

## Associations between motor competence and the risk of obesity in Brazilian adolescents Asociaciones entre la competencia motora y el riesgo de obesidad en adolescentes brasileños

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**Abstract.** Purpose: To assess whether motor competence is associated with the risk of obesity in adolescents. Methods: The sample consisted of 296 adolescents (56.1% girls) aged 12 to 15 years recruited from Rio de Janeiro, Brazil. Motor competence was assessed using the Körperkoordinationstest für Kinder (KTK). Body mass index (BMI) measures were used to classify the participants' weight status. Physical activity was determined through a validated self-administered questionnaire. Multinomial and binary logistic regression models, adjusted for potential confounders (i.e. age, sex and physical activity), were executed to examine the association between motor competence and risk of obesity. Results: Almost half of participants (48%) presented low motor competence. Among adolescents with obesity, 92.9% showed low motor competence. In addition, low motor competence was associated with a higher risk to be overweight (OR: 2.940,  $p=.006$ ) and obese (OR: 18.366,  $p<.001$ ), even after adjusting for potential confounders. Conversely, adolescents with adequate motor competence were less likely to be overweight (OR: .340,  $p=.006$ ) and obese (OR: .054,  $p<.001$ ). Conclusion: Having low motor competence can be a risk factor for obesity, while adequate motor competence was a protective factor against this disease. Pediatric obesity is multifactorial, including environmental aspects, yet this study showed that motor competence seems to be important to maintaining a healthy weight status in youth.

**Keywords:** motor development; weight status; overweight; physical activity; children.

**Resumen.** Objetivo: Evaluar si la competencia motora se asocia con el riesgo de obesidad en adolescentes. Métodos: La muestra estuvo compuesta por 296 adolescentes (56,1% niñas) de 12 a 15 años reclutados en Río de Janeiro, Brasil. La competencia motora se evaluó mediante el Körperkoordinationstest für Kinder (KTK). Se utilizaron medidas del índice de masa corporal (IMC) para clasificar el estado de peso de los participantes. La actividad física se determinó mediante un validado cuestionario autoadministrado. Se ejecutaron modelos de regresión logística multinomial y binaria, ajustando los posibles factores de confusión (es decir, edad, sexo y actividad física), para examinar la asociación entre la competencia motora y el riesgo de obesidad. Resultados: Casi la mitad de los participantes (48%) presentó baja competencia motora. Entre los adolescentes con obesidad, el 92,9% presentó baja competencia motora. Además, la baja competencia motora se asoció con un mayor riesgo de tener sobrepeso (OR: 2,940,  $p=0,006$ ) y obesidad (OR: 18,366,  $p<0,001$ ), incluso después de ajustar por posibles factores de confusión. Por el contrario, los adolescentes con competencia motora adecuada tenían menos probabilidades de tener sobrepeso (OR: 0,340,  $p=0,006$ ) y obesidad (OR: 0,054,  $p<0,001$ ). Conclusión: Tener una baja competencia motora puede ser un factor de riesgo para la obesidad, mientras que una adecuada competencia motora demostró ser un factor protector contra esta enfermedad. La obesidad pediátrica es multifactorial, incluidos los aspectos ambientales; sin embargo, este estudio demostró que la competencia motora parece ser importante para mantener un peso saludable en los jóvenes.

**Palabras clave:** desarrollo motor; estado de peso; exceso de peso; actividad física; adolescentes

Fecha recepción: 23-09-23. Fecha de aceptación: 14-02-24

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### Introduction

Childhood obesity is a global health problem whose prevalence has rapidly increased over recent decades (World Health Organization, 2020a). About 380 million children and adolescents are overweight or obese worldwide (World Health Organization, 2020b), and rates continue to rise (Kumari et al., 2022). This is a concern because excess adiposity in childhood and adolescence is associated with adverse health consequences, including cardiovascular, metabolic, and mental disorders (Marcus et al., 2022). Yet obesity is preventable given that it is also influenced by modifiable factors. Beyond key factors like nutrition and physical activity, there is emerging evidence that motor competence can be considered modifiable in preventing obesity across childhood (Chagas et al., 2021a).

