Original Article

Is the association between unhealthy weight and academic performance influenced by children's physical activity level?

A associação entre peso não saudável e desempenho escolar é influenciada pelo nível de atividade física em crianças?

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ABSTRACT

The purpose of this study was to verify the association between unhealthy weight and academic performance and the influence of physical activity level (PAL) in elementary school children. This study was conducted with 450 elementary school students (50% girls) enrolled in 1st to 4th grades. PAL was assessed by self-reported questionnaire of typical physical activity and daily food intake (DAFA). Academic achievement (Portuguese and Mathematics) was estimated based on the academic performance system of public schools from Recife/Brazil. Binary logistic regression was used to verify the association between unhealthy weight (underweight and overweight) and normal weight with academic performance. The results showed that 26.6% of the students presented overweight, 11.1% presented underweight, 49.1% and 50.9% were classified as high and low PAL, respectively. In addition, 56.9% had sufficient academic performance in Portuguese and 51.1% had sufficient academic performance in Mathematics. Students with overweight presented higher odds for insufficient performance in Portuguese when compared to normal weight counterparts, even when adjusted for reported PAL, gender and age (OR = 1.69; 95%CI: 1.08-2.64). The results corroborate with evidences that unhealthy weight is associated with poor academic performance in children.

KEYWORDS

Educational Status; Elementary Students; Obesity.

RESUMO

O objetivo deste estudo foi verificar a associação entre peso não saudável e desempenho escolar e a influência do Nível de Atividade Física (NAF) em crianças do ensino fundamental. Este estudo foi realizado com 450 alunos do ensino fundamental (50% meninas) matriculados na 1ª a 4ª série. NAF foi avaliado indiretamente através de um questionário de auto relatado Dia Típico de Atividade Física e Alimentação (DAFA). Desempenho escolar (Português e Matemática) foi estimado com base no sistema de desempenho escolar das escolas públicas do Recife / Brasil. Regressão logística binária foi utilizada para verificar a associação entre o peso não saudável (baixo peso e sobrepeso) e peso normal, com o desempenho escolar. Os resultados mostraram que 26,6% dos estudantes apresentavam sobrepeso, 11,1% apresentavam baixo peso, 49,1% e 50,9% foram classificados como alto e baixo NAF, respectivamente. Em adição, 56,9% apresentavam desempenho suficiente em Português e 51,1% apresentavam desempenho suficiente em Matemática. Estudantes com sobrepeso apresentaram maior odds para desempenho insuficiente em português quando comparados aos seus pares com peso normal, mesmo quando ajustada por reportada NAF, gênero e idade (OR = 1.69; 95%IC: 1.08-2.64). Os resultados corroboram com evidências de que o peso não saudável é associado com pobre desempenho escolar em crianças.

PALAVRAS-CHAVE

Desempenho escolar; Escolares; Obesidade.

INTRODUCTION

Besides the well-known deleterious effects of overweight on physical health, some studies have reported the association between high Body Mass Index (BMI) and low academic performance in children[1,2].

A prospective cohort study conducted by Brook et al.[3] after following 470 individuals over 22 years demonstrated a negative association between overweight and intellectual development. It is possible that high BMI may also decrease numeric abilities[4]. Similarly, underweight also seems to be associated with low academic performance. Chang et al.[5] reported that underweight during early life (<2 years) produces irreversible damages on intellectual development, suggesting that underweight may be related to educational deficits in children[6]. Both under and overweight, which may collectively be called unhealthy weight, are an undesirable health status and constitutes the extremes of malnutrition[7]. Therefore, these two extremes of the weight, can be, somehow, involved in educational achievement in children.

Conversely to BMI, it is suggested that Physical Activity Level (PAL) can improve overall health, cognitive function and academic performance[8,9]. An epidemiological study conducted with 75.066 students revealed that moderate PAL has a positive effect on academic performance for both boy and girls[10]. However, the association between weight status and academic performance has been largely studied, it is not yet know if PAL, would influences this relationship.

It is known that PAL is able to decrease cardiovascular risk factors even in overweight people[11], thus we hypothesized that PAL may confuse the association between weight status and academic performance, attenuating the deleterious effects of unhealthy weight on academic performance in children.

The results from the present study may have important implications to the Brazilian educational system, contributing to develop strategies to improve the academic performance of the elementary school children. Therefore, the purpose of this study was to analyze the association between unhealthy weight and academic performance and the influence of PAL in elementary school children of the Recife city. The reason to group underweight and overweight is that both are considered risk factors of physical inactivity in children, morbidity, and mortality in adults[12] and may also influence academic performance. However, from our knowledge this has yet not been examined.

