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Relationship between physical activity and BMI with level of motor coordination performance in schoolchildren

Relação entre atividade física e IMC com o nível de desempenho motor coordenado de crianças em idade escolar

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Abstract – International studies have shown that motor coordination was inversely associated with adiposity, and directly associated with other health outcomes. However, there are few national studies addressing this issue and the results are divergent. The aim of this study was to analyse the relationship between physical activity and body mass index (BMI) with the level of motor coordination performance in children. This cross-sectional study was performed with children aged 5-7 years old. The level of motor performance was evaluated by normative data of the motor quotients assessed by KTK test. BMI was calculated by body weight and height. The level of physical activity was assessed by a questionnaire applied by interviewers with parents. Statistical analysis was performed by Spearman and Pearson test, and multiple linear regression. The sample included 665 children with mean age of 6.29 (± 0.75) years old, and 52.6% were male. It was verified which total motor quotient (TMQ) was directly related to physical activity score (0.096; p = 0.013) and inversely related to BMI (-0.284; p<0.001). The relationship between BMI and TMQ was moderated by family income. BMI was inversely related to the level of motor performance, and the score of physical activity was directly related to the level of motor performance in children in a higher family income.

Key words: Body mass index; Child; Motor activity; Motor skills.

Resumo – *Achados de estudos internacionais evidenciam que a coordenação motora está inversamente relacionada à adiposidade e positivamente associada com outros desfechos em saúde. No entanto, observa-se poucos estudos nacionais abordando esta temática e os resultados são divergentes. O objetivo deste estudo foi analisar a relação entre a atividade física e o índice de massa corporal (IMC) com o nível de desempenho motor coordenado de crianças em idade escolar. Trata-se de um estudo transversal conduzido com crianças de 5 a 7 anos de idade. O nível de desempenho motor coordenado foi obtido a partir dos dados normativos dos quocientes motores do KTK. O IMC foi calculado a partir dos dados de massa corporal e estatura. O escore do nível de atividade física foi obtido por meio de um questionário, administrado face a face com os pais das crianças. Para análise dos dados foram empregados os testes de correlação de Spearman, de Pearson e a regressão linear múltipla. A amostra foi constituída por 665 crianças, com média de idade de 6,29 anos ±0,75, dos quais 52,6% eram do sexo masculino. Verificou-se que o escore do quociente motor total (QMT) foi diretamente relacionado ao escore da atividade física (0,096; p= 0,013) e inversamente relacionado ao IMC (-0,284; p<0,001). A relação entre o IMC e o QMT foi moderada pela renda familiar. O IMC foi inversamente relacionado ao nível de desempenho motor coordenado e o escore da atividade física foi diretamente relacionado à coordenação motora em crianças com maior renda familiar.*

Palavras-chave: *Atividade motora; Criança; Destreza motora; Índice de massa corporal.*

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INTRODUCTION

Poor coordinative performance can affect the acquisition of motor skills and overall child development. In this regard, motor coordination has been included as a topic of discussion in different areas of research. Recently, there has been an increasing interest of researchers on the relationship between levels of physical activity and adiposity with motor coordination in children[1-2].

Synthesis studies have shown that motor coordination is inversely related to body mass index and directly related to cardiorespiratory capacity and musculoskeletal fitness in children and adolescents[3-4]. Similarly, longitudinal[5-6] and cross-sectional studies[7-8] have indicated that motor coordination is directly related to the level of physical activity and participation in sports activities.

In the national context, there are few studies addressing this theme and the results are divergent. For example, it was found that the level of physical activity[9], participation in sports activities[10] and body mass index[11-12] were not related to motor coordination. On the other hand, other studies have identified that motor coordination was positively associated with the level of physical activity[11], participation in sports activities[13] and negatively associated to body weight status[10,13]. In addition, most of these studies were conducted in the southern and southeastern regions of the country and were conducted in small and non-representative samples of the populations investigated.

In view of the above, the aim of this study was to analyse the relationship between physical activity and body mass index with the level of motor coordination performance in schoolchildren. The analysis of the relationship between physical activity and adiposity with motor coordination constitutes a relevant research proposal, which can subsidise in the planning of interventions focusing on children at school age.