Motor competence is a global term which refers to the level of proficiency that people obtain in a wide variety of motor tasks, including those in active play, physical education classes and sport activities (Chagas & Marinho, 2021). The reason for the association between motor competence

and obesity is that motor competence influences youth behavior patterns that, in turn, can affect weight status over development (Chagas et al., 2021b). One behavioral pattern that can be influenced by motor competence is physical activity level, with longitudinal evidence having indicated that motor competence is a predictor of physical activity in young people (Britton et al., 2020; Chagas & Marinho, 2021). In short, there is an assumption that young people with low motor competence can feel discouraged about engaging in physical activities, resulting in their higher risk to become overweight and obese (Chagas et al., 2021a; Stodden et al., 2008).

A recent systematic review found strong evidence, in both directions, for negative associations between motor competence and weight status in young people (Barnett et al., 2022). In fact, evidence has supported motor competence as both a predictor (Chagas et al., 2021b; Duncan et al., 2021) and an outcome (Chagas & Marinho, 2021; Lima et al., 2019) of youth adiposity levels. In addition, comparative studies have shown that young people with obesity have poorer motor competence than individuals of healthy weight (Chagas & Batista, 2019; Battaglia et al.,

2021; Herlitz et al., 2021). However, less is known as to whether children with low motor competence are at increased risk for becoming overweight and/or obese.

In one such investigation, Dos Santos et al. (2018) found that motor competence was not associated with children's risk of being overweight and obese. Conversely, two previous studies (Chagas et al., 2021a; Lopes et al., 2014) found that young people with low motor competence had increased risk to be overweight/obese. In addition, Henrique et al. (2020) found mixed results, given that performance on locomotor, but not object control skills, was inversely associated with the risk of obesity in preschool children. Altogether, these previous findings have been inconsistent and, therefore, it remains unclear whether young people with low motor competence are at increased risk of obesity.

On the other hand, having adequate motor competence can be a protective factor against obesity, given that higher motor competence is expected to be associated with higher engagement in physical activity and then to have a healthier weight status (García-Marín & Fernández-López, 2020; Stodden et al., 2008). In this regard, Henrique et al. (2020) found that preschool children with higher locomotor skills were likely to present with central obesity. However, it is still unknown whether adolescents with adequate motor competence have lower risk to be overweight and obese.

Another gap concerns how or whether the association between motor competence and risk of obesity is influenced by physical activity. Physical activity is a behavior pattern defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Carpensen et al., 1985). Given that weight status is affected by energy expenditure, physical activity is key to maintaining a healthy body weight. As such, physical activity can influence the relationship between motor competence and risk of obesity.

The main aim of this study was to assess whether motor competence is associated with risk of obesity in adolescents. In addition, the secondary aim of this study was to examine whether such an association is influenced by physical activity. We hypothesized that adolescents with lower motor competence would be at increased risk for obesity. Conversely, we expected that adolescents with adequate motor competence would be less likely to present with obesity. In addition, we hypothesized that physical activity can influence the relationship between motor competence and risk of obesity.

## Methods

This research design was cross-sectional.

### Participants

A convenience sample with 310 participants aged 12 to 15 years was recruited from a low-income area of Rio de Janeiro city, Brazil. Exclusion criteria required individuals

to have no history of injury or disease which could affect motor performance and not to be classified as underweight. Fourteen volunteers were excluded based on these criteria, resulting in a final sample of 296 individuals (56.1% girls). Schools' authorities provided formal authorization for this research. Parent consent and participant assent were obtained. Ethical approval was acquired from the University's Ethics Committee (CAAE: 07617018.4.0000.5259).

### Measures

Body weight (kg) and height (cm) were measured using an electronic scale and a stadiometer. Body mass index (BMI) was calculated ( $\text{kg}/\text{m}^2$ ) and then, using the World Health Organization growth reference for adolescents (De Onis et al., 2007), the weight status of each participant was determined as 'underweight,' 'healthy weight,' 'overweight,' or 'obesity.' As noted above, underweight participants were excluded from the analysis.