METHODS

Participants

This cross-sectional study was carried out with public elementary school students, from Recife, an urban city in the northeast of Brazil, aged 6 to 11 enrolled in 1st and 4th grades. Students were randomly selected by using 2-stage cluster sampling process (the Political-Administrative Areas of the city and schools as units at the first and second stages, respectively). At the first stage, one of the six Political-Administrative Areas (PAA) of the city was selected. For convenience, we opted to randomize only one PAA, in this sense, the PAA1 was the randomized region. Children were recruited from October to December of 2010, thirteen schools were eligible to participate in the ran-

domization with 2053 students enrolled in 1st and 4th grades. Afterwards, four schools were randomly selected within this PAA.

After acceptance of the child to participate on a voluntary basis, parents or legal guardians of the children signed an informed consent. Inclusion criteria were to be enrolled in 1st to 4th grades and not present any from restriction to PA (motor or mental impairment). Students who did not complete all the required measurements (n=22), were transferred to another school (n=0) and who refused to participate of the study (n=28) during data collection period were excluded. The final sample analyzed consisted of 450 students (225 girls) (Figure 1). The study protocol was approved by the Ethics Committee of the University of Pernambuco (#188/10).

The required sample size was calculated considering the following parameters: 95% confidence interval; power of 80%; prevalence of 35% of the outcome among exposed (unhealthy weight). Based on these criteria, the estimated sample size was 400 students. The initial sample size was increased by 20% to deal with attrition and for confounding adjustment in analysis. The number of schools selected was established considering logistical and human resources available.

Anthropometric measures

Students were weighed wearing light clothing and no shoes on a Fillizola scale (Filizola- SA, São Paulo, Brazil) to the nearest 0.5 kg. Height was measured using a stadiometer to the nearest 0.1 cm. Measurements were performed by the same researcher, using the same equipment routinely calibrated. All procedures were performed according to Lohman et al.[13]. BMI was calculated as body weight (Kg) divided by height squared (m²) (kg/m²). BMI adjusted for age was used to classify the children as: 1.underweight (BMI-for-age<5th percentile); 2.normal weight (5th to 85thpercentile) and; 3.overweight (BMI-for-age>85th percentile), according to the World Health Organization (WHO) criteria[14]. Afterwards, they were placed in two groups: normal weight and unhealthy weight (underweight + overweight).

Physical activity measures

A questionnaire of typical physical activity and daily food intake (DAFA) was used to assess PAL. DAFA is a validated instrument developed by Barros et al.[15] specifically for Brazilian children aged from seven to ten years old. DAFA is a structured questionnaire with answers based on the choice of physical activities and food intake. The term "typical week day" in the application of the questionnaire was used to determine physical activities accomplished and food consumed in the majority of week days (from monday to friday). However, in the present study, only PAL data was analyzed. In the section of physical activities of DAFA two types of measures were obtained:

a) Intensity of physical activities accomplished during a normal day. Measures are reported by the subjects through a hedonic scale with three illustrations, in the extreme left are the slow physical activities (light) and in the extreme opposite, activities that are performed with more speed (vigorous);

b) General level of physical activities determined based on the sum of scores related to activities subjects reported to perform.

The PAL was determined based on the sum of scores related to activities reported (light, moderate or vigorous). For activity was given a score; one point for light intensity, three points for moderate and nine points for vigorous intensity. Thereafter, children who had a total score lower than 50th were placed in a low PAL group (Low) and those above 50th in the high PAL group (High).

Questionnaire administration was performed in the classroom by two research assistants with the help of the students' teacher. The questionnaire was introduced to the children with a brief exhibition of all sections highlighting the required information related to what is usually performed in the majority of week days. Following instructions with words, gestures, movements and contexts, the assistants and the teacher helped the children to answer in each session.

Academic performance measures

Academic performance was estimated based on the academic performance system used in all public schools from Recife. The academic performance system of the municipal schools is a subjective measure, based through academic skills that should to be achieved by students during the school year. However, in the present study, only were used measures academic skills achieved in Portuguese and Mathematics. The measures of academic performance were obtained by teachers, which were responsible for issuing a report, containing information whether students were able to achieve competencies related to discipline of Portuguese (writing and reading knowledge) and Mathematics (skills and ability to make calculations and logic tests). Afterwards, academic performance was categorized into two groups: 1.Sufficient - for those who achieve the proficiency expected, and; 2.Insufficient - for those who did not achieve the expected proficiency.

