Physical growth, school environment, and birth information in the physical activity of children: a multilevel analysis

Crecimiento físico, entorno escolar e información del nacimiento en la actividad física de los niños: un análisis multinivel

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Abstract

Introduction: There is increasing academic and policy interest in promoting children and young people's health by ensuring that the school environment supports healthy behaviors.
Objective: The study aim to describe and interpret the variability of children's PA based on individual characteristics and school context using the multilevel modeling approach.
Methodology: A total of 453 (236 boys and 217 girls) children aged 5 to 7.5 years old were assessed. Anthropometry, Birth information, organized regular physical activity (sports), physical activity (PA), Socioeconomic status and School environment context were assessed. A multilevel modeling approach was used to identify hierarchical effects (child and school levels).
Results: In model (M0) (β=60.54; p<0.01), only 1.4% of the total variance in children's MVPA level was explained by differences in the school context, while the remaining 98.6% is explained by individual predictors. After the inclusion of child-level predictors (M1), only the nutritional status variable was significantly associated with time in MVPA (β= -5.13; p=0.04). In Model 2, adding the school context information did not change the order of any factor's importance. However, the nutritional status variable remains significantly associated with time in MVPA (β= -5.08; p=0.04).
Conclusions: In conclusion, only nutritional status was associated with variation in MVPA. Although individual characteristics exert greater influence on MVPA than characteristics of the school context, policies to promote physical activity and control overweight and obesity at school should be developed with the aim of encouraging the adoption of more active and healthy lifestyles.

Keywords

Birth weight; multilevel modeling; schoolchildren; type of delivery.

Resumen

Introducción: Existe un creciente interés académico y político en promover la salud de los niños y los jóvenes garantizando que el entorno escolar apoye comportamientos saludables.
Objetivo: El estudio tiene como objetivo describir e interpretar la variabilidad de la actividad física de los niños en función de las características individuales y el contexto escolar utilizando el enfoque de modelado multinivel.
Metodología: Se evaluó a un total de 453 niños (236 niños y 217 niñas) de 5 a 7,5 años. Se evaluaron datos antropométricos, información sobre el nacimiento, actividad física regular organizada (deportes), actividad física (AF), nivel socioeconómico y contexto escolar. Se utilizó un modelo multinivel para identificar los efectos jerárquicos (nivel infantil y escolar).
Resultados: En el modelo (M0) (β=60,54; p<0,01), solo el 1,4% de la varianza total en el nivel de AFMV de los niños se explicó por diferencias en el contexto escolar, mientras que el 98,6% restante se explica por predictores individuales. Tras la inclusión de predictores a nivel infantil (M1), solo la variable estado nutricional se asoció significativamente con el tiempo en AFMV (β= -5,13; p=0,04). En el Modelo 2, añadir la información del contexto escolar no modificó el orden de importancia de ningún factor. Sin embargo, la variable estado nutricional sigue estando significativamente asociada con el tiempo en AFMV (β= -5,08; p=0,04).
Conclusiones: En conclusión, solo el estado nutricional se asoció con la variación en la AFMV. Si bien las características individuales influyen más en la AFMV que las del contexto escolar, se deben desarrollar políticas para promover la actividad física y controlar el sobrepeso y la obesidad en la escuela, con el objetivo de fomentar la adopción de estilos de vida más activos y saludables.

Palabras clave

Peso al nacer; modelado multinivel; escolares; tipo de parto.

Introduction

Children are inherently active and are given this opportunity to engage in physical activity (PA), either systematically (i.e., school physical education classes and/or sports activities), or spontaneously (i.e., unstructured and unsupervised play), along the day (Cumming, 2013). However, for PA to be more effective, a better understanding of socioecological determinants is necessary, either at the beginning of life or throughout the different stages of growth, development, or the interrelationship within and across different levels of influence (Nau et al., 2022; Elhakeem et al., 2017, Galindo-Perdomo et al., 2023).

Regarding the birth condition, low birth weight (LBW) has been related to a lower ability in sports, non-involvement in regular PA (Andersen et al., 2016), and changes in nutritional status, with negative consequences for PA and health-related physical fitness (Almeida et al., 2011). In this context, Svedenkrans et al. (2013) highlight that preterm birth, or small for gestational age, may predict a lower capacity to perform PA. However, in response to natural engagement in physical activity and/or systematized through physical exercises, these capacities can be increased, including benefits for mental health and well-being in later stages of development (Brylka et al., 2021; Tikanmäki et al., 2016).