METHODOLOGICAL PROCEDURES

This is a cross-sectional epidemiological study from a research project titled "Longitudinal Study of Health and Wellbeing of Children in Preschool" (ELOS-Pre). The target population of this study was pre-school children (3 to 5 years old) enrolled in public and private schools in the area covered by the Regional Education Management of Recife, PE. The project was approved by the Ethics Committee for Research with Humans of the University of Pernambuco (CAAE: 0096.0.097.000-10). Parents or legal guardians of participating children signed the Free and Informed Consent Form.

The minimum sample size for the Elos-Pré Project was defined considering the following parameters: (a) target population estimated in 49,338 children; (b) estimated prevalence of the variables of interest in the study population was set at 50%; (c) 95% confidence interval; (d) maximum toler-

able error of four percentage points; and, (e) effect size of the pre-established sampling at 1.5 due to the cluster sampling resource. In order to deal with possible losses and refusals during follow-up, the minimum sample size, initially estimated in 890 subjects, was increased by 20%, resulting in a sample of 1,068 children. The sample calculation was carried out using a strategy adopted in cross-sectional studies to obtain a representative and accurate sample. Subsequently, sample dimensioning was used to determine the statistical power with the sample size reached in the first follow-up.

The sample selection was performed using the single-stage cluster sampling procedure, considering the school as the sample unit. All schools with pre-school classes were considered eligible for inclusion in the study. Based on data provided by the Recife Department Education, the number of pre-school students enrolled in the year prior to field collection was estimated at 49,038, distributed in 782 schools. Considering an average number of 38.5 children enrolled in each school and in order to achieve the desired sample size (n = 1,068), it was established that data collection would be performed in 28 schools.

In order to ensure representativeness of the target population, the proportionality of children in the schools according to type (public or private) and their distribution in the six political-administrative regions of the city of Recife was adopted as stratification criterion. Considering size, schools were classified as: "small size", those with fewer than 50 children enrolled; "medium-sized", those with 50 to 199 students; and "large size", those with a number equal to or greater than 200 children enrolled in early childhood education.

The present study was carried out with children aged 5-7 years who participated in the second evaluation of the ELOS-Pre project. In this evaluation, conducted during the period from August to November 2012, it was intended to analyse all children who had been evaluated at baseline and remained to reside in Recife. For the location of children, telephone contact was made with parents in order to identify the schools in which the children were enrolled. At each school, data collection time lasted at least five days in order to ensure that children who missed one or more days of classes could be located and included in the study. In addition, school staffs were asked to obtain up-to-date information on children who were transferred to other schools. Finally, in cases where children were not located using strategies mentioned above, home visits were made. Data collection teams were composed of undergraduate and graduate students. All the field collection was directly supervised by researchers involved in the project.

The level of motor coordination performance was obtained of the motor quotient of each of the four tests that compose the KTK (KörperkoordinationsTest für Kinder), and it was generated by the sum of the scores reached in each of the attempts of each task. Initially, four motor quotients were obtained: Motor quotient of task 1 - MQ1 (backwards balance); motor quotient of task 2 - MQ2 (hopping on one leg); motor quotient of task 3 - MQ3 (jumping sideways); motor quotient of task 4 - MQ4 (shifting

platforms). The Total Motor Quotient (TMQ) was also used, which results from the sum of the scores obtained in each of the tasks. In addition, the normative values derived from the reference tables of the Kiphard and Schilling study[14] were used to analyse the motor quotients of the KTK tasks.

