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Obesity and decrease of daily physical activity among children and adolescents: a follow-up study

Obesidade e redução da atividade física diária de crianças e adolescentes: um estudo longitudinal

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Abstract – We analyzed the effect of obesity on daily physical activity (DPA), light-intensity physical activity (LPA), moderate-intensity physical activity (MPA) and vigorous- intensity physical activity (VPA) in children and adolescents. Overall, 462 students from a public school (53.6% boys; aged 7-12 years) were involved in this one-year longitudinal study. Physical activities and sedentary behaviors (SB) were reported in the questionnaire Food Intake and Physical Activity of Students (Web-CAAFE). Obesity was evaluated through Body Mass Index (BMI z score ≥ 2). Obesity was observed in 16.5% of participants, but it did not influence LPA, MPA or DPA. However, VPA were 20% less frequent among obese students (β^2=0.80; CI 95%: 0.66-0.98). Obese girls showed less frequency of VPA than non-obese boys (Mean Difference = -0.97; CI 95%: -1.36 to -0.57). Non-obese girls showed less VPA than non-obese boys (Mean Difference = -1.18; CI 95%: -1.40 to -0.95) and obese ones (Mean Difference = -0.57; CI 95%: -0.90 to -0.24). Obese boys showed fewer VPA, if compared to non-obese ones (Mean Difference = -0.61; CI 95%: -0.96 to -0.26). The analysis of the obesity-sex-age interaction showed a greater reduction in VPA among obese girls aged 10 years or more when compared to obese girls aged 7-9 years, and among boys obese and non-obese regardless of age. Amounts of VPA and SB increased simultaneously among non-obese boys and non-obese children aged 7-9 years. Obesity reduced VPA in the sample during the follow up of one year, independently of age and SB.

Keywords: Motor activity; Pediatric obesity; Students.

Resumo – *O estudo analisou o efeito da obesidade na atividade física diária (AFD) e nas atividades físicas leves (AFL), moderadas (AFM) e vigorosas (AFV). Trata-se de um estudo longitudinal com seguimento de um ano. Participaram 462 estudantes de escola pública (53,6% meninos; 7-12 anos de idade). Atividades físicas foram relatadas no questionário Consumo Alimentar e Atividade Física de Escolares (Web-CAAFE). Obesidade foi avaliada pelo escore z do Índice de Massa Corporal (IMC-para idade ≥+2). Obesidade ocorreu, na média, em 16,5% dos participantes, mas não influenciou as AFL, AFM ou AFD. Porém, reduziu em 20% as AFV (β^2 =0,80; IC95%: 0,66-0,98). Maiores reduções ocorreram em meninas com obesidade comparadas a meninos sem obesidade (Diferença Média = -0,97; IC95%: -1,36 a -0,57) e em meninas sem obesidade comparadas a meninos sem obesidade (Diferença Média = -1,18; IC95%: -1,40 a -0,95) e com obesidade (Diferença Média = -0,58; IC95%: -0,90 a -0,24). AFV declinou mais em meninos com obesidade comparados aos congêneres sem obesidade (Diferença Média = -0,61; IC95%: -0,96 a -0,26). Quando apreciada a interação entre obesidade, sexo e idade, meninas com obesidade com 10 anos ou mais só não exibiram maior redução na AFV, quando comparadas às congêneres sem obesidade na mesma faixa etária (Diferença Média: -0,181; IC95%: -0,48 a 0,12). A frequência diária de AFV cresceu com o aumento dos comportamentos sedentários. Obesidade reduziu a AFV na amostra, sobretudo entre meninas com 10 anos ou mais.*

Palavras-chave: *Atividade motora; Obesidade pediátrica; Estudantes.*

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INTRODUCTION

The understanding that physical activity is crucial in the prevention of obesity comes from cross-sectional designed studies[1]. But cross-sectional studies can lead to inaccurate interpretations as they do not adequately establish the causal link[2].

Results of longitudinal studies are not unanimous about the association between physical activity and childhood obesity. Some studies show that participation in sports groups and regular structured exercise programs leads to a slower increase in BMI levels, or a decrease of its levels during childhood[3,4].

Other studies show the existence of a bidirectional association between BMI, structured sports, and free time physical activities[5], or even the absence of effect on BMI[6].