In this context, the ecological model proposed by Sallis et al. (2006), highlights the existence of multiple influences of the physical environment on physical activity. Presenting as a fundamental characteristic the interdependence of individual traits and environmental/contextual characteristics in the explanation of PA differences within a hierarchical structure and at different levels (Sallis et al., 2006).

Notwithstanding what is presented, it is known that there are factors that can be identified as determinants of PA in schoolchildren, including the schools themselves, given the differences that may exist between them, which, to a certain extent, present some variability, which may favor in increasing the level of physical activity (Salway et al., 2019; Wang et al., 2017; Pereira et al., 2020). For instance, Gomes et al. (2014) showed that the size of the school, its location, type of playground area, frequency of physical education (PE) classes, PE time, and PE teacher qualifications were associated with the PA levels of schoolchildren. In addition, Wang et al. (2017) identify that school support for PA is associated with an increase in PA, and Nielsen et al. (2010) observed that recreational facilities positively influenced children's PA. Pereira et al. (2020), investigated the variability of PA in individual and school context variables, and determined that 18.2% of children's differences in PA were explained by school variables. Salway et al. (2019) also investigated the variability of PA for different contexts (child, parents, school, and neighborhood) in boys and girls, determining that the differences in PA related to school context were 8% and 9%, respectively.

In this way, it is possible to consider that the school environment presents itself as an important context/environment in child development (Salway et al., 2019; Wang et al., 2017; Pereira et al., 2020), where children spend most of their day-to-day (Queiroz et al., 2016). During planned and organized Physical Education (PE) classes, children's learning and motor development are influenced in many ways (Lubans et al., 2010; Morgan et al., 2013).

The selection of individual and school-related variables in this study is based on the need for a broader and more integrated understanding of the factors that influence physical activity in children, in line with the ecological model that emphasizes the interaction between personal characteristics and environmental contexts. Variables such as age, sex, BMI, socioeconomic level, sports participation, birth weight, and type of delivery were chosen because they reflect key aspects of child development and have been individually associated with different levels of physical activity. Similarly, elements of the school environment—such as school type, school size, and the presence of sports facilities—represent contextual factors that can either facilitate or restrict movement opportunities during school hours. However, current literature still lacks studies that combine these variables within a single analytical model, particularly using statistical approaches such as multilevel modeling, which can capture variability between individuals and contexts. Therefore, by integrating these dimensions, the present study aims to address an important gap, offering a more accurate and multifaceted view of the determinants of physical activity in childhood.

Thus, this study aimed to describe and interpret the variability of children's PA based on individual characteristics (age, sex, BMI, socioeconomic level, participation in sports, frequency and duration of participation in sports, birth weight, and type of delivery) and school context (school type, school size, and presence of sports court) using the multilevel modeling approach.

Method

Participants

Data of this study is part of the longitudinal study project designed to assess the longitudinal changes in health, physical activity practices, anthropometric parameters, motor skills performance, and other lifestyle factors in preschool children (Longitudinal Study of Health and Well-Being in Preschool Children, also called ELOS-Pré Project) (Barros et al., 2019). The ELOS-Pré Project started in 2010, and data have been collected every other year (i.e., 2010, 2012, and 2014) in preschools in Recife, Pernambuco State, Brazil.

Recife has a population that is over 1.5 million inhabitants. Recife is a coastal city marked by a great socioeconomic contrast and health inequalities, for instance, some districts have Human Development Indexes (HDI) over 0.95 while in others it is lower than 0.70. According to the Brazilian Institute of Geography and Statistics in 2010, when data collection was performed, the infant mortality rate in Brazil was around 19.9 deaths per 1.000 live births. In Recife, this rate was even lower (11.5 deaths per 1.000 live births).

For the current study, only children that were analyzed in 2012 (ELOS-Pré study) were included. Thus, 453 (236 boys and 217 girls) children aged 5.0 to 7.5 years old were assessed. These were made because we use only data of children with an objective assessment of physical activity (i.e., accelerometers). To calculate the age to the decimal, each student's registered birth age was used. Age was calculated using the date of birth (day, month, year), and the date (day, month, year) the anthropometric measurements were taken. The age groups were formed considering the age below or above 0.50 i.e., the intermediary age was considered as a whole year.

Data were collected in the schools by the same research team between August and December of each year, according to the school calendar. All public and private schools with preschool classes were considered eligible for inclusion in the study. The schools were randomly selected from a list provided by the Department of Education. The selection of schools was carried out respecting the proportionality of the distribution of schools according to the size i.e., numbers of students in the build area ("small size" [<50 students], "medium-size" [50 to 199 students], and "large size" [≥200 students]), type of school (public and private), and political-administrative regions (i.e., kindergarten schools, in turn, were distributed in the area of coverage of the six political-administrative regions (PARs) of Recife).

