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Comparative analysis of gross motor coordination between overweight/obese and eutrophic children

Análise comparativa da coordenação motora grossa em crianças com sobrepeso/obesidade e eutróficas

Análisis comparativo de la coordinación motora gruesa en niños con sobrepeso / obesidad y eutróficas

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Abstract

Introduction: Overweight and obese children may have lower motor coordination score than normal-weight children. **Objective:** To compare gross motor coordination between overweight/obese and normal-weight children and investigate the associated factors with the motor coordination scores. **Method:** This cross-sectional study involved 169 children of both genders, aged 6-9 years. Children with malformations, bone, muscle, and joint or neurological disorders, and BMI z < -2 were excluded. Gross motor coordination was assessed by the "Körperkoordinationstest für Kinder" (KTK). The associated factors with the motor coordination scores were analyzed by linear regression. **Results:** The mean scores for balancing backwards (84.2 ± 13.2 vs. 91.0 ± 15.0), hopping over on one foot (127.9 ± 10.1 vs. 132.3 ± 12.1), shifting platforms sidewise (123.5 ± 23.4 vs. 129.8 ± 14.9), as well as the overall motor scores (112.5 ± 14.8 vs. 118.8 ± 11.6) were significantly lower ($p < 0.05$) in overweight/obese children when compared to normal-weight children. The percentage of poor motor scores (< 85) in balancing backwards was higher in overweight/obese children (60.4% vs. 36.4%, $p = 0.004$) and was similar for jumping sideways (18.8% vs. 9.9%, $p = 0.116$), as well as for

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shifting platforms sidewise (6.3% vs. 0.8%, p = 0.070). By multiple linear regression analysis, the variables overweight/obesity and sports practice for less than 2 times/week decreased significantly ($p < 0.05$) the motor coordination score by -18.7 and -15.6 points, respectively. **Conclusion:** The overweight/obese children scored lower in the motor coordination tests compared to the normal-weight children. Overweight/obesity and low frequency of physical activity were associated with lower scores of gross motor coordination.

Keywords: Child. Overweight. Obesity. Motor Skills.

Resumo

Introdução: *Crianças com sobrepeso/obesidade podem ter menores escores de coordenação motora, comparadas às eutróficas.* ***Objetivo:*** *Comparar a coordenação motora grossa entre escolares com sobrepeso/obesidade e eutróficos e analisar os fatores associados aos escores de coordenação motora.* ***Método:*** *Este estudo transversal incluiu crianças de 6-9 anos, de ambos os sexos. Foram excluídas crianças com malformações congênitas, deformidades osteomioarticulares, distúrbios neurológicos ou IMC < -2 escore-z. Avaliou-se a coordenação motora grossa pelos testes Körperkoordinations test für Kinder (KTK). Fatores associados aos escores de coordenação motora foram analisados por regressão linear.* ***Resultado:*** *As médias dos escores na marcha para trás (84,2 ± 13,2 vs. 91,0 ± 15,0), saltos monopedais (127,9 ± 10,1 vs. 132,3 ± 12,1), transferência em plataformas (123,5 ± 23,4 vs. 129,8 ± 14,9) e o escore global dos testes (112,5 ± 14,8 vs. 118,8 ± 11,6) foram significantemente menores (p < 0,05) em crianças com sobrepeso/obesidade, comparadas às eutróficas. A porcentagem de alunos com escore motor deficiente (< 85) foi maior no sobrepeso/obesidade na marcha para trás (60,4% vs. 36,4%, p = 0,004) e semelhantes nos saltos laterais (18,8% vs. 9,9%, p = 0,116) e transferência lateral (6,3% vs. 0,8%, p = 0,070). Na análise de regressão linear múltipla, as variáveis sobrepeso/obesidade e prática de esporte < 2 vezes/semana reduziram significantemente (p < 0,05) o escore motor global em 18,7 e 15,6 pontos, respectivamente.* ***Conclusões:*** *Crianças com sobrepeso/obesidade apresentaram menores escores de coordenação motora que as eutróficas. Sobrepeso/obesidade e baixa frequência de atividade física se associaram a menores escores de coordenação motora grossa.*