The applicability of this instrument and the quality of data have been pointed out in several studies[8,15]. In the present study, intraclass correlation coefficients ranged from 0.70 to 0.94 in the intra-rater assessment and ranged from 0.59 to 0.81 in the inter-rater evaluation. The application of this battery took an average 20 minutes per child and all performed the tasks barefoot. The implementation protocol and the other information on the KTK application are available at the following electronic address: http://www.gpesupe.org/downloads.php?categoria=Manuais

The body mass and height measurements were collected to calculate the body mass index (BMI). Body mass was obtained using G.Tech® portable digital scale (model Glass 6), previously calibrated, with a variation of 0.1 kg and capacity up to 150 kg. Height was evaluated by portable Welmy® stadiometer with support base (model II), with an accuracy of 0.5 cm. The BMI [body mass (kg) / height (m) ^{2}] was calculated for each child. Three measurements were performed for each child, and the mean value of measurements was adopted as the final measure. The results of the pilot study indicated that the intra-class correlation coefficients of body mass and height measurements were greater than 0.95.

The level of physical activity was measured by parents reporting the time spent by children on games and playing outdoor in the three periods of the day (morning, afternoon and night), both on a typical weekday and weekend. The questionnaire applied was the translation of the inventory to estimate the time spent in games and playing outdoor proposed by Burdette et al.[16]. In the pilot study conducted by Oliveira et al.[17], the inventory showed good reproducibility indicators with Spearman correlations equal to or greater than 0.83 ($p < 0.01$).

The time reported by parents in each of these six reference periods was recorded considering five numerical scores and respective response categories: 0 minutes (0); 1-15 minutes (1); 16-30 minutes (2); 31-60 minutes (3); and more than 60 minutes (4). Thus, for each child, parents reported six estimates of time spent on physical activities typical for their age, three related to the day of the week and three related to a typical weekend day. Then, a global score was calculated, expressing the child's level of physical activity ([week: 3 reference periods x 4 (maximum score per period) x 5 days = 60 points; weekend: 3 periods x 4 (maximum score per period) x 2 days = 24 points]), with variation from 0 (insufficiently active) to 84 points (active).

To obtain this information it was used the ELOS-Pre questionnaire applied through a face-to-face interview with parents or legal guardians of children, available for consultation at the site link: http://www.gpesupe.org/downloads.php. The instrument was previously tested and the results of the pilot study indicated that the instrument is practical and relatively easy to apply when administered as an individual interview[17]. The data of

demographic and behavioural variables it was obtained by the questionnaire that presented test-retest consistency coefficients above 0.8517. The time of application of the questionnaire ranged from 8 to 15 minutes.

Data tabulation was performed in the EpiData Entry software, version 3.1, using automatic controls of amplitude and consistency in data entry. A second data entry was conducted in order to check and control data quality. Data analysis was performed using the STATA software, version 10.

Descriptive statistics (frequency distribution, central tendency and dispersion measures) were used to describe the variables. The normality of continuous variables was analysed using the Kolmogorov-Smirnov test. In addition, independent and dependent variables, confounding factors (sex, age, family income, prematurity and birth weight) were included in the analysis and were treated as covariates. Binary categorical covariates were coded for dummy variables.

To verify significant differences in motor quotients between boys and girls, the T-Test for independent samples and the Mann-Whitney U-Test were performed. The correlation tests of Spearman and Pearson were used to verify the relation between physical activity score and BMI with the motor quotients of the KTK.

Multivariate analysis was performed by multiple linear regression adopting the backwards selection procedure to remove variables from the model. It was adopted as a statistical criterion for the permanence of variables in the model those presented p-values <0.20. Interaction tests were conducted to verify the need for stratification of analyses by inclusion in the analyses a variable that expressing the interaction among factors (e.g., physical activity score * Sex). Variance Inflation Factor (VIF) values were used as criteria for the analysis of the absence of collinearity, as well as the F values as a criterion to identify if the variables maintained in the final regression model are linearly related to the total motor quotient. The homoscedasticity condition was tested using the Breusch-Pagan-Godfrey Test (BPG) to analyse the variance of residues. The significance level for all tests performed was set at p-value<0.05.

RESULTS

In 2012, 700 children were identified, representing 67.3% (n=1,040) from the baseline (2010). However, 35 children did not complete the motor coordination test. Therefore, the final sample consisted of 665 children (retention rate = 63.9%) aged 5-7 years old (mean = 6.29, SD = 0.75), and 52.6% (n = 350) were male.