In the evaluations carried out in 2012, children who had been evaluated at baseline (2010) were followed, regardless of whether they remained in the same school where they were enrolled in 2010. All children who participated in the baseline, continued to live in Recife, and were aged between 5 and 7.5 years old were included. To locate the children, telephone contact with parents was made to identify them, in 2012 the schools where the children were enrolled. Children who did not complete or refused to perform any test proposed in the study were excluded. The study was performed according to the Helsinki Declaration and approved by the Ethics Committee of the University of Pernambuco (CEP/UPE: 097/10; CAAE – 0096.0.097.000–10). Parents or legal guardians of participating children signed the Free and Informed Consent Form.

Procedure

Anthropometry

Height was measured having the children's head in the Frankfurt plane with a stadiometer (Glicomed, Brazil) to the nearest 0.1 cm. Body mass was measured with children wearing light clothing and without shoes using a portable digital scale (Glicomed, Brazil) to the nearest 0.1 kg. All measurements were performed following the procedures suggested by Lohman (1986). Body mass and height values were used to calculate the body mass index (BMI): [BMI=mass (kg)/height(m2)]. The reliability coefficient, via intraclass correlation (ICC), of the anthropometric measurements was greater than 0.95.

Birth information

Information on the children's birth weight conditions was extracted from the child vaccination card which is a required document all children attending schools in Brazil need to present in the admission process. The current study adopted the following BW cut-points: LBW <2.500g and NBW >2.501g. The delivery methods were categorized into vaginal delivery and cesarean section.

Organized regular physical activity (sports)

The analysis of the practice of organized regular physical activity (ORPA) was based on information from the ELOS-Pré Questionnaire. Thus, the following questions were used: Question 64) Does your child participate in organized physical activities? Question 65 A) How many times a week? and Question 65 B) How long each session? Question 64 was dichotomized (i.e., 0=no and 1=yes). Based on the other responses, two variables were created, being; i) Number of sports practiced and ii) frequency and duration in which these activities were performed, this variable being operationalized by the product of frequency vs duration (variable expressed in minutes).

Physical Activity

The objective assessment of physical activity was performed by monitoring with accelerometers for seven consecutive days. Actigraph accelerometers (GT3X + model, ActiGraph, Pensacola, USA) were used. In 2012, all children who had been monitored in 2010 were sought out so that they could be evaluated again and the parents interviewed. The children's parents were instructed in person on the use of accelerometers and trained by the researchers to place the devices positioned on the waist to the right of the hip. Accelerometers were placed early in the morning and removed only when the child went to sleep, swim or shower. During the monitoring period, parents were instructed to fill in a diary reporting the time of placement and removal of the device, as well as the reasons for not using the accelerometers.

During the collection period, the team made telephone contacts with the parents to identify possible doubts and difficulties in keeping the child with the device in use. All children were monitored for at least seven consecutive days, including the two weekend days. After returning the equipment used in the monitoring, the data were downloaded using specific software (Actilife. version 6) for further processing. The reduction of raw data was also performed using the Actilife software, adopting parameters suggested in the literature (Trost et al., 2011). The acceleration signal of this device is captured and digitized by a converter according to the interval defined by the researcher, usually every 15 seconds. In the present study, recording intervals (epoch's) of 15 seconds were used as recommended in the literature (Reilly, 2008). To classify the intensity of physical activities and sedentary behavior, the cutoff points suggested by Evenson et al. (2008), were adopted, namely: sedentary activities (<100 counts/minute); light activities (100-2295 counts/minute); moderate activities (2296-4011 counts/minute); and vigorous activities (≥4.012 counts/minute). From the definition of these cut-off points, measures were derived expressing the daily time spent by the children at different levels of intensity. In addition to presenting a measure of general physical activity expressed in counts/minute. For this study, only the mean time spent in moderate to vigorous physical activity (MVPA) was used.

Socioeconomic status

The classification of the socioeconomic level was evaluated by determining the economic classes proposed by the Brazilian Association of Research Companies. The criterion uses the points system and considers the number of assets and the education of the heads of households employed, providing the grouping of families in classes A (high), B1, B2, C1, C2, and D, E (low). The improvement in the socioeconomic level will be characterized by the ascension of families from the lowest to the highest classes, and the worsening in the opposite direction, characterizing the descent of families.

School environment context

The variables analyzed at the school level were represented by some characteristics of the school to which children in second childhood were inserted. In addition, the online platform QEdu (https://www.qedu.org.br/) was also used, which provides structural, pedagogical, and academic performance information for public and private schools in the country. Thus, the variables analyzed at the school level were the following: type of school (Public=0 and Private=1), size of the school (average number of students enrolled), and the presence of a multi-sport court (yes=0 and no =1).