Physical activity level was determined using a translated and cross-culturally (Chagas et al., 2020) adapted version of the Physical Activity Questionnaire for Older Children (PAQ-C; Kowalski et al., 1997) into the language of the participants [internal consistency, Cronbach's  $\alpha = 0.85-0.87$ ; test-retest reliability with a time interval of 1 day, Intra-class Correlation Coefficient (ICC) = 0.90]. The PAQ-C is a self-administered seven-day recall instrument, appropriate for elementary school aged children approximately between eight and 14 years old who are currently in school 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, each scored on a five-point scale. PAQ-C scores range between 1 and 5 points.

Motor competence was assessed using the *Körperkoordinationstest für Kinder* (KTK). The KTK is a valid and reliable instrument (Kiphard & Shilling, 2007) for middle school-aged children and consists of four subtests. The first is walking backwards on balance beams of decreasing width. Each beam was crossed three times, with a maximum of eight steps per trial allowed. The second subtest involved one-legged hopping over an obstacle, formed with an increasing pile of pillows. Only three trials were allowed for each obstacle, and three, two, or one point(s) were awarded for successful performance on the first, second, or third try, respectively. The third task was two-legged sideways jumping across a wooden slat, positioned in the middle of an area (60cm x 100cm), for 15 s as quickly as possible, where the participant should: land inside the area, with both feet simultaneously, without touching the wooden slat while jumping. The final task involved moving sideways on wooden boards 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 raw test scores of the KTK test items were transformed into sex and age standardized values and into a measure indicating overall motor competence level ac-

according to the original norms (Kiphard & Shilling, 2007). These KTK adjusted scores range between 40 and 150 points.

This study considered motor competence as a categorical variable with two levels: 1) 'adequate'; and 2) 'low'. The original KTK scale (Kiphard & Shilling, 2007) was used to make these classifications, given that previous studies showed that the original factor structure of the KTK is adequate to assess (Moreira et al., 2019) and to discriminate (Draghi et al., 2021; Santos et al. 2020) motor competence of Brazilian young people. Then, the motor competence levels classified as normal or higher at original KTK scale (i.e. score > 85), were considered as 'adequate,' whereas those classified as below normal (i.e. score ≤ 85) were considered as 'low'.

### Data analysis

Descriptive statistics were determined for all measurements. The Kolmogorov–Smirnov test confirmed acceptable normality of the data distributions. Pearson correlation coefficients were determined to check the association between motor competence level (as a continuous variable) and BMI. Two-way analyses of variance (ANOVAs) were used for comparisons of motor competence levels according to sex and weight status (healthy weight, overweight and obesity, with post-hoc analyses conducted with the Tukey test).

Logistic regressions were used to examine whether low motor competence is associated with the risk of obesity, adjusting for potential confounders. For this, we constructed two models of analyses, considering two (healthy weight and overweight/obesity) or three (healthy weight, overweight and obesity) categories of weight status as the dependent variables. Before regression analyses, the correlations between predictors were examined in order to check their multicollinearity. Colinearity diagnostics indicated acceptable values and then logistic regressions were executed.

In Model 1, we used a multinomial logistic regression, in which weight status (dependent variable) was split into three categories: healthy weight, overweight and obesity. Motor competence ("low" and "adequate") was hypothesized as the main predictor in two pathways: without adjustments (crude analysis, Model 1a) and with adjustments (adjusted analysis, Model 1b), considering age, sex and physical activity level as potential confounders. The likelihood ratio and goodness of fit tests indicated that the data fit the model. In Model 2, we conducted a sex-specific analysis also considering motor competence ("low" and "adequate") as the main predictor in both crude (Model 2a) and adjusted (Model 2b) analyses. Age and physical activity were considered potential confounders in the adjusted analysis (Model 2b). In order to increase our statistical power, we split weight status into only two categories (healthy weight and overweight/obesity) and then performed a binary logistic regression. The Hosmer and Lemeshow test confirmed

that the data fit the model. In all models, motor competence was assessed as a risk factor (i.e. low motor competence as the exposure and adequate motor competence as the reference category) and as a protective factor (i.e. adequate motor competence as the exposure and low motor competence as the reference category) for overweight and obesity. A significance level of 5% ( $\alpha = 0.05$ ) was adopted in all statistical tests. Statistical analyses were executed using IBM SPSS software version 22.0.