Regarding family income, it was found that 70.6% of parents earned less than two minimum wages. The family income reported by parents/guardians ranged from less than R$ 311,00 to more than R$ 6.220,00. In addition, 14.9% of children were born premature (<37 weeks) and 12% were born with low birth weight (<2.500 g). Other sample characteristics are presented in Table 1.

Table 1. Description of demographic, anthropometric and physical activity variables stratified by sex

Variables	All (n=665)		Boys (n= 350)		Girls (n= 315)	
	Mean (SD)	Median (IIQ)	Mean (SD)	Median (IIQ)	Mean (SD)	Median (IIQ)
Age (years old)	6.3 (0.7)	6.0 (5-7)	6.3 (0.7)	6,0 (5-7)	6,3 (0,7)	6,0 (5-7)
Body weight (kg)	24.7 (6.0)	23.2 (14.9-48.3)	24.9 (6.3)	23,0 (13,6-53,0)	24,5 (5,6)	23,2 (14,2-46,5)
Height (cm)	120.9 (7.8)	120.5 (104-139.7)	121.3 (7.5)	121,0 (101,5-172,1)	120,4 (8,1)	120,0 (71,3-177,6)
BMI (kg/m^2)	16.8 (3.1)	16.0 (11.1-28.0)	16.7 (3.1)	15,9 (7,76-34,0)	16,8 (3,1)	16,1 (8,9-42,5)
PA	36.1 (18.5)	36.0 (0.0-80)	36.1 (17.9)	36,0 (0-84)	36,0 (19,1)	36,0 (0-84)
Public school	52.6%		50.6%		53.6%	

SD = standard deviation; IIQ = Interquartile range; PA = physical activity.

It was found that the mean and median age, body weight, height, BMI values and the score of physical activity were similar between boys and girls. In addition, it was observed that the proportion of children enrolled in public schools was higher in girls compared to boys.

Table 2 shows the descriptive measures of motor quotients, which express the level of motor coordination performance considered the total sample and stratified by sex. It was verified that only the total score of motor quotient (TMQ) showed normal distribution. Considering the mean values of motor quotients of each task, it was identified that children had lower performance in jumping sideways the tasks of lateral jump (QM3) and backwards balance (QM1) when compared to the other subtests that demand strength and speed (QM2), laterality and spatiotemporal structuring (QM4).

Table 2. Comparison of motor quotients by sex on the children enrolled in schools in the city of Recife-PE, 2012.

Variables	All		Boys		Girls		
	Mean (SD)	Median (IIQ)	Mean (SD)	Median (IIQ)	Mean (SD)	Median (IIQ)	p-value
MQ1	89.7 (15.9)	91.0 (54-132)	88.0 (16.2)	89.0 (54-128)	91.5 (15.4)	92.0 (57-132)	0.007*
MQ2	94.2 (17.8)	93.0 (53-146)	100.2 (16.2)	98.0 (62-146)	87.5 (17.1)	86.0 (53-143)	<0.001*
MQ3	73.1 (13.3)	72.0 (47-135)	76.3 (14.0)	75.0 (48-120)	69.6 (11.4)	69.0 (47-135)	<0.001*
MQ4	92.2 (13.4)	93.0 (53-136)	93.7 (14.3)	94.5 (54-136)	90.5 (12.1)	91.0 (53-125)	<0.001*
TMQ	83.4 (14.6)	83.0 (45-138)	86.3 (15.1)	86.5 (46-123)	80.1 (13.5)	80.0 (45-138)	<0.001**

MQ1 = motor quotient in backward balance; MQ2 = motor quotient in hopping on one leg; MQ3 = motor quotient in jumping sideways; MQ4 = motor quotient in shifting platforms; TMQ: total motor quotient; SD = standard deviation; IIQ = Interquartile range.
* T-Test for the independent sample. ** Mann-Whitney U-Test.

It was observed that the mean and median values of motor quotients of KTK tasks were higher in boys, except for MQ1 (backwards balance),

which was higher in girls. The results have shown that girls perform better on balance tests while boys perform better on jumping and shifting platform tests.