Data analysis

First, descriptive statistics included mean and standard deviation, for numerical variables, and distribution of absolute and relative frequencies, for categorical variables. Differences between boys and girls were evaluated with t and chi-square (χ^2) tests. Subsequently, the modeling of the relationship between the children's time spent in moderate to vigorous physical activities, their characteristics (level 1), and school context factors (level 2) were performed using STATA 14.0 software, using maximum likelihood estimation procedures. Multilevel analysis was chosen because it accounts for the hierarchical structure of the data, allowing for the simultaneous evaluation of individual and contextual (school-level) factors influencing children's physical activity. Then, a "step by step" approach using the enter input method was used as follows: model (M0), without predictors, was used to determine how much of the total variation in MVPA was explained by schools. Then, a new model (M1), including only child-level variables (age, sex, BMI, socioeconomic level, participation in sport, frequency and duration of participation in sport, birth weight, and type of delivery), as well as a sex-for-age interaction was included in the model to test for differences in boys and girls in MVPA by age. In the last model (M2), variables of the school context (type of school, school size, and sports court) were added. As these are two-level models, random components are in the child and the school. All parameters were estimated with the restricted maximum likelihood technique and all predictors were centered, as suggested by West et al., (2007). As mentioned in the literature (Hox et al., 2017), the sequential models were compared based on Deviance differences, and the significance level was set at p≤0.05.

Results

Descriptive analyzes of the variables at the children's level are described in Table 1. No significant differences were found in the variables studied, except for the birth weight category (i.e., LBW= 7.52% boys and 14.55% girls), which showed that the proportion of girls classified as having low birth weight was higher than that found in boys at baseline.

Table 1. Descriptive statistics for child-level variables (n=453)

Variables	Boys (n=236) Mean±SD	Girls (n=217) Mean±SD	t	*p*
Age (years)	6.30±0.74	6.30±0.73	-0.48	0.96
Body mass (kg)	25.09±6.84	24.88±6.03	0.35	0.73
Height (cm)	121.28±7.17	121.11±7.21	0.26	0.80
BMI (kg·m^{-2})	16.88±3.33	16.79±2.80	0.28	0.78
ORPA (day/min)	36.42±78.61	37.40±91.29	-0.12	0.90
MVPA (min/day)	59.24±22.19	60.04±23.83	-0.37	0.71
	n (%)	n (%)	χ^2	p
Socioeconomic status				
Low	97 (41.10)	71 (32.72)	3.50	0.17
Medium	106 (44.92)	109 (50.23)		
High	33 (13.98)	37 (17.05)		
Sports participation				
Yes	59 (25.0)	46 (21.20)	0.92	0.34
No	177 (75.0)	171 (78.80)		
Categorical birth weight				
Low birth weight	17 (7.52)	31 (14.55)	5.57	0.02
Normal weight	209 (92.48)	182 (85.45)		
Delivery methods				
Cesarean	109 (46.38)	98 (45.16)	0.07	0.80
Varginal delivery	126 (53.62)	119 (54.84)		

BMI – body mass index; ORPA – Organized regular physical activity; MVPA – moderate to vigorous physical activity.

Information on the school context is presented in Table 2. The number of students in schools ranged from 29 to 1,631 and about 60.10% of schools are public. In addition, only 23.08% had a sports court.

Table 2. Descriptive statistics for school-level variables (n=37)

Characteristics of the school	Mean ± SD	Min-Max
Size of the school (number of students)	426.79 ± 419.59	29 -1.631
	Category	(%)

Type of school	Public	60.10
	Private	39.90
Presence of a multi-sport court	Yes	23.08
	No	76.92

Table 3 presents the results of the multilevel analysis, showing the estimates (β) and the standard error, as well as their respective significance values. In the first model (M0), the variance value ρ=7.42/ (7.42 + 513.30) = 0.014 was calculated, i.e., 1.4% of the total variance in children's MVPA level is explained by differences in the school context, while the remaining 98.6% is explained by individual predictors. The intercept in this model refers to the mean MVPA time for all children (60.54 minutes per day).
After the inclusion of child-level predictors (M1), the variance value ρ=6.67/ (6.67 + 505.46) = 0.013 was calculated, only the nutritional status variable was significantly associated with time in MVPA (β= -5.13; p=0.04). In other words, overweight children are less active than normal-weight children. Model 1 fits the data significantly better than Model 0 [deviance in M0 = 3651.38 and in M1=3486.94; ΔD= -164,44]. With the inclusion of variables at the school context level (M2), the variance value ρ=8.74/ (8.74 + 519.56) = 0.016 was calculated, none of the characteristics presented showed to be significantly associated with time in MVPA (p>0.05), whilst previous results remain similar in their interpretation, i.e., the nutritional status variable remains significantly associated with time in MVPA (β= -5.08; p=0.04). Although, M2 fitted better than M1, as evidenced by the slight reduction in Deviance values, [deviance in M1=3486.94 and M2=3486.58; ΔD= - 0.36], the inclusion of variables from the school context did not help to explain the MVPA.