## Results

Descriptive statistics of age, body weight, stature, BMI percentile, physical activity and motor competence level are provided in Table 1. Almost half of the participants (48%) presented low motor competence. The prevalences of participants with healthy weight, overweight and obesity were, respectively, 73.3%, 17.2% and 9.5%. Among adolescents with obesity, 92.9% showed low motor competence (Table 2). The relative frequency of participants with "low" and "adequate" motor competence who presented healthy weight, overweight or obesity is shown in Table 2. Pearson correlation analysis confirmed an inverse association between BMI and all motor competence scores in boys and girls (Table 3).

Table 1.

Descriptive statistics (mean ± standard deviation) by weight status of the 296 participants

	Healthy Weight (n=217)	Overweight (n=51)	Obese (n=28)
Age (years)	13.5 (±0.7)	13.6 (±0.6)	13.7 (±0.7)
Body Weight (kg)	46.9 (±7.7)	63.0 (±8.2)	79.1 (±12.7)
Height (m)	1.58 (±0.1)	1.61 (±0.1)	1.60 (±0.1)
Physical Activity	2.8 (±0.8)	2.5 (±0.7)	2.6 (±0.7)
Motor Competence	91.2 (±18.2)	75.4 (±22.4)	62.41 (±20.6)

Table 2.

Cross-tab and chi-square test considering categories of motor competence (MC) and weight status (n=296)

	Healthy weight (n=217)	Overweight (n=51)	Obese (n=28)	Chi-square
Low MC (n=142)	82 (37.8%)	34 (66.7%)	26 (92.9%)	38.760 <sup>a</sup>
Adequate MC (n=154)	135 (62.2%)	17 (33.3%)	2 (7.1%)	(<.001) <sup>b</sup>

<sup>a</sup> Pearson chi-square

<sup>b</sup> Asymptotic two-sided significance

Table 3.

Pearson correlation coefficients between BMI and all motor competence scores.

	Walking Backwards	One-legged hopping	Sideways jumping	Moving sideways	MC Global
Boys	r = -.444** p<.001	r = -.614** p<.001	r = -.266** p=.002	r = -.235** p=.007	r = -.505** p<.001
Girls	r = -.493** p<.001	r = -.460** p<.001	r = -.362** p<.001	r = -.256** p=.001	r = -.478** p<.001

\*\*denotes significance level at p<.01.

The two way ANOVA ( $F=33.792$ ,  $p<.001$ ,  $\eta^2=.189$ ) with Tukey post hoc testing confirmed that both overweight and obese adolescents performed worse on measures of motor competence than healthy weight individuals. Also, adolescents with obesity presented poorer motor competence than participants who were overweight. In addition, the ANOVA test revealed that girls

had lower motor competence than boys ( $F = 23.973$ ,  $p < .001$ ,  $\eta^2 = .076$ ). There was no significant interaction effect between sex and weight status ( $F = .540$ ,  $p = .583$ ,  $\eta^2 = .004$ ).

In Model 1a (crude analysis), the multinomial logistic regression indicated that low motor competence was linked to a higher risk to be overweight [Odds Ratio (OR): 3.293, Confidence Interval (CI): 1.730 – 6.267,  $p < .001$ ] and obese (OR: 21.402, CI: 4.950 – 92.543,  $p < .001$ ). On the other hand, adequate motor competence was linked to a lower risk to be overweight (OR: .304, CI: .160 – .578,  $p < .001$ ) and obese (OR: .047, CI: .011 – .202,  $p < .001$ ). When adjusted for potential confounders (Model 1b), low motor competence was also associated with the risk of being overweight and obese (Table 4). In addition, the adjusted analysis revealed that physical activity, as well as age and sex, were not significant confounders. Conversely, to have adequate motor competence was associated with a lower risk of being overweight (OR: .340, CI: .158 – .731,  $p = .006$ ) and obese (OR: .054, CI: .012 – .257,  $p < .001$ ).

