https://doi.org/10.6063/motricidade.45582

Original Article

Energy balance and obesity in Brazilian schoolchildren: A study in public and private schools

Short title: Energy Balance and Obesity in Schoolchildren

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DECLARATIONS

Conflicts of Interest:

Nothing to declare.

Funding:

This study was funded by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) [APQ-03879 – 23, and APQ-03316 – 23], and Universidade do Estado de Minas Gerais (UEMG). Researchers of this proposal received research grants from UEMG. This work was supported by the Fundação para a Ciência e a Tecnologia (grant numbers: UID/04045/2025; UID/6157/2025 - doi: https://doi.org/10.54499/UID/06157/2025).

CRediT authorship contribution statement:

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Lucas Rios Drummond: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Data curation, Formal analysis, Resources, Funding acquisition.

EDITORIAL INFORMATION

Received: 18 January 2026.
Accepted: 28 March 2026

Edited by:
Filipe Rodrigues (https://orcid.org/0000-0003-1327-8872)
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Abstract

Obesity is a metabolic disorder characterised by a chronic inflammatory condition and an excessive accumulation of body fat. The last four decades have seen an increase in the prevalence of overweight and obesity in children worldwide, with an emphasis on an accelerated growth in countries such as Brazil. The study aimed to evaluate the prevalence of obesity and to quantify energy intake, energy expenditure, and energy balance in children attending public and private schools. The sample consisted of 132 children from 6 to 12 years old, enrolled in the public and private network of 4 schools in the municipality. The children's body mass index (BMI), the parents' BMI and their concern about their children's body mass were evaluated. For the assessment of energy expenditure and intake, a record of physical and food activities was filled out by the students' parents. Using the Compendium of Physical Activities, energy expenditure was measured and, using the Food Composition Table, energy intake was measured. The total prevalence of obesity among schoolchildren in Divinópolis was 28%. The results indicate a high prevalence of obesity in children from both schools. It was also found that children from private schools have a higher energy balance than children from public schools, which is related to the lower energy expenditure in children from private schools. This indicates that children from private schools are more likely to develop overweight and obesity if no intervention or lifestyle change is performed.

Keywords: Childhood obesity; Energy balance; Public and private schools.

Introduction

Childhood obesity is a multifactorial condition characterised by excessive accumulation of body fat and associated with metabolic, hormonal, and inflammatory alterations that can compromise health already during childhood (Ciężki et al., 2024; Marcus et al., 2022; Stratakis et al., 2025). Over the past four decades, the prevalence of overweight and obesity in children has increased markedly on a global scale, becoming one of the main public health concerns (Cesare et al., 2019; Gao et al., 2023; Zhang et al., 2024). In developing countries, such as Brazil, this increase has occurred at a particularly accelerated pace, reflecting changes in dietary patterns, levels of physical activity, and lifestyle among pediatric populations (Ferreira et al., 2021; Santos et al., 2023; Nilson et al., 2024). This scenario is especially concerning, as excess weight in childhood is associated with the persistence of obesity into adulthood and a higher risk of cardiovascular diseases, type 2 diabetes, and other chronic comorbidities (Chung et al., 2023; Daley & Balasundaram, 2025; Welsh et al., 2024).

From a pathophysiological perspective, the development of obesity results from a sustained positive energy balance, in which energy intake exceeds energy expenditure over time (Ghanemi et al., 2018; Oussaada et al., 2019). In children, this imbalance is strongly influenced by behavioral and environmental factors, such as high consumption of ultra-processed foods, reduced engagement in physical activity, and increased sedentary behavior, all of which have been consistently associated with excessive body weight gain during childhood (Arafa et al., 2024; De Saraiva Moura & De Carvalho, 2025; Mescoloto et al., 2023; Meneses-Echavez et al., 2025; Oliveira et al., 2024; Wang et al., 2024). This set of factors promotes the progressive accumulation of adipose tissue and contributes to the establishment of a chronic low-grade inflammatory state, with relevant metabolic and functional repercussions (Marcus et al., 2022; Stratakis et al., 2025).

Beyond individual behavioural aspects, family and social factors play an important role in determining the risk of childhood obesity (Campbell, 2016; Gal et al., 2025; Tavalire et al., 2020). Evidence indicates that characteristics such as parental body mass index (BMI), birth weight, and the home environment exert a significant influence on children's nutritional status, reflecting the interaction between genetic, environmental, and cultural components (Bernardo et al., 2010; Gal et al., 2025; Nielsen et al., 2022; Santos et al., 2022; Williams et

al., 2018). Additionally, parents' perceptions of and concerns about their children's body weight may influence the adoption of dietary habits and physical activity patterns, playing a relevant role in the prevention or progression of excess weight during childhood (Tomayko et al., 2021; Yılmaz et al., 2025).