Table 3. Multilevel results for the three-consecutive moderate to vigorous physical activity models

Parameters	Model 0 β (SE)	p	Model 1 β (SE)	p	Model 2 β (SE)	p
Level 1 (Children's Predictors)						
Intercept	60.54 (1.29)	<0.01	-8.34 (43.84)	0.85	-8.43 (43.92)	0.85
Age (years)			-3.72 (4.93)	0.45	-4.01 (4.98)	0.42
Sex (boys)			10.52 (19.76)	0.59	10.95 (19.82)	0.58
Age * Sex			1.82 (3.12)	0.56	1.86 (3.13)	0.55
Nutritional Status (overweight)			-5.13 (2.60)	0.04	-5.08 (2.63)	0.04
Birth-weight (kg)			0.50 (1.69)	0.77	0.42 (1.69)	0.81
Delivery methods (varginal)			-3.29 (2.43)	0.18	-3.37 (2.46)	0.17
Socioeconomic status (medium)§			-2.80 (2.65)	0.29	-2.41 (2.80)	0.39
Socioeconomic status (High) §			-2.81 (3.82)	0.46	-2.46 (4.46)	0.58
Sports participation (yes)			4.12 (4.70)	0.38	3.35 (4.78)	0.48
ORPA (day/min)			-0.04 (0.02)	0.10	-0.04 (0.02)	0.12
Level 2 (School predictors)						
Type of school (private)					-3.31 (4.11)	0.42
Size of the school (nº of students)					-0.01 (0.01)	0.61
Presence of a multi-sport court (no)					1.47 (4.50)	0.75
Variance components						
School	7.42 (11.28)		6.67 (12.01)		8.74 (14.06)	
Children	513.30 (37.21)		505.46 (37.88)		519.56 (38.90)	
Deviance	3651.38		3486.94		3486.58	
Number of estimated parameters	2		13		16	

SE: Standard Error; ORPA – Organized regular physical activity

Discussion

The aim of this study was to describe and interpret the variability of children's PA level based on individual characteristics (age, sex, BMI, socioeconomic level, participation in sports, frequency and duration of participation in sports, birth weight and type of delivery) and school context (school type, school size and presence of a sports court). The descriptive results of the present study showed that there was no significant effect between boys and girls on the variables analyzed, with the exception of birth weight, showing that the proportion of children with low birth weight was higher in girls.

Different results in sample characterization have been identified. For example, Yamakita et al. (2018), did not identify significant differences in birth data between boys and girls. Santos et al. (2018), also found no differences between genders in the PN, although they did observe differences in body composition, that is, girls had higher body mass and fat percentage than boys, while boys were taller than girls.

In the present study, the use of multilevel analysis allowed a greater exploration of the entire essence contained in the results, so that the attribution of meaning to the parameters estimated by this methodology represents a qualitative leap in the exploration of the results, mainly due to the possibility of establishing more complex hypotheses. comprehensive and enlightening.

In the null Model (M0), (total variation in MVPA explained by schools) it was expected that the school context had a strong influence on the PA level of the assessed children. However, only 1.4% of the total variance in children's MVPA level was explained by school context, while the remaining 98.6% was attributed to individual predictors. Schools represent an accessible environment to encourage engagement in physical activities and healthy behaviors in schoolchildren (Wang et al., 2017; Gråstén, 2017). Nonetheless, Ip et al. (2017), reports that a school environment favorable to physical activities is also associated with a lower risk of obesity in children and adolescents, since it allows an increase in physical activity levels, mainly because children spend a considerable part of the day at school.

When inserting the variables at the child's level (M1), only the nutritional status variable was significantly associated with time in MVPA (β= -5.13. p= 0.04), suggesting that overweight children are less active than normal weight children. Many studies have suggested that overweight and obesity interfere with or prevent children from having an adequate level of daily MVPA. Pereira et al. (2017), showed that overweight and obese children were approximately 12% less likely to meet the recommendations for moderate-to-vigorous physical activity compared to normal-weight children. On the other hand, Dumuid et al. (2018), analyzed children from different locations, grouped by similar lifestyle behaviors, and observed that the most active were more likely to have favorable weight status.