In addition, it was verified that the TMQ score was directly related to the physical activity score and inversely related to BMI. In addition, it was found that the score of physical activity was directly related to motor quotients of backwards balance and jumping sideways tasks. It was also identified that BMI was inversely related to the KTK motor quotient values, except for motor quotient of the shifting platforms task (Table 3).

Table 3. Correlation coefficients between the score of physical activity and BMI with children's motor quotient scores. Recife-PE, 2012

Variables	KTK Motor Quotients				
	MQ1*	MQ2*	MQ3*	MQ4*	TMQ**
PA	0.097 (p=0.013)	0.049 (p=0.205)	0.089 (p=0.021)	0.005 (p=0.893)	0.096 (p= 0.013)
BMI	-0.276 (p<0.001)	-0.244 (p<0.001)	-0.161 (p<0.001)	-0.020 (p<0.614)	-0.284 (p<0.001)

* Spearman correlation test; ** Pearson's correlation test.
Legend: KTK = KörperkoordinationsTest für Kinder; MQ1 = equilibrium motor quotient in shifting platforms; MQ2 = motor quotient in hopping on one leg; MQ3 = motor quotient in jumping sideways; MQ4 = motor quotient of shifting platform; TMQ: total motor quotient; PA = Physical Activity; BMI = Body Mass Index.

When analysing the relationship between possible confounding factors and TMQ, it was identified that gender, age and type of school were inversely related to TMQ, despite the poor magnitude of relationships. It was observed that birth weight had a borderline relationship with TMQ (Table 4).

Table 4. Pearson's correlation coefficients and respective p-values of demographic variables, school context, and early factors with TMQ

Variables	TMQ
	r (p)
Sex*	-0.211 (<0.001)
Age (years old)	-0.088 (0.023)
Family income (minimum wage)	-0.037 (0.331)
Type of school *	-0.079 (0.040)
Prematurity *	-0.067 (0.083)
Birth weight (grams)	-0.075 (0.054)

* Dummy variable.
Legend: TMQ: Total Motor Quotient.

The homoscedasticity analysis of the final model presented good quality in the estimation of the parameters analysed (p = 0.195). Although BMI remained related with TMQ, regardless of some confounding factors, family income was a moderating factor of this relationship (Table 5).

Table 5. Linear regression coefficients for analysis of the relationship between physical activity and BMI with the total score of motor quotient (TMQ).

Variables	TMQ					
	Crude			Adjusted		
	ß (standard error)	ß standard	p-value	ß (standard error)	ß standard	p-value
PA	0.07 (0.03)	0.09	0.013	0.05 (0.03)	0,07	0,061*
BMI	-1.34 (0.18)	-0.28	<0.001	-1.27 (0.17)	-0,27	<0,001*
Stratification by family income (<2 minimum wages)						
PA	0.04 (0.03)	0.06	0.200	0.03 (0.03)	0,04	0,340 [a]
BMI	-1.39 (0.20)	-0.30	<0.001	-1.30 (0.20)	- 0,28	<0,001 [b]
Stratification by family income (≥2 minimum wages)						
PA	0.19 (0.06)	0.21	0.003	0.17 (0.06)	0,19	0,007 [a]
BMI	-1.20 (0.39)	-0.24	0.001	-1.12 (0.34)	-0,23	0,001 [b]

* Adjusted by sex (VIF = 1.01), age (VIF = 1.17), type of school (VIF = 1.18), prematurity (VIF = 1.01), birth weight (VIF=1.01). R^2 adjusted = 0.15. F = 17.01 (p value <0.001).
[a] Adjusted by sex (VIF = 1.01), age (VIF = 1.17), type of school (VIF = 1.18), prematurity (VIF = 1.02), birth weight (VIF=1.00), physical activity score (VIF = 1.02). R^2 adjusted = 0.181. F = 15.45 (p value <0.001).
[b] Adjusted by sex (VIF = 1.02), age (VIF = 1.16), type of school (VIF = 1.14), prematurity (VIF = 1.04), birth weight (VIF=1.03), BMI score (VIF = 1.04). R^2 adjusted = 0.094. F = 3.81 (p value = 0.001).

