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Association between the environment for physical activity in public schools and childhood obesity: a view in the light of complex systems

Associação entre ambiente para atividade física em escolas públicas e obesidade infantil: um olhar à luz de sistemas complexos

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Abstract *This article aims to analyse the relationship between physical activity (PA) environment at schools, sex, age, and obesity in children, using a network approach. This is a cross-sectional study, with 1,200 children (8.1±1.0 years old) from eight public schools in the same municipality. Weight and height measurements were assessed to calculate the Body Mass Index (BMI) and classified as healthier weight or overweight. To assess the PA environment at school, a interview with the school´s manager was conducted. The association between the PA environment at school and obesity was tested using a Network Analysis performed on the Jasp software. Positive associations between BMI and Physical Education classes (0.847), physical education teacher (0.349), break duration (0.564), and indoor sports court (0.662) were observed. Negative associations were seen with sex (-0.212) age (-0.387), extracurricular PA (-0.492), and playground (-0.557). Additionally, the centrality indicators highlighted extracurricular PA (1.789) as the variables with the highest betweenness values, and BMI with the highest closeness (2.239) and strength (1.230) values. Extracurricular PA and the presence of playgrounds in school´s environment are associated with healthier weight in low-income children.*

Key words *School environment, Physical activity, Obesity*

Resumo *O objetivo deste artigo é analisar a relação entre ambiente de atividade física (AF) nas escolas, sexo, idade e obesidade em crianças, usando uma abordagem de rede. Trata-se de um estudo transversal com 1.200 crianças (8,1±1,0 anos) de oito escolas públicas do mesmo município. Peso e estatura foram avaliadas para cálculo do Índice de Massa Corporal (IMC) e classificadas como peso saudável ou sobrepeso. Para avaliar o ambiente de AF na escola, foi aplicado um questionário por meio de entrevista com o gestor da escola. A associação entre o ambiente de AF na escola e a obesidade foi testada por meio Análise de Redes realizada no software Jasp. Foram observadas associações positivas entre o IMC e as aulas de Educação Física (0,847), professor de educação física (0,349), duração do intervalo (0,564) e quadra poliesportiva (0,662). Associações negativas foram observadas com sexo (-0,212), idade (-0,387), AF extracurricular (-0,492) e playground (-0,557). Adicionalmente, os indicadores de centralidade destacaram a AF extracurricular (1,789) como a variável com o maior valor de intermediação, e o IMC com o maior valor de proximidade (2,239) e força (1,230). A AF extracurricular e a presença de playgrounds no ambiente escolar estão associadas a um peso mais saudável em crianças de baixa renda.*

Palavras-chave *Ambiente escolar, Atividade Física, Obesidade*

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Introduction

During childhood, obesity is associated with cardiovascular risk factors, such as dyslipidemia, hypertension, diabetes and coronary heart disease[1], with behavioural and emotional disorders[2], low physical activity (PA) and fitness levels[3], and increased sedentary time[1], becoming a severe health problem. Thus, its early prevention is a public health priority[4]. It is emergent to avoid children´s exposure to obesogenic environments[5], which do not favour the choice of healthy habits, such as adequate caloric intake and PA practice[6]. The school is recognized as an essential environment to promote schoolchildren´s healthy behaviours, considering its pre-planned, segmented, and supervised structure[7]. Previous studies have shown that the school environment, when well oriented, may lead schoolchildren to adopt a healthier lifestyle[8,9].

Childhood is a critical phase to adopt healthy behaviours, such as PA[10], which may contribute to a healthy weight status. Nonetheless, PA prevalence in six-to-ten-years-old schoolchildren has decreased substantially, and many schoolchildren do not comply with PA recommendations[11]. Moreover, for schoolchildren from low-income families, PA opportunities are even worse, due to the lack of PA environments[1,4]. Thus, the school environment may be a potential environment to promote PA, especially when considering its greater flexibility for structural changes, and the possibility of implementing a transversal health promotion program, which may impact on several schoolchildren simultaneously. Likewise, it has a fundamental role in providing healthy opportunities, especially in low-income contexts, where schools are the only environment where schoolchildren may engage in PA[6].