Palavras-chave*: Criança. Sobrepeso. Obesidade. Destreza Motora.*

Resumen

Introducción: *Niños con sobrepeso/obesidad pueden tener menores escores de coordinación motora, comparados a las eutróficas.* ***Objetivo:*** *Comparar la coordinación motora gruesa entre escolares con sobrepeso/obesidad y eutróficos, y analizar factores asociados a coordinación motora.* ***Método:*** *Este estudio transversal incluyó niños de 6-9 años, de ambos géneros. Se excluyeron: niños con malformaciones congénitas, deformidades osteomioarticulares, trastornos neurológicos o IMC < -2 escore-z. Se evaluó la coordinación motora gruesa por las pruebas Körperkoordinations test für Kinder (KTK). Factores asociados a los escores de coordinación motora fueron analizados por regresión lineal.* ***Resultado:*** *Las medias de los escores en la marcha hacia atrás (84,2 ± 13,2 vs. 91,0 ± 15,0), saltos monopedales (127,9 ± 10,1 vs. 132,3 ± 12,1, transferencia en plataformas (123,5 ± 23,4 vs. 129,8 ± 14,9) y escore global (112,5 ± 14,8 vs. 118,8 ± 11,6) fueron significativamente menores (p < 0,05) en niños con sobrepeso/obesidad, comparados a las eutróficas. El porcentaje de alumnos con escore motor deficiente (< 85) fue mayor en sobrepeso/obesidad en la marcha hacia atrás (60,4% vs. 36,4%, p = 0,004) y similares en los saltos laterales (18,8% vs. 9,9%, p = 0,116) y transferencia lateral (6,3% vs. 0,8%, p = 0,070). En el análisis de regresión lineal múltiple, las variables sobrepeso/obesidad y práctica de deporte < 2 veces/semana redujeron significantemente (p < 0,05) el puntaje motor global en 18,7 y 15,6 puntos, respectivamente. Conclusiones: Niños con sobrepeso/obesidad presentaron menores escores de coordinación motora que las eutróficas. Sobrepeso/obesidad y baja frecuencia de actividad física se asociaron a menores escores de coordinación motora gruesa.*

Palabras clave: *Niño. Sobrepeso. Obesidad. Destreza Motora.*

Introduction

Global estimates show that the prevalence of overweight/obesity among children has increased from 4.2%, in 1990, to 6.7%, in 2010. Moreover, in 2010 there were approximately 43 million overweight/obese children worldwide, of whom 35 million resided in developing countries [1].

Obese children and adolescents frequently show a higher frequency of physical and psychological comorbidities [2], such as arterial hypertension, diabetes, insulin resistance, dyslipidemias, coronary diseases, and sleep disorders [3, 4].

Furthermore, Utesch et al. [5] pointed out that overweight/obese children had greater difficulty, both in motor skills and in the future, and were less prone to a physical activity routine. Another study conducted with 165 children showed worse scores for abdominal activities, balance, and 6-minute walk test among children with severe obesity when compared to their eutrophic pairs [6]. According to Liang et al. [7], obese subjects have twice as many motor difficulties as their normal-weight counterparts.

In childhood and adolescence obesity may also affect the neurocognitive functions, such as cognitive processing speed, speech, learning, memory, attention, and visual and spatial performance [7, 8].

In this sense, the literature points out that poor motor coordination, not only negatively affects normal motor development, but may also influence the development of academic activities and peer interaction in social and physical activities [9, 10].

Although the knowledge that motor disorders may interfere with the academic or daily life activities, there are few studies in gross and fine motor coordination, specially using the KTK test in obese schoolchildren [11].

In this context, this study aimed to compare gross motor coordination between overweight/obese and normal-weight children, as well as to investigate associated factors with the gross motor coordination scores.