Statistical analysis

Data were analyzed using the software STATA 12.0 for Windows. Comparisons between genders were performed by independent Mann-Whitney and Chi-square tests. The associations between insufficient and sufficient academic performance in Portuguese and Mathematics) and BMI were assessed by binary logistic regression. Were performed analyzes of interaction between gender and PAL with BMI. Were considered as potential confounders: age, sex and PAL. Interactions between BMI and gender were also analyzed. Significance level was set at $p<0.05$. Calculations performed posteriori showed that the sample have power to identify significant OR values equal to 1.75 with prevalence of the outcome in exposed ranging from 30% to 50%, and 2 or higher, with the prevalence of the outcome in exposed ranging from 15% to 75%.

RESULTS

From the total of 500 students who volunteered to participate in the study, 22 children did not complete all the required measurements and 28 children refused to participate of the study, totaling 50 students excluded from the analysis. Thus, a total of 450 children (225 girls) aged from 6 to 11 years were included in the sample. The table 1 shows the description of the independents variables, gender, age, BMI and PAL. The results showed a prevalence of overweight of 26.6% (95%CI: 22.6-31.0) and 50.9% (95%CI: 46.1-55.6) to low PAL.

TABLE 1 – Sample distribution in relation to gender, age, BMI and PAL.

	N	% (95%CI)
GENDER		
Female	225	50.0 (45.2-54.7)
Male	225	50.0 (45.2-54.7)
AGE		
≥8 years old	203	45.1 (40.4-49.8)
<8 years old	247	54.9 (50.1-59.5)
BMI		
Normal weight	280	62.2 (57.5-66.7)
Underweight	50	11.1 (8.3-14.3)
Overweight	120	26.6 (22.6-31.0)
PAL		
Low	229	50.9 (46.1-55.6)
High	221	49.1 (44.4-53.8)

[a]Adjusted by PAL, gender and age
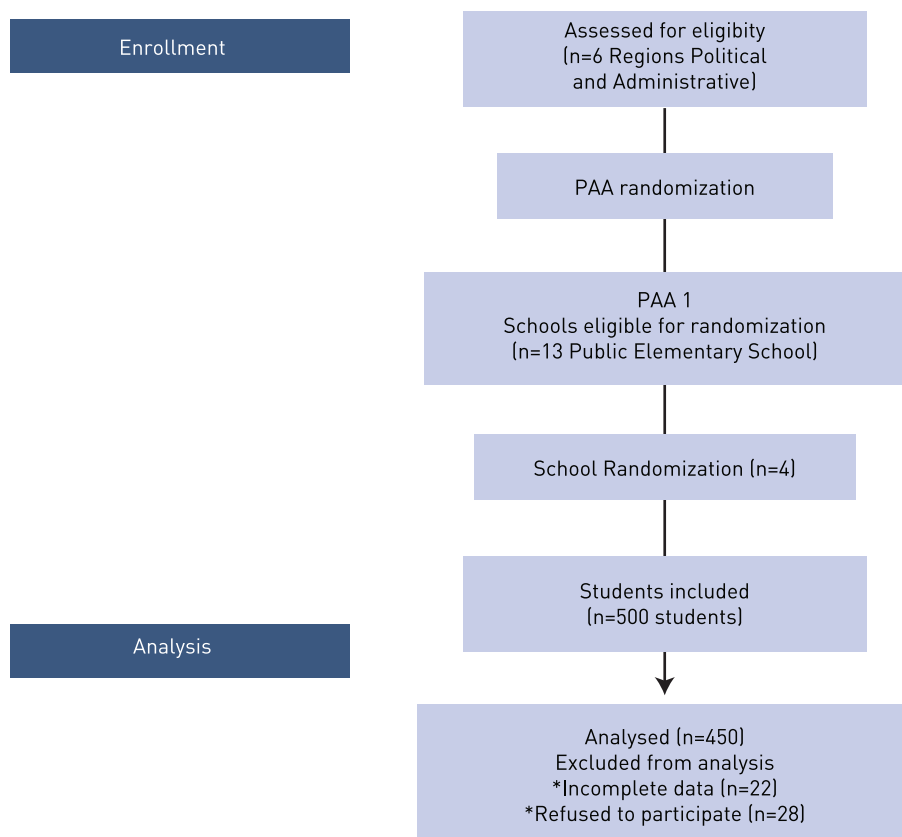
FIGURE 1 – Sample selection.