In Model 2a (crude analysis), the binary logistic regression showed that low motor competence was associated with an increased risk of being overweight/obese in boys (OR: 9.889, CI: 3.731 – 26.211,  $p < .001$ ) and girls (OR:

3.067, CI: 1.401 – 6.710,  $p < .001$ ), while adequate motor competence was linked to a lower risk in boys (OR: .101, CI: .038 – .268,  $p < .001$ ) and girls (OR: .326, CI: .149 – .714,  $p = .005$ ). Low motor competence was also associated with the risk of being overweight/obese even after adjusting for potential confounders in both sexes (Model 2b, Table 5). Furthermore, Model 2b showed that physical activity and age were not significant confounders. On the other hand, to have adequate motor competence was associated with a lower risk of being overweight/obese in boys (OR: .142, CI: .051 – .394,  $p < .001$ ) and girls (OR: .308, CI: .126 – .751,  $p < .010$ ).

Table 4.

Model 1b: the adjusted analysis of the multinomial logistic regression reporting the risk of adolescents with low motor competence being overweight and obese ( $n=296$ ).

	B	Wald	P value	OR	95% CI	
					Lower	Upper
Overweight	MC status*	1.078	7.663	.006	2.940	1.368 6.317
	Sex*	.053	.017	.895	1.055	.478 1.205
	Age	-.011	.002	.965	.989	.609 1.607
	PA	-.295	1.442	.230	.745	.460 1.205
Obesity	MC status*	2.910	13.530	<.001	18.366	3.895 86.606
	Sex*	.006	<.001	.991	1.006	.340 2.974
	Age	.233	.473	.492	1.262	.650 2.451
	PA	.157	.243	.622	1.170	.627 2.183

Note: Low motor competence was considered as the exposure and adequate motor competence as the reference category.

Table 5.

Model 2b: the adjusted analysis of the binary logistic regression reporting the risk of being overweight and obese in boys and girls.

	Boys ( $n=130$ )					Girls ( $n=166$ )						
	B	Wald	p	OR	95% CI		B	Wald	p	OR	95% CI	
					Lower	Upper					Lower	Upper
MC status	1.949	14.061	.000	7.024	2.536	19.456	1.179	6.701	.010	3.252	1.332	7.941
Age	.228	.347	.556	1.256	.589	2.679	-.014	.003	.957	.986	.583	1.667
PA	-.424	1.412	.235	.654	.325	1.317	-.011	.002	.967	.989	.588	1.664

Note: low motor competence was considered as the exposure and adequate motor competence as the reference category.

## Discussion

The purpose of this study was to assess whether motor competence is associated with the risk of obesity in adolescents. Our findings indicated that low motor competence was associated with a higher risk of being obese, even after adjusting for potential confounders like physical activity. In addition, the sex-specific analysis confirmed that low motor competence was associated with an increased risk of being overweight/obese in both boys and girls. Conversely, adolescents with adequate motor competence were less likely to present obesity. Altogether, our findings suggest that to have low motor competence can be a risk factor for obesity, while adequate motor competence was a protective factor against this disease. Therefore, this study reinforces the importance of having adequate levels of motor competence for a healthy weight status in adolescence.

This study assessed a sample of Brazilian adolescents. Approximately half of the participants (i.e. 48%) presented low motor competence. This high prevalence is a concern because to have adequate motor competence is associated with a number of health benefits like a healthy

weight status and physical fitness (Chagas & Barnett, 2023; Lopes et al., 2020). Concerning weight status, our findings showed that 92.9% of adolescents with obesity showed low motor competence and a negative correlation between BMI and motor competence was confirmed in boys and girls. Furthermore, motor competence in youth has recently been proposed as a correlate of cognition, academic performance, mental and metabolic health (Lima et al., 2022).