Methods

This is a cross-sectional study with a convenience sample of 6-9-year-old children, of both genders, enrolled at two public schools in Itabuna, BA, Brazil. Exclusion criteria were congenital malformations, bone, muscle, and joint deformities, neurological disorders that prevented test performance, and the body mass index (BMI) z-score for age below -2, classified by the World Health Organization (WHO) [12] as underweight or severe underweight.

The motor coordination was assessed by the "Körperkoordinationstest für Kinder" (KTK) [Body Coordination Test for Kids] [13, 14]. This test is composed by the following subtests: 1) balancing backwards over three progressively narrow boards (6 cm, 4.5 cm, and 3 cm wide) and walking up to 8 steps. Three valid trials were recorded. Participants were not allowed to touch the floor with their feet during the test. 2) Hoppingon one foot over rectangular foam rubber mats (50 cm x 20 cm x 5 cm each), placedon top of each other. The maximum height was 60 cm. The right and left legs were tested separately, and subjects were allowed three trials. 3) Jumping sideways as fast as possible with both feet together over a lath on the floor in two sets of 15 seconds. 4) Shifting platforms sidewise. The child had to stand on one platform and move the other identical platform to the opposite side, using both hands, then move sideways to the other platform and repeat this procedure as often as possible for two sets of 20 seconds [13, 14] (Figure 1).

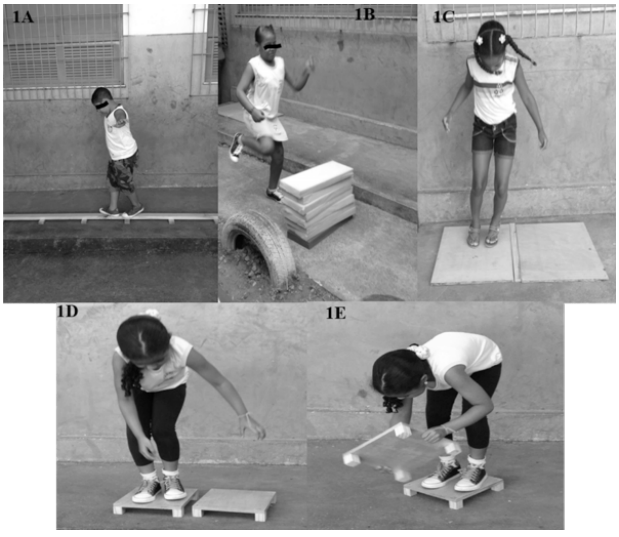

Figure 1 – 1A: balancing backwards; 1B: hopping over on one foot; 1C: jumping sideways; 1D/1E: shifting platforms.

The overall objective of the KTK is to measure the degree of motor deficit for the activities of balance, rhythm, laterality, speed, and agility. The balancing backwards measures the child's degree of stability in backward movement; hopping over on one foot assesses lower limb coordination and dynamic energy

/ strength; jumping sideways measures the velocity; and the shifting platforms sidewise measures laterality and spatiotemporal structuration [10].

The KTS tests were applied for the participant children after the researcher had instructed and demonstrated the trial. The motor scores for each test, as well as that for the overall motor score, were calculated according to the test guidelines [14] and classified as normal if above 85 points, and as low motor performance when less than or equal to 85 [14].

The KTS test is widely used in Germany, and in other countries, by many healthcare professionals, being specially applied by physical educators [9, 15]. In Brazil, the KTS test was validated by Gorla et al. [14] and has been used to assess gross motor coordination in 5-14-year-old children [16, 17].

In this study, the children's weight was measured wearing light clothes and no footwear, on a Welmy analog scale (model R-110, series 11953) with precise 100 g and variation of 2 to 150 Kg. Each child's height was measured with a stadiometer (Nutri Vida, São Paulo, SP, Brazil), with intervals of 0.5 cm between the set values.

Overweight was defined as a BMI z-score greater or equal to 1 and less than 2, and obesity was stated when BMI z-score was equal or greater than 2 [12].

At the baseline, the following information was collected: sociodemographic and anthropometric data, and frequency of physical activity outside of the school schedule per week.

The Research Ethics Committee of the Federal University of São Paulo (#238.369) approved this study. At the start of the study, all parents or legal guardians were asked to give a written informed consent, as well as all children.