There were no differences between boys and girls for age (8.8±1.4; 8.7±1.5), weight (30.1±7.9; 31.6±10.0), height (134.4±9.4; 134.7±11.2) and BMI (16.5±3.0; 17.1±3.6). For girls, the prevalence of underweight was 8.4% (95%CI: 5.1-12.8), normal-weight 64.9% (95%CI: 58.2-71.1) and overweight 26.7% (95%CI: 21.0-32.9). For boys, the prevalence was 13.8% (95%CI: 9.5-18.9), 59.6% (95%CI: 52.8-66.0) and 26.6% (95%CI: 21.0-32.9) for under-

weight, normal-weight and overweight, respectively. Insufficient achievement in Portuguese was verified in 45.8% (95%CI: 39.1-52.5) and 40.4% (95%CI: 33.9-47.1) of boys and girls (Figure 2a). Concerning to Mathematics, 51.6% (95%CI: 44.8-58.2) (boys) and 46.2% (95%CI: 39.5-52.9) (girls) had insufficient performance (Figure 2b). There were no statistical differences between genders on academic performance.
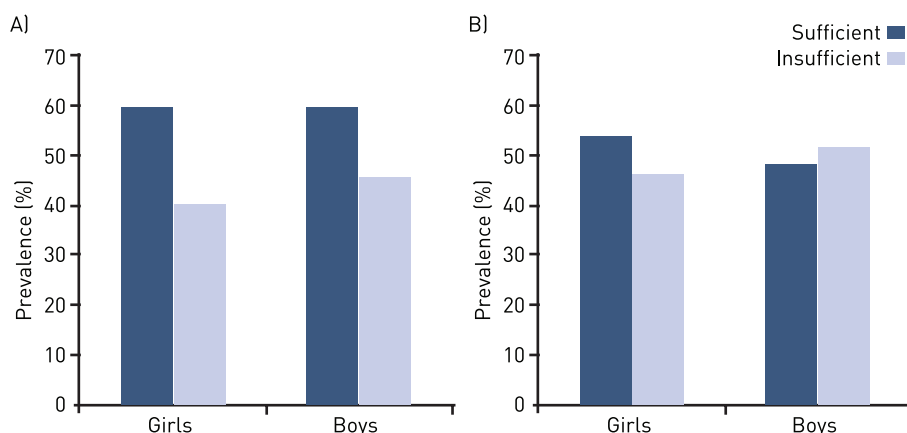
FIGURE 2 – Academic performance in Portuguese (A) and Mathematics (B) of elementary-school children by gender.

There was no interaction between PAL and BMI in the analyzed models (Portuguese: p = 0.78 and Mathematics: p = 0.71) the same was found to gender (Portuguese: p = 0.26 and Mathematics: p = 0.35). Unadjusted logistic binary regression revealed no associations between underweight and academic performance in Portuguese or Mathematics. However, a significant association between overweight and academic performance in Portuguese (but not in Mathematics) was reported. In multivariate analysis the overweight remained significantly associated with insufficient performance in Portuguese after adjustment for PAL, age and sex (OR = 1.69; 95%CI: 1.08-2.64) (Table 2). Overweight children are at 70% more *odds* at risk to have lower performance in Portuguese than counterparts with normal weight.

When the analysis was performed between unhealthy weight (under + overweight) and academic performance no associations were verified (Table 3).

DISCUSSION

The main finding of the present study is the negative association between overweight and academic performance in Portuguese even when adjusted for PAL, gender and age. These results support findings from previous studies that looked into the effect of BMI on academic performance and verified that normal weight students showed better grades, better trends in reading scores, greater school attendance and better discipline when compared with overweight[2] and underweight[5] counterparts. Furthermore, children who were overweight from kindergarten to the end of 3rd grade showed poor academic achievements and more behavioral problems[1]. However, no study has examined the association of both underweight and overweight and academic performance.

In another cohort study, Carter et al.[16], examined whether obesity during pre-school to primary school years was related to Mathematics performance,

TABLE 2 – Crude and adjusted Odds Ratio (OR) for insufficient academic performance with respectively 95% confidence intervals according to BMI in elementary-school children.

Variables	Crude OR (95% CI)	p-valor	Adjusted[a] OR (95%CI)	p-valor
Academic performance in Portuguese				
Normal Weight	1		1	
Underweight	1.01 (0.55-1.86)	0.95	1.07 (0.58-1.98)	0.81
Overweight	1.66 (1.07-2.60)	0.02	1.69 (1.08-2.64)	0.02
Academic performance in Mathematics				
Normal Weight	1		1	
Underweight	0.79 (0.43-1.46)	0.46	0.87 (0.47-1.61)	0.66
Overweight	1.37 (0.89-2.11)	0.15	1.41 (0.91-2.18)	0.12

[a]Adjusted by PAL, gender and age.