DISCUSSION

The present study aimed to analyse the relationship between physical activity and BMI with the level of motor coordination performance of schoolchildren. The main findings were: boys presented better performance in motor tests when compared to girls; BMI was inversely related to the level of motor coordination performance and the physical activity was directly related to the level of motor coordination performance in children in a higher family income.

However, the findings presented here should be analysed with caution. The level of physical activity reported by parents may have been overestimated. Another limitation to be considered was the use of physical activity measures that do not consider activities that the children perform in the school context. It is known that for some children, school is the only opportunity for the practice of physical activities. The fact that the present study is linked to a longitudinal study may to some extent have "selected" parents and children more likely to healthier and more active lifestyles.

Nevertheless, the study was conducted with a representative sample of school-age children. All data collection procedures were previously tested and presented good reproducibility indicators in the pilot study. The choice of specific researchers for the application of motor tasks, the use of control strategies in the adjusted analyses for the main confounding variables and the double entry of tabulated data contributed to the internal validity of the study.

Based on the normative data of KTK motor quotients, it was observed that the mean value of the TMQ score of the present study (83.4 ± 14.6) was lower than the mean value of the TMQ score of German children who were part of the group where the KTK reference data were originated (100

± 15.0)[14], of Belgian children (96.5 ± 14.3)[18] and Portuguese children (84.9 ± 12.4)[19]. The findings of this study also revealed that the proportion of children with impaired motor coordination (insufficiency or disorder) was similar to a study performed with children (6-7 years) of a public school in northern Portugal[18]. However, it was higher in comparison to results observed in most of the studies conducted with European children[14,18,20-21].

Given the above, it was observed that the cutoff points suggested by the KTK creators[14] present low values for the classification of high (131-145) and good coordination (116-130), as well as for coordination disorders (71-85) and insufficiency (56-70). Moreover, most of the studies that presented reference values for the KTK score showed mean values lower than those conducted with German children and adolescents (5-14 years), which originated the reference data of this instrument. In addition, there are no reference standards for Brazilian children.

Regarding motor performance in each KTK task, it was found that the children in the present study presented a lower performance in jumping sideways and backwards balance tasks. Vandorpe et al.[18] identified that Flemish children presented a lower performance in backwards balance and shifting platforms tasks.

In addition, it was identified that, except for the backwards balance test, boys performed better on motor tests compared to girls. International studies revealed that girls performed better on balance tests while boys performed better on jumping tests[18,20]. Deus et al.[22] reported that the shifting platforms task is the one that presents less variation in the mean values in both sexes. Some authors have reported that differences in levels of motor coordination performance between boys and girls can be explained by the opportunities given in the family and school environment that may or may not favour a diversified motor repertoire[23-24].

In the present study, it was found that the physical activity score was directly related to backwards balance, shifting platforms and jumping sideways motor quotients. In the adjusted analysis, it was identified that the physical activity score was directly related to levels of motor coordination performance only in children with higher family income.

International studies have indicated that children who perform more physical activities have higher motor coefficients than those with lower levels of physical activity[8,22,25]. There is also evidence that motor coordination can be considered an important condition for engaging in organised physical activities so that high motor competence can increase the level of physical activity and participation in sports activities and vice versa[26].

In addition, it was found that BMI was inversely related to the KTK motor quotient values, except for shifting platforms motor quotient task. These results corroborate previous studies on the inverse relationship between adiposity indicators (BMI or BF%) and TMQ values of the KTK test[5,7,25,27-29]. However, some of these investigations have shown weak to moderate correlation[7,27-28], while another study revealed high correlation[5] between these variables.

In general, international studies have indicated that overweight children present lower levels of motor coordination, being more pronounced in shifting platforms[20] and hopping on one leg tasks[5,20]. This result may be partly explained by the increased mass in the different body segments that lead to inefficiency in the movement pattern[4], which would prevent the child from achieving success in certain motor tasks, especially those involving body transport in space, skills that involve running and jumping. According to Vandorpe et al.[18], hopping on one leg tasks, besides requiring dynamic coordination, require other physical properties such as strength, resistance and explosion.