Aspects of the school environment, such as physical education (PE) classes, are associated with higher PA levels among schoolchildren[12]. However, in Brazilian schoolchildren, the results of a previous study showed that participation in PE classes was not associated with schoolchildren´ protection for overweight and obesity[13]. In fact, opportunities for PA in school environments through physical education classes should be part of multicomponent programs aimed at changing schoolchildren's lifestyles designed to combat childhood obesity. Review studies reported that interventions focusing on changing schoolchildren's behaviour at the school environment have been ineffective in achieving these goals[14,15]. Therefore, children´s PA at schools seems to be determined by different PA opportunities at school settings, that are dynamically interrelated to create a healthier pattern for schoolchildren´s PA engagement[16,17]. The PA environment at schools may be seen as a complex system composed of different levels, that can emerge through interactions of varying school components, and assessed through a Network perspective, which considers its non-linear, dynamic and adaptive characteristics[18]. For this reason, it is essential to carry out studies that analyse these phenomena in the light of complex systems, especially in low-income populations that present in their contexts very different realities from the previously studied populations. Thus, this study aimed to analyse the relationship between PA environment at schools and schoolchildren´s obesity status, using a network approach.

Methods

Study design

This cross-sectional study used data from the "Panpes" program, aimed to analyze the effect of a multicomponent intervention on health and behavioural outcomes of obese children. All the Helsinki Declarations' ethical aspects were followed[19], and the project was approved by the Research Ethics Committee of Health Science Center (protocol No. 1.311.598) and by the Education Board of the city. Parents and children signed a consent before participating.

Eligibility criteria and setting

Eligibility criteria for schools and children´s selection was established as follows: public elementary schools should have central and suburban and underserved areas in Petrolina-PE, Brazil. Still, having a covered gym with at least 100 students. Therefore, eight schools met the eligibility criteria. The schoolchildren were considered eligible if they were aged 6 to 10 years, enrolled in one of the eligible schools. Based on this, 2,231 children were eligible. All parents of registered children aged 6 to 10 years were invited, and 1,283 accepted to participate. However, 83 children were not included in the study because they missed school on data assessments. So, 1,200 children, in four different city areas of the city (North, South, East, and West) were analysed.

Measurements were performed during two months (October to December 2015) by five

physical education teachers, who were previously trained and supervised by the project´s coordinator. On the first assessments the first day, an interview was held with the school managers to assess the school's environment and children's sociodemographic data (date of birth and sex). In the following days, the children's anthropometric assessments were carried out. Approximately four days were required to assess all children participating in each school.

Variables and protocols

Anthropometric measurements

Anthropometric measurements were performed (weight and height) according to WHO procedures[20], and carried by previously trained evaluators. Weight was determined on a digital platform scale, Wiso®, model W801, with an accuracy of up to 100 g, and height was determined using a Sanny® metallic measuring tape attached to the wall, with an accuracy of 0.1 cm. Body mass index (BMI) was calculated by dividing body weight with the squared height in meters (kg/m2) and, for analysis purposes, BMI was dichotomized into 0) healthy weight (>85th percentile) and 1) unhealthy weight (<85th percentile)[20]. The sex variable was dichotomized into 0) male and 1) female.

PA environment at schools

To assess the PA environment at schools, the questionnaire developed by Mélo *et al.*[21] which aims to analyse preschools' environment for PA was used, and adapted for elementary school. For the present study, some original questions of the instrument were used, which were later divided into organizational and structural environments. For the organizational environment, the following issues were considered: 1) Does the school offer PE classes (1st to 4th year)? (0 - No x 1 - Yes); 2) Are the classes taught by a PE teacher? (0 - No x 1 - Yes); 3) How long does each break last; 6) Does the school offer extracurricular PA? (0 - No x 1 - Yes). For the structural ones, the following questions: 1) does the school have an indoor sports court?; 2) does the school have a playground? The answers were dichotomized as 0 = No and 1 = Yes, for analysis.