TABLE 3 – Crude and adjusted Odds Ratio (OR) for insufficient academic performance with respectively 95% confidence intervals of normal and unhealthy weight in elementary-school children.

Variables	Crude OR (95% CI)	p-valor	Adjusted[a] OR (95%CI)	p-valor
Academic performance in Portuguese				
Normal Weight	1		1	
Unhealthy weight	0.69 (0.47-1.02)	0.06	0.67 (0.46-1.10)	0.06
Academic performance in Math				
Normal Weight	1		1	
Unhealthy weight	0.85 (0.58-1.25)	0.42	0.81 (0.56-1.19)	0.30

[a]Adjusted by PAL, gender and age.

independent of other factors, such as age, sex and ethnicity in a large representative sample of Canadian children. The results showed that being obese in the pre-school years, but normal weight in primary school was associated with better Mathematics performance. Additionally, children who were always obese and those that developed obesity from pre to primary school performed no differently on the Mathematics test than children who were never obese. Although in our study we do not have a track record of BMI during early years, the findings of this study support ours as there was no significant difference in academic performance on the Mathematics test between unhealthy and normal BMI children.

Recently, Bisset et al.[17], analyzed prospectively childhood BMI trajectories to describe their association with subsequent academic and cognitive outcomes. The authors found that during childhood, being overweight does not increase the risk of poor educational outcomes. Instead, being underweight may increase the risk of poor cognitive outcomes. In our study, using a cross-sectional design, we did not observe association between underweight and academic performance.

In relation to PAL, most of the studies do not treat PAL as a possible factor that may influence the relationship between weight status and academic performance, and only treat the association separately with the outcome. Few studies which investigated the association between PAL and academic performance have found a positive relationship between academic performance and PAL, especially regarding vigorous activities[18,19] however, others have not found this association[20,21]. Morales et al.[22] found a linear relation between

self-reported daily PAL and academic performance. However they have not assessed participants BMI. In the present study, we find no influence of PAL on academic performance. Academic performance is probably not a simple phenomenon that can be explained only by BMI and PAL, various other factors such as: family environment and socioeconomic level[23] might be related with academic performance.

The present study is innovative because it contains important information about the subject, emphasizing the practice of regular PA as a way to positively influence not only on the parameters of health, but also can bring benefits to academic performance. This is also the first study, from our knowledge, which looked to a sample of underweight and overweight (unhealthy weight) instead of these groups in isolation. Possible limitations of this study include lack of an objective measurement of PAL, the reliability and validity of self-report PAL for children are questionable. Generally, children present different concepts of time; sensitivity to socially desirable responding; and difficulty separating behavioral intentions and actual behavior, all this may decrease the psychometric properties of self- report[24]. In relation to academic performance, the confiability on measures of teacher-reported needs care, because it is a subjective measure that does not reflect an objective measure of academic performance, recognizing these limitations standardized measurements of academic achievement can be better instruments.

Similarly, socioeconomic status has normally been associated with academic achievement and this was also not measured. Evidence shows that there is a positive association between socioeconomic status and academic performance[23]. Additionally, Gurley-Calvez and Higginbotham (2010)[25] found negative associations between obesity and reading proficiency in high poverty districts, but obesity rates have little effect in lower poverty districts. Commonly, students of public schools belong to lower socioeconomic classes and children with low-income families tend to have lower school performance. Another limitation is that students are clustered in different schools and classrooms and this might account for the different learning experiences and larger variation in academic performance, which may have influenced the results. Further limitations include the use of the BMI as a tool for assessing unhealthy weight, as BMI does not distinguish between fat mass and lean body mass, and furthermore the use of categories based on BMI percentiles can be problematic[26].

In the present study we observed that overweight children tend to have lower academic performance than normal weight children, without influences of PAL in this association. Despite these results, one should take into account that changes in lifestyle through proper nutrition and increased energy expenditure with PAL should be encouraged for this population, regardless of the response in academic performance, considering the other benefits associated with this behavior in the reduction of cardiovascular risk and other factors associated with unhealthy weight. Given the above, future research should seek more studies to verify if these results can be extrapolated to other populations, for example adolescents and longitudinally examine whether increases in PAL could mediate the association between BMI and academic performance, i.e. bring improvements in academic performance of children independent of the weight status.

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