In addition, Stodden et al.[26] presented a conceptual model about the relationship between motor competence, physical activity and obesity. Based on this model, the authors propose that levels of physical activity may increase or decrease the risk of obesity, and consequently, altered body composition will influence motor competence, predicting a feedback effect. They also reported that these relationships are influenced by other contextual factors (environment, family, socioeconomic status, culture, nutrition, self-efficacy, etc.), which affect the opportunity for an individual to be physically active and have good motor coordination.

CONCLUSION

The present study showed that BMI was inversely related to the level of motor coordination performance and the score of physical activity was directly related to motor coordination in children in a higher family income. The findings of this investigation provide important information regarding the relationships between physical activity and overweight with motor coordination in children. The understanding of the relationships between these variables may help Physical Education's teachers to plan their classes and guide the actions developed by other professionals outside the school environment.

In addition, considering that this is a topic that needs to be addressed more depth by researchers due to its complexity and importance, some suggestions have been presented for future research. Further longitudinal and experimental studies are needed in order to better clarify the relationship between these variables. Researchers should also consider the reciprocal causal relationship between these variables over time in their research and interventions. In addition, they should analyse the influence of other possible confounding factors on the relationship between these variables, such as perceived motor competence, physical fitness, sexual maturation, and type, amount, and intensity of physical activities performed in and out of school.

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REFERENCES

1. Robinson LE, Stodden DF, Barnett LM, Lopes VP, Logan SW, Rodrigues LP, et al. Motor competence and its effect on positive developmental trajectories of health. Sports Med 2016; 45(9):1273-84.
2. Logan SW, Robinson LE, Wilson AE, Lucas WA. Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. Child Care Health Dev 2011; 38(3): 305-15.
3. Luz LGO, Seabra AFT, Santos R, Padez C, Ferreira JP, Coelho-e-Silva MJ. Associação entre IMC e teste de coordenação corporal para crianças (KTK): uma meta-análise. Rev Bras Med Esporte 2015;21(3):230-5.
4. Cattuzzo MT, Santos Henrique R, Ré AH, Oliveira IS, Melo, BM, Sousa Moura M, et al. Motor competence and health related physical fitness in youth: a systematic review. J Sci Med Sport 2016;19(2):123-9.
5. D'Hondt E, Deforche B, Gentier I, De Bourdeaudhuij I, Vaeyens R, Philippaerts R, et al. A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. Int J Obesity 2013;37(1):61-7.
6. Lopes VP, Rodrigues LP, Maia JA, Malina RM. Motor coordination as predictor of physical activity in childhood. Scand J Med Sci Sports 2011; 21(5):663-9.
7. Morrison KM, Bugge A, El Naaman B, Eisenmann JC, Pferiffer KA, Andersen LB. Inter-relationships among physical activity, body fat, and motor performance in 6- to 8-year-old Danish children. Pediatr Exerc Sci 2012; 24(2):199-209.
8. Vandorpe B, Vandendriessche J, Vaeyens R, Pion J, Matthys S, Lefevre J, et al. Relationship between sports participation and the level of motor coordination in childhood: a longitudinal approach. J Sci Med Sport 2012; 15(3): 220-5.
9. Sá CSC, Carvalho B, Mazzitelli C. Equilíbrio e coordenação motora em escolares praticantes e não praticantes de atividades física e/ou lúdica extra-escolar. Rev Neurociên 2014; 22(1):29-36.
10. Pelozin, F, Folle A, Collet C, Botti M, Nascimento JV. Nível de coordenação motora de escolares de 09 a 11 anos da rede estadual de ensino da cidade de Florianópolis/SC. Rev Mackenzie Educ Fís Esporte 2009; 8(2):123-32.
11. Spessato BC, Gabbard C, Valentini NC. The role of motor competence and body mass index in children's activity levels in physical education classes. J Teach Phys Educ 2013; 32(2):118-30.
12. Catenassi FZ, Marques I, Bastos CB, Bassi L, Roque ERV, Gerage AM. Relação entre índice de massa corporal e habilidade motora grossa em crianças de quatro a seis anos. Rev Bras Med Esporte 2007; 13(4): 227-30.
13. Collet C, Folle A, Pelozin, F, Botti M, Nascimento JV. Nível de coordenação motora de escolares da rede estadual da cidade de Florianópolis. Motriz 2008; 14(4): 373-80.
14. Kiphard EJ, Schilling F. Köperkoordinationstest für kinder: KTK. Manual. Weinheim: Beltz Test, 2007.
15. Cools, W. Martelaer KD, Samaey C, Andries. Movement skill assessment of typically developing preschool children: a review of seven movement skill assessment tools. J Sports Sci Med 2009; 8(2):154-68.
16. Burdette HL et al. Parental report of outdoor playtime as a measure of physical activity in preschool-aged children. Arch Pediatr Adolesc Med 2004;158(4):353-7.
17. Oliveira NKR, Lima RA, Mélo EM, Santos CM, Barros SSH, Barros MVG. Reprodutibilidade de questionário para medida da atividade física e comportamento sedentário em crianças pré-escolares. Rev Bras Ativ Fis Saude 2011; 16(3):228-33.
18. Vandorpe B, Vandendriessche J, Lefevre J, Pion J, Vaeyens R, Matthys S, et al. The Körperkoordinations Test für Kinder: reference values and suitability for 6-12-year-old children in Flanders. Scand J Med Sci Sports 2011; 21(3):378-88.
19. Lopes LO, Lopes VP, Santos R, Pereira BO. Associações entre actividade física, habilidades e coordenação motora em crianças portuguesas. Rev Bras Cineantropom Desempenho Hum 2011; 13(1):15-21.