Statistical Analysis

Numerical variables were expressed as mean ± standard deviation or median (range). Normally distributed variables were compared by the t test, otherwise the Mann–Whitney U test was used. Categorical variables were expressed as number (percentage) and compared by the chi-square test or by the Fisher's exact test. Factors that could potentially be associated with lower motor coordination score were examined with the univariate and the multiple linear regression analyses. First the researchers of this study performed a univariate analysis of the clinical variables that could possibly be associated with the motor scores. Variables with statistical significance below 0.20 upon univariate and regression analysis (except for the collinear variables with the same clinical significance) were included in the multivariate analysis.

All analyses were conducted using the SPSS for Win/v.17.0 (IBM SPSS *Statistics, Somers*, NY). The level of significance was set at 5%.

Results

At the time of the study, 225 children aged 6-9 years were enrolled in the two biggest schools of Itabuna that agreed to participate in the study. Thirty-two (82.1%) of 45 enrolled students in school A and 137 (81.1%) of 180 enrolled students in school B were included in the sample. Of 225 children, 17 (7.6%) fulfilled the exclusion criteria, and 208 (92.4%) children met the inclusion criteria. Of these, 39 (18.8%) students did not agree to participate; thus, the final study sample was composed of 169 (81.3%) students.

The mean age of the sample was 8.1 ± 1.2 years old (range = 6.0 – 9.9) and 85 of the studied sample (50.3%) were male. One hundred and twenty-one children (71.6%; 95%CI: 64.4 – 77.9%) were normal-weight, 29 of them (17.2%; 95%CI: 12.2 – 23.6%) were overweight, and 19 of them (11.2%; 95%CI: 7.3 – 16.9%) were obese. For comparison purposes, the children were divided into two groups: normal-weight (n = 121) and overweight/obese (n = 48). Both groups had similar age (8.2 ± 1.3 vs. 8.0 ± 1.2, p = 0.770) and male gender participation (52.1 vs. 49.6%, p = 0.182). But the two groups had different weight (36.6 ± 8.4 vs. 25.8 ± 4.5kg, p < 0.001) and BMI z-score (1.9 ± 0.7 vs. -0.3 ± 0.8, p < 0.001).

Practice of physical activity for at least twice a week was similar for both the overweight/obese and the normal-weight groups (87.5% vs. 80.2%, p = 0.260).

The mean motor quotient for hopping over on one foot (127.9 ± 10.1 vs. 132.3 ± 121.1 ± 12.1, p = 0.027), balancing backwards (84.2 ± 13.2 vs. 91.0 ± 15.0, p = 0.027), and shifting platforms sidewise (123.5 ± 23.4 vs. 129.8 ± 14.9, p = 0.038) subtests, as well as for the overall test scores (112.5 ± 14.8 vs. 118.8 ± 11.6, p = 0.04) were significantly lower for the overweight/obese compared to the eutrophic group. There were no significant differences in the jumping sideways subtest or in the maximum height of obstacles in the hopping over on one foot subtest (Table 1).

Table 1 – Means and standard deviations of the motor quotients of the performed tests according to the nutritional status

	Overweight/ obese (n = 48)	Eutrophic (n = 121)	p
MQ jumping sideways	103.5 ± 16.4	105.8 ± 16.1	0.399
MQ hopping over on one foot	127.9 ± 10.1	132.3 ± 12.1	0.027
MQ balancing backwards	84.2 ± 13.2	91.0 ± 15.0	0.007
MQ shifting platforms	123.5 ± 23.4	129.8 ± 14.9	0.038
MQ overall score	112.5 ± 14.8	118.8 ± 11.6	0.004

Note: MQ: motor quociente score; p value: t test.

