, other complementary mechanisms, as perceived motor competence and physical fitness, can have influenced the approached relationship.

Another way to explain our findings concerns the role of physical activity level in this interrelationship. Indeed, it is expected the higher physical activity level among adolescents, higher their opportunities for practice. Considering that opportunities for practice is essential for motor development[27], it is expected that physical activity level is associated with motor coordination. However, the levels of physical activity showed for adolescents may not necessarily to be linked with diversified and increased opportunities for practice. Thus, the influence of physical activity on relationship between motor coordination and BMI can be low or inexistent. In this sense, the role of physical activity as a mediator mechanism, such as proposed in the conceptual framework proposed by Stodden *et al*.[28], may vary in according to opportunities for practice experienced by individuals.

This study had some limitations. First, motor coordination and physical activity were assessed using a test composed by gross motor skills and a self-reported questionnaire, respectively. Thus, the inference of our results is limited to these specific measures in adolescents. Second, both instruments used for assessing physical activity and motor coordination were not adapted to Brazilian population. Also, the small sample size was relatively small. Future investigations using different measurement tools should be conducted in order to corroborate or refuse our results.

Conclusions

Physical activity level influenced the association between motor coordination and BMI in normal weight adolescents, but not in overweight and obese. The increased negative effects of excess body mass, as well as the variability of opportunities for practice according to physical activity level, seem to explain these findings. Also, complementary analyses assessing the potential mediating effects of physical activity on the relationship between motor coordination and BMI should be considered in future studies. As practical application, physical educators and physicians must encourage not only a health weight status, but also the development of motor coordination among adolescents. Moreover, elevated levels of physical activity associated with diversified and increased opportunities for practice should also be promoted by health care professionals, as physical educators and physicians.

Conflict of interest

The authors do not declare a conflict of interest.

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