20. D'Hondt E, Gentier I, Deforche B, Tanghe A, De Bourdeaudhuij I, Lenoir M. Weight loss and improved gross motor coordination in children as a result of multidisciplinary residential obesity treatment. Obesity 2011; 19(10):1999-2005.
21. Olesen L, Kristensen PL, Ried-Larsen M, Grøntved A, Froberg K. Physical activity and motor skills in children attending 43 preschools: a cross-sectional study. BMC Pediatrics 2014; 14(229): 1-11.
22. Deus RKBC, Bustamante A, Lopes VP, Seabra AT, Silva RMG, Maia JAR. Modelação longitudinal dos níveis de coordenação motora de crianças dos seis aos 10 anos de idade da Região Autônoma dos Açores, Portugal. Rev Bras Educ Fís Esporte 2010; 24(2):259-73.
23. Valdivia AB, Cartagena LC, Sarria NE, Seabra TIS, Teixeira AF, Silva RMG, et al. Coordinación motora: influencia de la edad, sexo, estatus socio-económico y niveles de adiposidad en niños peruanos. Rev Bras Cineantropom Desempenho Hum 2008; 10(1):25-34.
24. Lopes VP, Maia JAR, Silva RG, Seabra A, Morais FP. Estudo do nível de desenvolvimento da coordenação motora da população escolar (6 a 10 anos de idade) da Região Autônoma dos Açores. Rev Port Ciên Desp 2003; 3(1): 47-60.
25. Graf C, Koch B, Kretschmann-Kandel E, Falkowski G, Christ H, Coburger S, et al. Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). Int J Obes Relat Metab Disord 2004; 28(1):22-26.
26. Stodden DF, Goodway JD, Langendorferr SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. Quest 2008; 60(2):290-306.
27. D'Hondt, Deforche B, Gentier I, Verstuyf J, Vaeyens R, De Bourdeaudhuij I, et al. A longitudinal study of gross motor coordination and weight status in children. Obesity 2014; 22(6):1505-11.
28. Melo MM, Lopes VP. Associação entre o índice de massa corporal e a coordenação motora em crianças. Rev Bras Educ Fís Esporte 2013; 27(1):7-13.
29. D'Hondt E, Deforche B, De Bourdeaudhuij I, Lenoir M. Relationship between motor skill and body mass index in 5- to 10-year-old children. Adapt Phys Activ Q 2009; 26(1):21-37.

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