Data analysis

For descriptive analysis, frequency distribution and chi-square test were used. For analysis of associations, a Machine Learning technique called Network Analysis was used to establish interactions between variables from a graphical representation. The "Fruchterman- Reingold" algorithm was applied so, data were presented in the relative space in which variables with stronger associations remain together, and the less strongly associated variables were repelled from each other[22]. The least absolute contraction and selection operator was used to obtain regularization and to obtain a less sparse model[23]. The partial correlation parameter was adjusted to 0.25 to create a network with greater parsimony and specificity[24].

To quantify the importance of each node in the network, we then calculated the betweenness and strength centrality indices: (1) betweenness centrality, estimated from the number of times that a node is part of the shortest path among all other pairs of nodes connected to the network; (2) closeness centrality, determined from the inverse of the distances from one node to all others; (3) strength centrality which is the sum of all the weights of the paths that connect a node to the others. The variables were configured in four attributes: 1) demographics characteristics; 2) Organizational environment school 3) Structural environment school; 4) Obesity indicators. The positives correlations were represented in blue colour and the negatives correlations in red colour. Analyses were performed in Jasp (0.12.1).

Results

Table 1 shows the results of the prevalence of obesity between sex and age of students. There no significant differences between sexes among age strata.

The main results of the network analysis showed positive associations between BMI with PE classes (0.847), PE teacher (0.349), break duration (0.564) and indoor sports court (0.662). Negative associations were seen between BMI and sex (-0.212), age (-0.387), extracurricular PA (-0.492) and playground (-0.557).

The network between the assessed variables is shown in Figure 1. The blue lines represent the positive associations and the red the negative ones. The thickness of the lines represents the strength of the associations. The network is a graphical representation of Table 2, so the strongest associations in the network, are BMI with PE classes, PE teacher, break duration, indoor sports court, sex, age, extracurricular PA and playground.

The centrality indicators highlighted that extracurricular PA (1.789) showed the highest

Table 1. Prevalence of obesity indicators in schoolchildren aged 6 to 9 years from public schools in the Vale do São Francisco region of Pernambuco in 2015.

Variables	6-year-old		p*	7-year-old		p*	8-year-old		p*	9-year-old		p*	10-year-old		p*
	Boys (n=9)	Girls (n=20)		Boys (n=195)	Girls (n=187)		Boys (n=243)	Girls (n=214)		Boys (n=191)	Girls (n=192)		Boys (n=699)	Girls (n=672)	
BMI			.260			.647			.294			.833			.561
Healthy (%)	21.6	73.9		51.6	48.4		54.4	45.6		50.2	49.8		51.4	48.6	
Unhealthy (%)	50.0	50.0		48.4	51.6		48.5	51.5		48.9	51.1		49.3	50.7	

*p<0.05 of the Chi-Square Test. BMI=Body Mass Index.

Source: Authors.