The percentage of children with altered overall motor coordination (score < 85) was higher in the overweight/obese group than in the eutrophic group (4.2% vs. 0%, p = 0.005). When compared to their normal-weight counterparts, the overweight/obese students showed a higher frequency of altered gross motor coordination (MQ < 85) during the balancing backwards subtest (60.4% vs. 36.4%, p = 0.004), and greater likelihood of deficits on the shifting platforms sidewise subtest (6.3% vs. 0.8%, p = 0.070). Both groups had similar scores on the jumping sideways subtest (18.8% vs. 9.9%, p = 0.116). None of the students had altered motor function on the hopping over on one foot subtest.

Sports practice for less than two times per week, compared to more than two times per week, scored less in jumping sideways (140.0 ± 15.6 vs. 110.5 ± 17.7, p = 0.045), and in the overall score (116.0 ± 12.8 vs. 121.8 ± 12.6, p = 0.025), respectively (Table 2).

Table 2 – Mean and standard deviations of the motor quotients of the performed tests according to the level of physical activities

	Sports < 2 times/week (n = 139)	Sports > 2 times/week (n = 30)	p
QM jumping sideways	104.0 ± 15.6	110.5 ± 17.7	0.045
QM hopping over on one foot	130.5 ± 11.8	133.3 ± 1 2.0	0.226
QM balancing backwards	88.3 ± 14.6	92.8 ± 15.7	0.232
QM shifting platforms	127.4 ± 18.6	131.0 ± 14.0	0.307
QM overall score	116.0 ± 12.8	121.8 ± 12.6	0.025

Note: MQ: motor quociente score; p value: t-test

Male and female children showed similar mean motor quotient for hopping over on one foot (130.7 ± 11.5 vs. 131.3 ± 12.0, p = 0.743), balancing backwards (88.5 ± 13.1 ± 89.6 ± 16.5, p = 0.649), and shifting platforms sidewise (129.1 ± 18.4 vs. 126.9 ± 17.3, p = 0.427) subtests, as well as for the overall test scores (72.3 ± 22.1 vs. 83.4 ± 19.5, p = 0.112). However, for jumping sideways (110.5 ± 14.5 vs. 99.8 ± 16.0, p < 0.001), boys presented higher mean score than girls.

By linear univariate analysis, the associated factors with lower overall motor coordination scores were from the overweight/obese group, BMI, BMI-z-score, and practice of sports for less than two times a week (Table 3).

Table 3 – Univariate linear regression analysis for associated factors with the overall motor scores

	Beta	CI 95%	p
Female	−11.264	−23.338 to 0.810	0.067
Overweight/obesity	−19.843	−33.021 to -6.664	0.003
BMI (kg/cm^2)	−3.510	−5.481 to -1.540	0.001
BMI z-score	−5.196	−9.869 to -0.524	0.030
Sports for < 2 times/ week	−17.489	−33.223 to -1.756	0.030

After excluding collinear variables and adjusting them for gender, overweight/obesity, and sports for < 2 times/week, the associated factors with overall motor coordination scores were overweight/ obesity and practice of sports for less than twice a week (Table 4).

Table 4 – Multiple linear regression analysis for associated factors with the overall motor scores

	Beta	95%CI	p
Overweight/obesity	−18.700	−31.813 to -5.587	0.005
Sports for < 2 times/ week	−15.579	−31.055 to -0.103	0.049

Note: Adjusted for gender. Overweight/obesity and Sports for < 2 times/week.

Conclusion

This study showed a high frequency of overweight/ obese children and also low level of physical activity outside the school, compared to the 6.7% worldwide prevalence of childhood overweight and obesity (95%CI: 5.6%, 7.7%) in 2010 [1].

The overweight/obese children presented lower overall motor coordination scores and lower scores than the eutrophic scholars in the followings

sub-tests: hopping over on one foot, balancing backwards, and shifting platform sidewise. The motor coordination lowest score was found in the overweight/obese children with physical activity for less than twice a week.