When the school context variables were added, Deviance showed that this model fitted better than the other models (M0 and M1), although the added variables did not help to increase the explanatory power of the MVPA. Our results showed that in M2 the nutritional status remained associated with the level of MVPA ($p \le 0.05$). On the other hand, none of the variables of the school context was associated with the level of MVPA.

One of the hypotheses of the present study was that the variables of the school context included, based on the variables of the individual, would be associated with MVPA and would help to explain its variation. Although some studies show that school context variables have little influence on different health outcomes, such as body mass index (Chaves et al., 2015; Pallan et al., 2014; Henrique et al., 2018), and motor coordination (Chaves et al., 2015), other studies show great influence of school context variables on physical fitness (Santos et al., 2018; Zhu et al., 2010). Two studies identified the existence of school influence in children, the first presents an association between the size of the playground and physical activity, suggesting that schools that have a larger playground dimension tend to have a low level of MVPA (Pereira et al., 2020) and the second presents an association with school support for physical activity, identifying that this school variable was positively associated with MVPA (Wang et al., 2017). In adolescents it was found that school size was associated with physical activity, students enrolled in schools with more than 500 students were less likely to meet physical activity recommendations (Gomes et al., 2022). However, in agreement with the findings of the present study Pereira et al. (2017), showed that the individual characteristics of children seem to be more relevant than the variables of the school context when observing the rates of compliance with PA/day recommendations.

The lack of consensus about the influence of the school context on different health outcomes, including PA, nutritional status and others, may be related to the amount of information available from schools. In the present study, only information on the size and type of school (public and private) and the presence of a multi-sports court were made available, which restricted us to know other aspects that could influence children's PA, such as the amount and duration of classes in physical education, the offer of extracurricular activities, the quality of the infrastructure and the existence of specific policies to promote PA and healthy habits in schools.

Despite our findings, this study is not without limitations. The cross-sectional design used prevents the attribution of causality in the relationships found. In addition, the absence of relevant information about the school context is a factor that limits the possibility of observing a greater influence of the school context on the level of MVPA. However, it has several strengths that need to be highlighted. First, the data from this study comes from a large epidemiological study (ELOS-Pré) that evaluated a large sample of children, proportionally randomized, from schools in the six political-administrative regions of the city of Recife-PE. Second, the use of accelerometers to objectively measure PA in children is a factor that deserves to be highlighted. Another strength of the study is the use of multilevel modeling to assess the combined effect of characteristics at the individual and school context levels on children's MVPA.

Conclusions

In conclusion, only nutritional status was associated with variation in MVPA. Although individual characteristics exert greater influence on MVPA than characteristics of the school context, policies to promote physical activity and control overweight and obesity at school should be developed with the aim of encouraging the adoption of more active and healthy lifestyles.

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References

Almeida, M. B., dos Santos, A. M., Barros, J. W., Santana, D. F., Almeida, S. S., Teixeira, M. M., ... & Leandro, C. G. (2011). Pode o nível de atividade física atenuar os efeitos do baixo peso ao nascer sobre o desenvolvimento neuromotor de crianças? Neurobiologia, 74(2), 191-202.

Andersen, L. B., Mota, J., & Di Pietro, L. (2016). Update on the global pandemic of physical inactivity. The Lancet, 388(10051), 1255-1256. https://doi.org/10.1016/S0140-6736(16)30960-6.

Barros, S. S. H., Nahas, M. V., Hardman, C. M., Bezerra, J., & Barros, M. V. G. (2019). Longitudinal follow-up of physical activity from preschool to school age: the ELOS-Pré study. Revista Brasileira de Cineantropometria e Desempenho Humano, 21, e59242. https://doi.org/10.1590/1980-0037.2019v21e59242

Brylka, A., Wolke, D., Ludyga, S., Bilgin, A., Spiegler, J., Trower, H., ... & Niessner, C. (2021). Physical activity, mental health, and well-being in very pre-term and term-born adolescents: An individual participant data meta-analysis of two accelerometry studies. International Journal of Environmental Research and Public Health, 18(4), 1735. https://doi.org/1735. 10.3390/ijerph18041735

Chaves, R., Baxter-Jones, A., Gomes, T., Souza, M., Pereira, S., & Maia, J. (2015). Effects of individual and school-level characteristics on a child's gross motor coordination development. International Journal of Environmental Research and Public Health, 12(8), 8883-8896. https://doi.org/10.3390/ijerph120808883

Cumming, S. (2013). New directions in the study of maturation and physical activity. In P. Katzmarzyk, M. Coelho, & E. Silva (Eds.), Growth and Maturation in Human Biology and Sports (pp. 129-138). Imprensa da Universidade de Coimbra, Portugal.