The existence of reverse or bidirectional causality between obesity and physical activity during childhood has been a common finding. These behaviors establish a complex relationship among themselves, as predictors of adiposity and the genesis of childhood obesity, and they can be influenced by sex and age variables, as well as by the prevalence of obesity in the baseline of longitudinal studies[7].

This study aimed to analyze the longitudinal association between obesity and the daily physical activity of children and adolescents. Also, the study investigated interactions with the variables sex, age, and sedentary behaviors.

METHODS

Participants

The study had a longitudinal design of a one-year follow-up, where the collection of data only happened during weekdays (Tuesday to Friday), in 2015. The data collection during baseline happened in May and the following up data collection happened in July, September, and November.

The study included a convenience sampling of students (second to fifth grade – elementary school) in a part-time public school located in the city of Feira de Santana, in the state of Bahia. This school did not offer Physical Education classes.

The study followed the ethical standards for research with human of Resolution No. 466/2012 of the National Health Council and was approved by the Research Ethics Committee of the *Universidade Estadual de Feira de Santana* (CAAE: 19499913.3.0000.0053).

Feira de Santana (619,609 inhabitants) shows the Human Development Index (HDI) of 0.712, the school enrollment rate in 6 to 14 years old of 97.4%, and infant mortality rate of 13.85 per 1,000 live births[8]. The participant school was selected because it complied with the survey protocol, which aimed to hold the study in a public institution of elementary school, with a computerized room and access to the Internet, the offer of school meals, and compliance of the principal and teachers. The school had five hundred and seven (507) students between the second and fifth grade of elementary school. There were included in the survey all the ones that showed interest in the study and who got permission from parents or guardians.

Measurement of obesity

Obesity was evaluated through values of BMI z scores (≥2) in relation to the reference curves from the World Health Organization[9]. For the calculation

of BMI, trained researchers assessed the anthropometric measures of body weight and height of the students, according to suggested standardization in literature[10]. The weight was assessed by using the digital scales Wiso®, Ultra Slim W801, with precision of 100g and maximum capacity of 180 Kg. Height was assessed by using a portable and collapsible stadiometer, with a platform and set square, Altura Exata®, with 213 cm of maximum height and precision of 0.1 cm. Students were on bare feet, wearing their school uniforms, and wore no head accessories during the assessment of the measures.

Measurement of physical activity and sedentary behavior

Physical activities and sedentary behaviors were self-reported in a web-based questionnaire: Web-CAAFE. The Web-CAAFE is a questionnaire which examines food consumption and physical activity during the previous day (24-hour recall). This instrument had been developed[11] and validated in two Brazilian cities, to be used with students from the second to fifth years of elementary school. The instrument showed adequate validity and reliability of physical activity[12] and of food intake[13,14] evaluation, and good internal consistence regarding the typing of the values of weight and height, for the calculation of BMI and classification of the weight status[15].

The participants choose figures from a list of up to 32 options (27 physical activities and 5 sedentary behavior), and each chosen activity popped up a window to state the intensity (information that was not used in the current study). The information on the duration was not collected, making impossible to classify the participants' level of physical activity through Web-CAAFE. The Demo version of the questionnaire can be viewed at: http://caafe.ufsc.br/portal/10/detalhes.

The participants finished the Web-CAAFE in the computerized room in the school, after they were taught on the general functioning of the software, and on the filling out of the questionnaire, with the help of lectures and visual aids, as banners. Students were told not to interact among themselves during the task, and the research team was there to help them, whenever requested, without inducing the answers.

Information about the sex and age variables was provided by the academic secretariat of the school, and it was available for all students. The daily amount of sedentary behavior was included in the modelling, for the appreciation of its effect in the main evaluated association.

Data analyses

Descriptive statistics were used to present the variables of the study. Values in metabolic equivalents (MET) were attributed to physical activities to discriminate light (LPA), moderate (MPA), and vigorous-intensity physical activities (VPA) ones, according to the compendium of energetic costs for youth[16]. Sedentary behaviors (SB) were added to the individual level, and they were represented by behaviors based on screens (TV, mobile phones, computers, and video games), or sitting positions (academic activities), and which energy expenditure was <1.5 MET.

Values in MET on daily vigorous physical activities in the thresholds of -3SD and 3SD were not considered plausible and they were excluded from the analyses. Students with disabilities and who were younger than 7 years old and older than 12 were also excluded. With this, the analysis failed to have the

data of 15 individuals on baseline (3.94%), 18 individuals on the first follow up collection (4.29%), 20 individuals in the second collection (4.83%) and 18 more individuals in the third one (4.50%).