Aligned with our results, a previous study found that the prevalence of delays and borderline impaired motor performance was high among Brazilian children (Valentini et al., 2022). Furthermore, the high prevalence of young people with low levels of motor competence has been reported in previous studies from different regions, including WEIRD (Western, Educated, Industrial, Rich and Democratic) countries, such as the United States (Goodway et al., 2010), Ireland (Philpott et al., 2023) and Australia (Hardy et al., 2013). More dramatically, a negative decline of motor competence in children has been observed over the last decades (Bardid et al., 2015; Koepfel et al., 2022). The decline in children's motor competence

is a global issue (Bardid et al., 2015) and, therefore, initiatives that foster the development of motor competence across childhood and adolescence are urgent.

On one hand, our analysis revealed that low motor competence was associated with a higher risk of being overweight and obese in adolescents, even after adjusting for potential confounders like physical activity. Furthermore, our sex-specific analysis confirmed that both boys and girls with low motor competence have increased risk for becoming overweight/obese. These findings are aligned with previous studies examining children (Lopes et al., 2014) and adolescent's motor competence (Chagas et al., 2021a). In addition, (Dos Santos et al. (2018) found that children aged between 7 and 10 years with lower motor competence were more likely to be overweight and/or obese, but not after adjusting for potential confounders such as body fatness and physical fitness. Considering that physical activity tends to correlate with physical fitness and that body fatness correlates with BMI and weight status (Pate et al., 2012), the divergent results between studies does not seem to be due to different covariates used in the analyses. Perhaps these contradictory findings are due to age-related differences (i.e. children vs. adolescents), given that the interrelationships among motor competence, physical activity and physical fitness are expected to strengthen over development (Stodden et al., 2008; Chagas et al., 2021b). Therefore, our findings suggest that low motor competence can be a risk factor for obesity in adolescents.

On the other hand, evidence has shown that children with higher motor competence are less likely to present central obesity (Henrique et al., 2020) and higher body fatness (Lima et al., 2019). Our findings confirmed these previous studies, given that adolescents with adequate motor competence presented lower risk of being overweight and obese. Such association was similar between sexes, that is, boys and girls with adequate motor competence had lower risk of being overweight/obese. Altogether, these results suggest that adequate motor competence can be a protective factor against becoming overweight and obese for adolescents.

The high prevalence of overweight and obese young people is a global issue. Considering that obesity is preventable and influenced by behavioral patterns, many societies have failed in protecting children and adolescents against this disease. In this regard, our study confirmed that a promising way to prevent obesity is to foster the development of motor competence. First, this is because the development of adequate levels of motor competence can be a protective factor against obesity in adolescents. Second, adolescents with low levels of motor competence showed an increased risk of being overweight and obese. In fact, motor competence has shown its importance for achieving a healthier weight status over time (Chagas et al., 2021b; Chagas & Marinho, 2021). Therefore, we recommend initiatives that promote the development of motor competence in young people through diversified

and abundant opportunities for practice – such as active play, sport activities and physical education classes – to prevent obesity in young people.

This study had some limitations. First, we did not fully address potential confounders, like socioeconomic status in our investigation. Second, our convenience sample limits the generalization of these results. Third, our cross-sectional design does not allow to establish causal mechanisms between level of motor competence and weight status. Instead, this study reinforces the correlative role of motor competence for a healthy weight status, and it confirms our hypothesis that motor competence is associated with the risk of obesity in adolescents. Additional studies with longitudinal designs, multiple time points and that account for other potential confounders as socioeconomic status are needed to improve our understanding regarding the relationship between motor competence and risk of obesity in youth.

## Conclusions

Motor competence is associated with the risk for overweight and obesity in adolescents. Having low motor competence can be a risk factor for obesity, while adequate motor competence was a protective factor against this disease. Pediatric obesity is multifactorial, including environmental aspects, yet this study showed that motor competence seems to be important to maintaining a healthy weight status in youth. Considering the high prevalence of low motor competence and overweight/obesity among children and adolescents, there is an urgent need for motor skills interventions in order to foster the development of motor competence and to prevent obesity in youth.

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