Dumuid, D., Olds, T., Lewis, L., Martin-Fernández, J., Barreira, T., Broyles, S., ... & Chaput, J.-P. (2018). The adiposity of children is associated with their lifestyle behaviours: A cluster analysis of school-aged children from 12 nations. Pediatric Obesity, 13(2), 111-119. https://doi.org/10.1111/ijpo.12196

Elhakeem, A., Cooper, R., Bann, D., Kuh, D., & Hardy, R. (2017). Birth weight, school sports ability, and adulthood leisure-time physical activity. Medicine & Science in Sports & Exercise, 49(1), 64. https://doi.org/10.1249/MSS.0000000000001077

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. Journal of Sports Sciences, 26(14), 1557-1565. https://doi.org/10.1080/02640410802334196

Galindo Perdomo, F., Camacho Coy, H., & Monterrosa Quintero, A. (2023). Association between levels of self-perceived physical activity and sociodemographic variables at school-children. *Retos*, *50*, 456–463. https://doi.org/10.47197/retos.v50.99157

Gomes, T. N., dos Santos, F. K., Zhu, W., Eisenmann, J., & Maia, J. A. (2014). Multilevel analyses of school and children's characteristics associated with physical activity. Journal of School Health, 84(10), 668-676. https://doi.org/10.1111/josh.12193

Gomes, T. N., Thuany, M., Dos Santos, F. K., Rosemann, T., & Knechtle, B. (2022). Physical (in)activity, and its predictors, among Brazilian adolescents: A multilevel analysis. BMC Public Health, 22(1), 1-9. https://doi.org/10.1186/s12889-021-12336-w

Gråstén, A. (2017). School-based physical activity interventions for children and youth: Keys for success. Journal of Sport and Health Science, 6(3), 290. https://doi.org/10.1016/j.jshs.2017.03.001

Henrique, R. S., Gomes, T. N., Tani, G., & Maia, J. (2018). Association between body mass index and individual characteristics and the school context: A multilevel study with Portuguese children. Journal of Pediatrics, 94, 313-319. https://doi.org/10.1016/j.jpedp.2017.09.018

Hox, J. J., Moerbeek, M., & Van de Schoot, R. (2017). Multilevel Analysis: Techniques and Applications. Routledge.

Ip, P., Ho, F. K.-W., Louie, L. H.-T., Chung, T. W.-H., Cheung, Y.-F., Lee, S.-L., ... & Mak, K.-K. (2017). Childhood obesity and physical activity-friendly school environments. Journal of Pediatrics, 191, 110-116. https://doi.org/10.1016/j.jpeds.2017.08.017

Lohman, T. (1986). Applicability of body composition techniques and constants for children and youths. Exercise and Sport Sciences Reviews, 14, 325-357.

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental movement skills in children and adolescents: Review of associated health benefits. Sports Medicine, 40(12), 1019-1035. doi: 10.2165/11536850-000000000-00000.

Morgan, P. J., Barnett, L. M., Cliff, D. P., Okely, A. D., Scott, H. A., Cohen, K. E., ... & Plotnikoff, R. C. (2013). Fundamental movement skill interventions in youth: A systematic review and meta-analysis. Pediatrics, 132(5), e1361-e1383. https://doi.org/10.1542/peds.2013-1167

Nau, T., Bauman, A., Smith, B. J., & Bellew, W. (2022). A scoping review of systems approaches for increasing physical activity in populations. Health Research Policy and Systems, 20(1), 104. https://doi.org/10.1186/s12961-022-00906-2.

Nielsen, G., Taylor, R., Williams, S., & Mann, J. (2010). Permanent play facilities in school playgrounds as a determinant of children's activity. Journal of Physical Activity and Health, 7(4), 490-496. https://doi.org/10.1123/jpah.7.4.490.

Pallan, M. J., Adab, P., Sitch, A. J., & Aveyard, P. (2014). Are school physical activity characteristics associated with weight status in primary school children? A multilevel cross-sectional analysis of routine surveillance data. Archives of Disease in Childhood, 99(2), 135-141. https://doi.org/10.1136/archdischild-2013-303987

Pereira, S., Borges, A., Gomes, T., Santos, D., Souza, M., Dos Santos, F., ... & Katzmarzyk, P. T. (2017). Correlates of children's compliance with moderate-to-vigorous physical activity recommendations: A multilevel analysis. Scandinavian Journal of Medicine & Science in Sports, 27(8), 842-851. https://doi.org/10.1111/sms.12671.