The daily amount of physical activity (DPA), LPA, MPA and VPA were the analyzed outcomes, being the variables obesity sex, age and daily amount of sedentary behaviors, the exposure variables. The effect of obesity on physical activity was analyzed through the modelling of generalized estimating equations (GEE), for repeated measures, by adopting the distribution of Poisson probability. GEE analysis allows the data analysis of all individuals in the sampling, even when there is loss of information, this way avoiding the selection bias. Beyond, GEE allows the analysis of categorical and discrete data (Poisson distribution), as in this study[17]. Statistical significance was evaluated through p value $p<0.05$.

RESULTS

The study included 478 students who agreed to participate and who had been previously given permission by parents or guardians. There was variation in the number of participants during follow up: May (n=381), July (n=419), with the increase being caused by the inclusion of thirty eight (38) students that had been authorized after baseline, September (n=414) and November (n=400), with losses due to quits and absences to classes, during the weeks when data was collected. After the use of exclusion criteria, the analytical sampling was made of four hundred sixty-two (462) people (53.6% of boys, average age of 9.2 years old, and prevalence of obesity of 16.5%).

There were not changes in the proportion of obese students during follow-up data collection. That is, former obese students in baseline, continued to be obese until the end of the year (Table 1). Overall, there was a decline in DPA and mild and moderate activities in the entire sample between the months of May and November (Figure 1). Students with obesity compared to those without obesity already had a lower daily amount of physical activities and moderate and vigorous activities since the baseline of the study, and these values declined even further until the end of the follow-up period, with emphasis on VPA. In the non-obesity group, VPA remained with little change throughout the year.

Table 1. Characteristics of the participants.

Characteristics	May (baseline) n = 367	July n = 398	September n = 394	November n = 379
% of boys	52.9	53.3	54.6	53.8
% of girls	47.1	46.7	45.4	46.2
% of students per age group				
7 years old	16.6	10.3	8.6	7.1
8 years old	21.3	21.9	22.6	18.2
9 years old	24.8	24.1	25.4	24.3
10 years old	25.9	28.9	27.4	25.9
11 years old	7.4	10.6	11.7	18.2
12 years old	4.1	4.3	4.3	6.3
DPA[a]	5.01	5.18	5.01	4.74
LPA[a]	1.25	1.53	1.10	1.09
MPA[a]	2.57	2.48	2.42	2.22

[a]Median (minimum - maximum). [b]Mean (±SD). LPA: amount of light- intensity physical activities. MPA: amount of moderate-intensity physical activities. VPA: amount of vigorous-intensity physical activities. DPA: daily amount of physical activities. SB: daily amount of sedentary behaviors. BMI: Body Mass Index.

Table 1. Continued...

Characteristics	May (baseline) n = 367	July n = 398	September n = 394	November n = 379
VPA[a]	1.24	1.23	1.56	1.47
SB[a]	3.99	4.77	4.12	4.09
BMI[b]	16.96 (12.3 - 31.01)	16.98 (12.55 - 31.16)	17.04 (12.44 - 31.06)	17.24 (12.78 - 32.80)
BMI z scores[b] (mean±SD)	0.54 (1.35)	0.53 (1.32)	0.55 (1.32)	0.58 (1.29)
% of obesity	16.6	16.3	16.8	16.6

[a]Median (minimum - maximum). [b]Mean (±SD). LPA: amount of light- intensity physical activities. MPA: amount of moderate-intensity physical activities. VPA: amount of vigorous-intensity physical activities. DPA: daily amount of physical activities. SB: daily amount of sedentary behaviors. BMI: Body Mass Index.