This study showed that except the jumping sideways subtest, the overweight/obese children presented lower motor coordination scores in all KTK subtests. In addition, there were higher percentage of overweight/obese children with altered scores of overall gross motor coordination and balancing backwards subtest compared to the normal-weight students. This performance of overweight/obese children on the KTS test may suggests that they have, compared to eutrophic children, lower motor coordination and dynamic energy, lower stability during movement, and lower degree of laterality and spatiotemporality. These results agree to other studies referring that overweight/obesity is associated with the delayed motor development in children [18, 19], and when compared to normal-weight children, obese children have significantly lower motor performance and tend to be less skilled in related tasks involving support, propulsion, and movement [20]. Likewise, a study with 6-9-year-olds and 13-year-olds showed that overweight/obese children had, respectively, 5.2 and 5.4 greater chance to present lower motor development scores than normal-weight children [21]. This reinforces the finding that the BMI increase affects normal motor patterns and flexibility [21]. Furthermore, a study with 1,276 children showed significantly lower scores on all KTK subtests in the overweight/obese children compared to their normal-weight counterparts [22].

In this study, multiple linear regression analysis showed that the overall motor coordination score was negatively associated with overweight/obesity and practice of sports for less than twice a week. As well as Henrique et al. [23] showed, motor coordination in children assessed by the KTK test was negatively associated with subcutaneous fat, higher BMI, and lower scores in physical fitness tests. Also, Freitas et al. [24] found that the BMI increase had a negative impact on the acquisition of coordination and essential motor skills, assessed by the KTK tests.

Regarding physical activity, as in this study, Morrison et al. [25] reported that children with high body fat percentages and low levels of physical activity showed worse motor performance. Another study evaluated 794 children and concluded that low levels of physical activity were negatively associated with motor ability between the overweight/obese groups [26].

Despite the well-recognized benefits of physical activity on motor development, adherence to it was extremely low in this study. Over 80% of the children performed physical activity at least twice a week at school, but only 20% performed physical activity outside the school environment.

As for the influence of physical activity on motor development, it is widely known that overweight children may experience motor difficulties that limit their participation in physical activity [27]. This may cause children to prefer a sedentary life to an active life and is directly associated with impaired development of motor skills [19]. This suggests that an early intervention program to control weight would benefit these children. Pona et al. [28] reported that after a program to control weight a significant interaction between child age and time of intervention revealed that younger children exhibited greater decreases in z-score body mass index over the treatment compared to older children.

In this study, the linear regression analysis showed that females and males presented similar overall KTK performance, only with a higher mean score in jumping sideways for boys than for girls. The literature is controversial regarding children's gender-related motor performance. A study with 2,470 children from 26 German schools showed that girls had better performance than boys on the balancing backwards and on the hopping over on one foot subtests, and no statistically significant differences on the jumping sideways and on the shifting platforms sidewise subtests [9]. A previous study that used the KTK on 627 children aged from 5 to 6 years found no differences in motor skills between males and females [29]. However, another study showed that boys had 1.72 more chance of motor discoordination than girls when walking in the cross bars [30]. Lopes et al. [31] evaluated 7175 overweight/obese and eutrophic children aged from 6 to 14 years with the KTK and concluded that regardless of gender, overweight/obese children had lower motor development scores when compared to the eutrophic group. The motor development of the sample was positively associated with the children's level of physical activity, while the opposite was associated with the concomitant BMI increase, especially observed in 11-year-old children, regardless of gender. It may suggest that the influence

of overweight/obesity on motor coordination may overlap the influence of gender [32] as this study observed. The gender variable has lost its statistical significance in the final model of the linear regression, remaining only the nutritional status variables and the physical activity level.

One strong point of this study is the fact that the KTK tests were performed by the same examiner, which ensured the administration uniformity. In addition, the fact that more than 80% of the students of both schools were included may have contributed to its internal validity.

The limitations of this study are its cross-sectional design, which preclude the case-effect nature of associated factors with gross motor coordination; and the inclusion of only two schools that may have compromised the external validity of this study. In addition, the authors point out the likelihood selection bias, since the students were included by spontaneous demand and both groups may not represent the real population in terms of nutritional status and motor coordination, which could have interfered in the results.

In conclusion, overweight/obese children had lower gross motor coordination scores than their normal-weight counterparts when assessed by the KTK tests. The associated factors with the lower motor coordination scores were overweight/obesity and sports practice for < 2 times/week.

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