Pereira, S., Reyes, A., Moura-Dos-Santos, M. A., Santos, C., Gomes, T. N., Tani, G., ... & Katzmarzyk, P. T. (2020). Why are children different in their moderate-to-vigorous physical activity levels? A multilevel analysis. Journal of Pediatrics, 96, 225-232. https://doi.org/10.1016/j.jped.2018.10.013.

Queiroz, D. R., Henrique, R. S., Feitoza, A. H. P., Medeiros, J. N. S., Souza, C. J. F., Lima, T. J. S., ... & Bastos, F. N. (2016). Competência motora de pré-escolares: Uma análise em crianças de escola pública e particular. Motricidade, 12(3), 56-63. http://doi.org/10.6063/motricidade.6886

Raudenbush, S., Bryk, A., Cheong, Y., & Congdon, R. (2004). Hierarchical Linear and Nonlinear Modeling. Lincolnwood, IL: Scientific Software International, Inc.

Reilly, J. J. (2008). Physical activity, sedentary behaviour and energy balance in the preschool child: opportunities for early obesity prevention: Symposium on 'Behavioural nutrition and energy balance in the young'. Proceedings of the Nutrition Society, 67(3), 317-325. http://doi.org/10.1017/S0029665108008604

Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., .& Kerr, J. (2006). An ecological approach to creating active living communities. Annual Review of Public Health, 27, 297-322. http://doi.org/10.1146/annurev.publhealth.27.021405.102100.

Salway, R., Emm-Collison, L., Sebire, S. J., Thompson, J. L., Lawlor, D. A., & Jago, R. (2019). A multilevel analysis of neighbourhood, school, friend, and individual-level variation in primary school children's physical activity. International Journal of Environmental Research and Public Health, 16(24), 4889. http://doi.org/10.3390/ijerph16244889.

Santos, C., Carolina Reyes, A., Moura-Dos-Santos, M. A., Pereira, S., Natacha Gomes, T., Tani, G., ... & Katzmarzyk, P. T. (2018). A multi-level analysis of individual- and school-level correlates of physical fitness in children. Annals of Human Biology, 45(6-8), 470-477. http://doi.org/10.1080/03014460.2018.1549684.

Santos, M. A. M., Verçosa, M. F., Gomes, T. N. Q. F., Maia, J. A. R., & Leandro, C. G. (2018). Birth weight, physical growth and body composition in children: A longitudinal study. Revista de Nutrição, 31(3), 287-297. https://doi.org/10.1590/1678-98652018000300003

Svedenkrans, J., Henckel, E., Kowalski, J., Norman, M., & Bohlin, K. (2013). Long-term impact of preterm birth on exercise capacity in healthy young men: A national population-based cohort study. PLoS One, 8(12), e80869. https://doi.org/10.1371/journal.pone.0080869.

Tikanmäki, M., Tammelin, T., Sipola-Leppänen, M., Kaseva, N., Matinolli, H.-M., Miettola, S., ... & Eriksson, J. G. (2016). Physical fitness in young adults born preterm. Pediatrics, 137(1), e20151289. https://doi.org/10.1542/peds.2015-1289.

Trost, S. G., Loprinzi, P. D., Moore, R., & Pfeiffer, K. A. (2011). Comparison of accelerometer cut points for predicting activity intensity in youth. Medicine & Science in Sports & Exercise, 43(7), 1360-1368. https://doi.org/10.1249/MSS.0b013e318206476e.

Zhu, W., Boiarskaia, E. A., Welk, G. J., & Meredith, M. D. (2010). Physical education and school contextual factors relating to students' achievement and cross-grade differences in aerobic fitness and obesity. Research Quarterly for Exercise and Sport, 81(sup3), S53-S64. https://doi.org/10.1080/02701367.2010.10599694.

Wang, L., Tang, Y., & Luo, J. (2017). School and community physical activity characteristics and moderate-to-vigorous physical activity among Chinese school-aged children: A multilevel path model analysis. Journal of Sport and Health Science, 6(4), 416-422. https://doi.org/10.1016/j.jshs.2017.09.001

West, B. T., Galecki, A. T., & Welch, K. B. (2007). Linear Mixed Models: A Practical Guide Using Statistical Software.

Yamakita, M., Sato, M., Suzuki, K., Ando, D., & Yamagata, Z. (2018). Sex Differences in Birth Weight and Physical Activity in Japanese Schoolchildren. Journal of Epidemiology, 28(7), 331-335. https://doi.org/10.2188/jea.JE20170078.

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