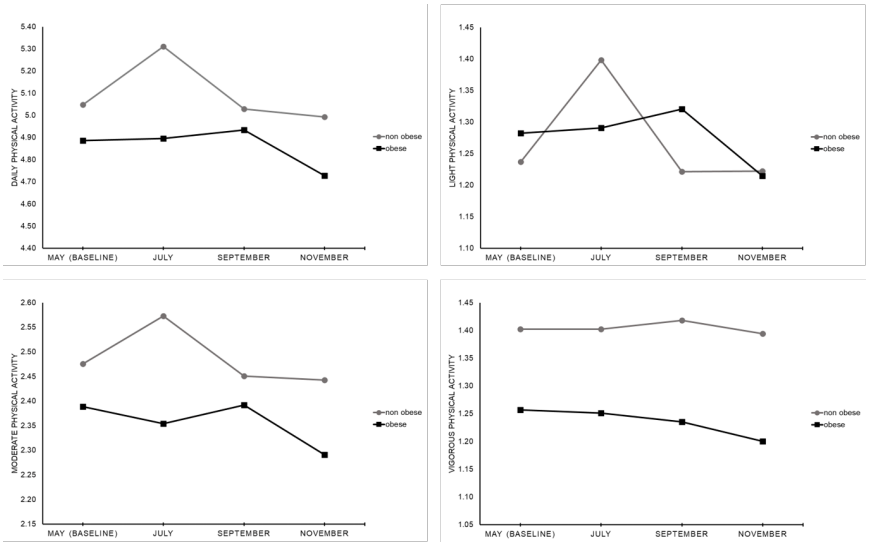

Figure 1. Longitudinal variation in physical activity in children and adolescents with and without obesity*. *Averages of the values predicted in the regression model (adjustment by sex, age and daily amount of sedentary behaviors).

When the magnitude of the effect of obesity on physical activities was assessed by the values of the regression coefficients, adjusted for sex, age, and daily quantity of sedentary behaviors, there was no significant decrease in DPA (p=0.431), MPA (p=0.779), or LPA (p=0.897). However, children and adolescents with obesity showed a statistically significant decrease in the daily amount of VPA (-20%) independently of sex and amount of daily sedentary behaviors (Table 2).

Table 2. Longitudinal effect of the variables of obesity, sex, age, and daily amount of sedentary behaviors on the daily frequency of physical activities and light, moderate and vigorous physical activities.

	AFL	AFM	AFV	AFD
Variables	β^2 (IC95%)*	β^2 (IC95%)*	β^2 (IC95%)*	β^2 (IC95%)*
Obesity	1.01 (0.82-1.25)	0.97 (0.78-1.20)	0.80 (0.65-0.98)†	0.94 (0.80-1.10)
Gender (female)	1.01 (0.84-1.22)	1.26 (1.08-1.47)†	0.44 (0.36-0.52)†	0.91 (0.80-1.03)
Age (≥10 years old)	0.73 (0.60-0.87)†	0.84 (0.73-0.97)†	0.89 (0.77-1.04)	0.83 (0.74-0.93)†
Sedentary Behavior	1.13 (1.10-1.15)†	1.05 (1.03-1.07)†	1.01 (0.99-1.03)	1.06 (1.05-1.07)†

*Estimated Coefficients through Generalized Estimating Equations (GEE) for repeated measures (distribution of Poisson probability). †Statistically significant values (p<0,05). LPA: amount of light-intensity physical activities. MPA: amount of moderate- intensity physical activities. VPA: amount of vigorous-intensity physical activities. DPA: daily amount of physical activities.

Gender variable modified the effect of obesity on VPAs. The interaction average between sex and obesity variables were appreciated in pairs, with adjustment for multiple comparisons through the method of significant minimum difference. Then, a greater decrease in VPA was observed among girls with obesity, compared to boys without obesity. Girls without obesity also showed a greater reduction in VPA than boys with and without obesity. Boys with obesity exhibited a greater decline in the daily frequency of VPA compared to their counterparts without obesity.

The interaction between obesity, sex, and age was also appreciated and girls with obesity aged 10 years or more exhibited a greater reduction in VPA when compared to boys with and without obesity, regardless of age group and when compared to 7-9-y-old girls with and without obesity.

The mean amount of daily VPA tended to increase as long as the frequency of SB among participants increased as well, like a compensatory effect, however it was more evident in boys compared to girls, in general, and among non-obese boys compared to the other groups (Figure 2).