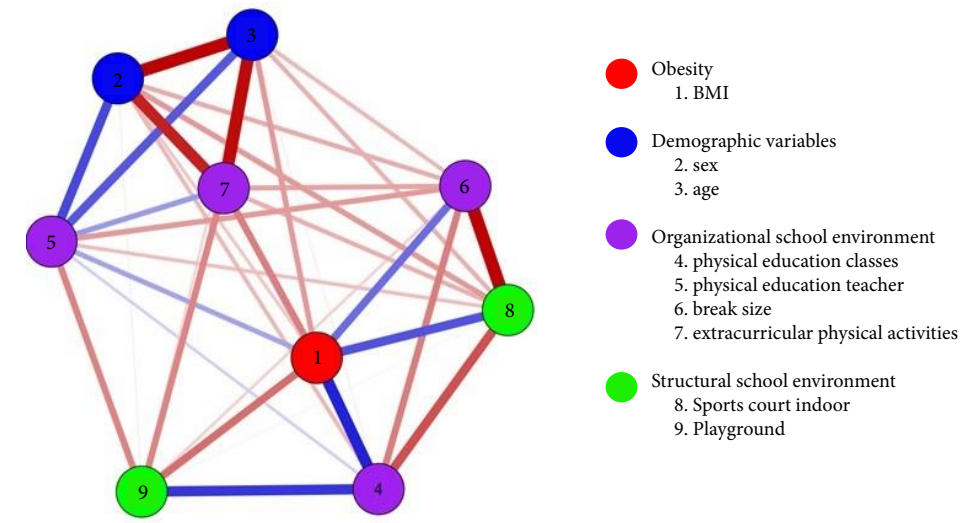

Figure 1. Network analysis of the study carried out schoolchildren aged 6 to 9 years from public schools in the Vale do São Francisco region of Pernambuco in 2015.

Source: Authors.

betweenness values, estimated from the number of times that a node is part of the shortest path among all the others pairs of nodes connected to the network, meaning this is the variable with the higher number of network relationships. Furthermore, BMI showed the highest closeness (2.239) which is determined from the inverse of the distances from one node to all others and strength (1.230) values, which is the sum of all the weights of the paths that connect a node to the others, indicating that BMI may be easily impacted by possible changes in the network (Table 3).

Discussion

The present study considered the network perspective to investigate the association between the PA environment at schools and children´s obesity status. The main results showed extracurricular PA and BMI as the main network's variables. Previous studies analysed the association between school environment and children's BMI[12,13]. However, as far as the authors know, this is the first study to consider the school environment's organizational and structural characteristics and BMI as part of a network system. Additionally, this study covered an important gap in the literature, when highlighting this issue for children living in a low-income context.

Table 2. Strength of associations between variables in the perspective of a network of the study carried out schoolchildren aged 6 to 9 years from public schools in the Vale do São Francisco region of Pernambuco in 2015.

Variables	BMI	Sex	Age	PEC	PET	Break duration	EPA	Sports court indoor	Playground
BMI	0.000								
Sex	-0.212	0.000							
Age	-0.387	-0.976	0.000						
PEC	0.847	-0.270	-0.062	0.000					
PET	0.349	0.700	0.641	0.180	0.000				
Break duration	0.564	-0.315	-0.270	-0.499	-0.388	0.000			
EPA	-0.492	-0.856	-0.942	0.171	0.386	-0.348	0.000		
Sports court indoor	0.662	-0.386	-0.297	-0.671	-0.243	-0.976	-0.301	0.000	
Playground	-0.557	0.052	-0.151	0.767	-0.473	-0.173	-0.470	0.039	0.000

BMI=Body Mass Index; PEC=Physical education classes; PET=Physical education teacher; EPA=Extracurricular physical activities.

Source: Authors.

Table 3. Centrality measures per variable of the study carried out schoolchildren aged 6 to 9 years from public schools in the Vale do São Francisco region of Pernambuco in 2015.

Variable	Network		
	Betweenness	Closeness	Strength
Body Mass Index	0.894	2.239	1.230
Sex	-0.894	-0.132	0.481
Age	-0.894	-0.891	0.379
Physical Education classes	0.894	-0.585	-0.260
Physical Education teacher	-0.894	-0.560	-0.524
Break duration	0.000	-0.579	-0.096
Extracurricular Physical Activity	1.789	1.024	0.976
Sports court indoor	-0.894	-0.271	0.008
Playground	0.000	-0.244	-2.193

Source: Authors.