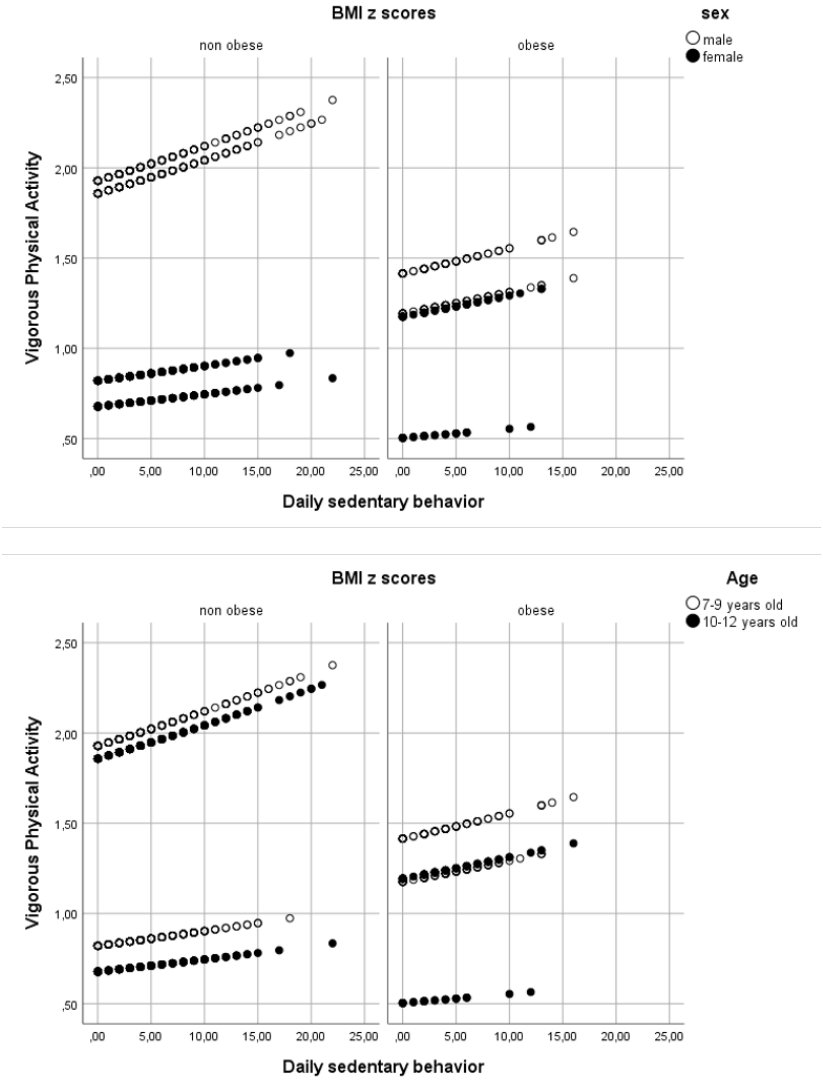

Figure 2. Longitudinal association between obesity and vigorous physical activity according to the daily amount of sedentary behavior and stratified by sex and age (values estimated by GEE modeling).

When age was taken into consideration, more daily SB were compensated by more average frequency of VPA in the age group between seven to nine years old, in a more significantly way than what had happened in the age group of 10 years old, or more, especially among non-obese students.

DISCUSSION

This study broadens the discussion on the relationship between obesity and physical activity, mediated by sedentary behaviors. Our results highlighted that obesity is associated to the reduction of vigorous physical activities among the participants. This effect was pronounced among girls with obesity, especially in the age group of 10 years or more, which exhibited a greater reduction in VPA compared to boys with and without obesity, regardless of age group, and when compared to 7-9-y-old girls.

Typical changes in adolescence, such as the appearance of secondary sexual characters, breast growth and hormonal changes and body composition among girls contribute to feelings of discomfort during physical activity and may explain their decline at this stage of life[18]. Obesity seemed to contribute to this phenomenon in the current sample.

There is evidence that reaching the recommendations of physical activity is associated to lower BMI, or less prevalence of obesity[1]. Nevertheless, these associations are mostly cross-sectional ones. Longitudinal studies that included children observed that the increase of body adiposity was associated the decrease of future physical activity[7].

In a longitudinal study held with children from the United Kingdom observed that children with higher levels of BMI at 6 years old, showed higher probability in keeping the profile of physical activities and sedentary behaviors, or to change for profiles with lower levels of physical activity at 9 years old[19]. Together, these are results that suggested the long-term influence of obesity on physical activity.

On the other hand, the engagement in organized sports and academic programs in kindergarten and first year of elementary school, lead to a slower increase of BMI among children[3].

Other studies showed the existence of reverse causality between the practice of physical activities or structured sports and BMI[5]. This association can be bi-directional, because low levels of physical activity can lead to the increase of body adiposity[20], and the increase of adiposity can restrict physical activity[2].

Socio-emotional consequences of obesity, such as anxiety, depression, low self-esteem, and social problems, as bullying and stigmas, contribute to keep children and adolescents away from the practice of exercises[21].