In the present study, the break duration was positively associated with children´s weight status. This result could be, at least partially, explained by the low break duration in the assessed schools (20 minutes), and the cultural Brazilian context, where children tend to spend their break times chatting on smartphones or snacking. High obesity levels may promote changes in important health outcomes of school-age children such as shorter sleep duration[25], lower values of inhibitory control[26], high cardiovascular risk[27], low PA[28], and low physical fitness levels[3]. This fact reinforces the importance of school´s environment in promoting a healthy lifestyle[7].

Indeed, PA should be encouraged in different settings to promote a healthy lifestyle[29], but particularly at school[30], and especially among low-income children. It requires remodeling the structural and organizational settings, that could be through PE classes, and trained staff to teach a healthy lifestyle through PA[31]. Although participation in PE classes has been associated with a better body composition profile[32] and with high levels of cardiorespiratory fitness and muscle strength in Brazilian students[13], a higher intensity and duration of PE classes should be encouraged[31], especially when considering the heterogeneity in PE offer and classes' procedures among the different Brazilian regions. Furthermore, a school´s curriculum, focused on active breaks, has been reported as effective to increase children´s PA[33]. Additionally, overweight children tend to spend less time on moderate to vigorous PA during the break, than their healthy-weight peers[34] and adequate spaces at schools are key for children to be active during this time[35]. Among low-income children, PA environments, such as a sports court, are associated with lower overweight[36], as schools may offer their unique opportunity to be active[37].

The negative association between BMI and PA during school hours extra has its partial explanation that all the schools evaluated were in

neighborhoods with high crime, which makes access to school difficult, especially for children whose parents work and cannot accompany their children in these activities[38]. Another possible explanation is that children with a healthy weight tend to engage more in extra physical activities than overweight[39]. Although positive associations have been seen between BMI and PE classes, PE teachers, break duration and indoor sports court, it is also important to highlight that the assessed children live and study in low-income settings, where the quality of those factors must be explored in future investigation. Moreover, extracurricular PA, focusing on structured and supervised activities, and playground to give children opportunity for unstructured PA, should be encouraged towards a health BMI.

Indeed, the approach adopted in this study, which focus on PA as part of a complex system[40], composed of different levels, and that emerges through interactions of different components, including school´s environment, allows to recognize the characteristics of the interrelationships between PA school´s environment and BMI through non-linear, dynamic relationships. Thus, the associations observed are part of a systemic approach, which concept has been introduced to understand the diversity of factors related to health behaviours[41], and should not be considered in isolation. Studies using this approach have focused on aspects of public health policies[42], health education[43], and obesity[44]. Thus, children PA, as a marker health behaviour, is part of that holistic perspective, that occurs by forming patterns responsive to the entire environmental context[45].

The present study has some limitations that need to be considered when interpreting its results: a) the questionnaire used to assess the school environment has not been validated and therefore does not present psychometric indicators. However, the questionnaire is quite simple and objective, with closed possible answers, what may reduce the bias risk; b) the lack of children's PA data is another limitation that should be considered for future studies. Nonetheless, the results cover a representative sample of children living in low-income contexts in Petrolina and used a systemic approach to lead with complex health problem of schoolchildren.

Conclusion

Extracurricular PA and the presence of playgrounds at school's environment are associated with a healthier weight status in obese low-income children. These results may support decision making and public policies for school's settings, towards children's health lifestyle.

Collaborations

AN Souza Filho: conceptualization, data curation, formal analysis, investigation, methodology, project administration, writing – original draft. TA Bezerra: conceptualization, data curation, investigation, methodology, project administration, writing – original draft. PFR Bandeira: conceptualization, data curation, formal analysis, writing – original draft. FO Carvalho: conceptualization, funding acquisition, methodology, project administration, supervision, writing – review & editing. LG Cabral: data curation, formal analysis, investigation, writing – original draft. A Brito: data curation, formal analysis, investigation writing – original draft. PH Guerra: formal analysis, writing – original draft, writing – review & editing. CML Martins: methodology, writing – review & editing.

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