Also, a higher body weight causes a stronger feeling of being tired during the physical activities, and pain and muscle discomfort that can also restrict the participation in physical activities[22], especially in the ones with more energy expenditure, or motor demand, as it is the case in vigorous physical activities. This is a possible explanation for the current finding in this study.

Among children and adolescents in this study, obesity slightly reduced the daily amount of daily physical activities. But its effect on vigorous-intensity physical activities was more pronounced and statistically significant.

Comparisons of results from this study with other ones that evaluate the longitudinal association between BMI and physical activity of children and

adolescents are limited by methodological differences, especially regarding follow up time, amount of physical activity, studied age group and socio-economic context.

In our study, the follow up time was shorter than the one that had been observed in similar studies[3,5,6], and it may have been determinant for the non-capture of most important reductions in physical activity, due to obesity, nor expressive changes in the values of BMI along time. However, the observed longitudinal effect should be useful for planning policies to promote physical activity in childhood and to reduce obesity. If the reduction in vigorous physical activity, with a potential contribution to the decrease in daily physical activity, continues for many years, the cumulative effect can have a negative impact on health in adult life, especially in the etiology of chronic diseases.

The use of BMI to represent adiposity in children and adolescents have limitations, because the index does not differentiate body mass and lean mass. Students from the age group in this study, are in an accelerated growing process, with expressive gain of lean mass (bones and muscles).

However, obesity was evaluated from the cutoff point of 2SD of BMI, according to the reference curves from the World Health Organization[9]. This way, it is believed that the probability of false-positive in the identification of obese children and adolescents is lower once the classification of obesity considers adjustments according to the variables of sex and age. It is important to highlight that the WHO growth charts were corrected to represent the ideal growth for children.

There are certain limitations in this study. Firstly, it was a convenience sample, and it limits generalizations, but it was of longitudinal design, and the findings can be considered strong.

Also, both outcome and cause were not obtained by using direct measurements. Physical activity was measured through self-report, which just encompassed the type of activity, so, we shall take responsibility of inherent errors (biases)[7], but the studies tacked an important matter to be deepened in future studies.

A strong point in this study was the inclusion of sedentary behaviors as a variable for the control of the association between physical activity and obesity. We observed simultaneous increases in the amounts of VPA and SB among non-obese boys and non-obese children aged 7-9 years, which shows the complex relationship between these behaviors. This was also observed for participants with obesity, but to a lesser extent and with no evident difference between boys and girls.

Physical activity and sedentary behavior are distinct, but they can coexist, and this relationship can happen, healthily or not, in children and adolescents[23]. Some findings suggest that children with high levels of physical activity, independently of sedentary behavior, present less adiposity, while other findings observed that lower prevalence of obesity was related to the combination of high physical activity and low sedentary behavior[24]. But there are also studies that suggest the relationship between sedentary behavior and obesity, has less or non-evidence of causality[25].

New longitudinal studies shall be held to clarify the effect of obesity and physical activity in children and adolescents, with more time for follow up, larger samples, and with the follow-up of food intake and other determinant potentials of physical activity in early life.

It is necessary to highlight that our results were obtained in the context of a school that did not offer physical education classes during the entire period of

the study, although the current Brazilian educational legislation establishes its mandatory nature. Physical education classes have a protective effect against the accumulation of sedentary behaviors and encourage children and adolescents to maintain physical activity throughout the day and increase girls' engagement in physical and sports activities[25].

CONCLUSIONS

We concluded that obesity reduced vigorous physical activities in the sample during the one-year follow-up, with a substantial reduction among girls aged 10 years and over. Higher daily amounts of vigorous activities occurred simultaneously with higher amounts of sedentary behaviors among participants without obesity, especially among boys and 7-9-y-old children. Light and moderate physical activities, and daily amount of physical activity were not influenced by obesity.

Ensuring physical education classes is a priority intervention in contexts similar to the one studied, as a strategy with the potential to decrease the decline of VPA among girls and to prevent the decrease in daily physical activity, due to obesity.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee –UEFS and the protocol (CAAE no. 19499913.3.0000.0053) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: GMJ. Performed the experiments: GMJ, LAD. Analyzed the data: EK, GMJ. Contributed reagents/materials/analysis tools: LAD, AKCB, LDMSA. Wrote the paper: GMJ, MAA, LAD, LDMSA, EK.

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