Additionally, socioeconomic factors significantly influence the prevalence of childhood obesity, as they condition access to healthy foods, opportunities for physical activity, and the availability of health-related information factors that directly impact the energy balance of school-aged children (Cabañas-Alite et al., 2025; Gautam et al., 2025; Hwang, 2025; Sales et al., 2023). In this context, the school is configured as a structuring environment of children's daily lives, influencing dietary routines, levels of physical activity, and sedentary behaviours (Arias-Silva et al., 2024; Garden et al., 2020; Souza et al., 2021). Thus, the type of educational institution attended, public or private, has been used as a relevant contextual indicator, as it reflects differences in the food and physical activity environments to which children are exposed (Arias-Silva et al., 2024; Jabri et al., 2021; Souza et al., 2021; Henriques et al., 2021).

Despite the extensive literature on childhood obesity, many studies present important methodological limitations, including the reliance on self-reported dietary and physical activity data and the heterogeneity of assessment tools and diagnostic criteria, which may affect the comparability and robustness of findings. Acknowledging these limitations is essential to appropriately contextualise existing evidence and to justify the relevance of further research. In the Brazilian context, investigations that integrate the analysis of energy intake, energy expenditure, energy balance, and the prevalence of obesity among schoolchildren, while simultaneously considering family factors and the school context, remain limited. In this scenario, the present study aimed to evaluate energy intake, energy expenditure, energy balance, and the prevalence of obesity in children attending public and private schools, as well as to analyse possible associations with family characteristics, including parental body mass index (BMI), birth weight, and parental concern regarding children's body weight.

Materials and Methods

Type of study and ethical considerations

This was a cross-sectional study with a quantitative approach. Data were collected in public and private schools from October 2018 to September 2019. The project was evaluated and approved by the Ethics Committee of the Universidade do Estado de Minas Gerais (Approval Protocol - 2,857,269).

To participate in the study, a lottery was carried out to define four schools where the research would be carried out: two from the public education network and two from the private education network in the city of Divinópolis-MG. After defining the schools, they received authorisation from the Municipal Department of Education to execute data collection. In a subsequent visit, the volunteers received the Free and Informed Consent Form and the Consent Term for signature by the volunteers and guardians who agreed to participate in the research. Those students who returned the signed terms participated in the survey.

Sample

The sample consisted of children from 6 to 12 years of age, of both genders, enrolled in the first cycle of elementary education in public and private schools in the city of Divinópolis-MG. Of the students invited to participate in the research, a total of 84 students from the public school system and 48 students from the private school system were authorised and agreed to participate, thus totalling 132 children. Of these 132, 36 students (19 students from the public network and 17 students from the private network) participated in all stages of the research.

Experimental protocol

During the visits to the selected schools, the following anthropometric data were collected: body mass and height. Body mass was measured in kilograms, with a precision of 100 grams using a digital scale. All subjects were weighed barefoot, placed in the centre of the scale platform, with arms extended by their sides and eyes fixed in front of them. Height was measured in centimetres, with a precision of 1 millimetre, using a tape measure; all subjects had their height measured barefoot, with their head, buttocks and heels leaning

against the wall and looking straight ahead. The BMI was calculated following the formula: BMI = body mass/height². The use of BMI was chosen by the researchers because it facilitates data collection, as it requires a small number of instruments, in addition to being a less invasive method when working with children.

In addition, they were given a pre-structured questionnaire formulated by the researchers in order to collect information about the child's parents and about the child. This questionnaire covered questions such as: parents' body mass, parents' height, child's birth mass, child's birth conditions and concerns about the child's body mass; it was to be returned within 15 days, when the researcher returned and collected them.

For the assessment of energy expenditure, a physical activity record was given to the volunteers to be filled in for 3 days. Along with this record, a booklet was delivered with orientations for completing it. After the return of the completed records, using the Compendium of Physical Activities (Ainsworth et al., 1993; Farinatti et al., 2003), the energy expenditure of each child was measured.

To assess energy intake, a food recall was given to the volunteers to be filled in for 3 days. Along with this record, a booklet was delivered with instructions for completing it. After the return of the completed records, using the Food Composition Table, the energy intake of each child was measured. The energy balance was obtained from the difference between energy intake and energy expenditure.

The diagnosis of obesity was based on the children's body mass index and on the cutoff points proposed by Must et al. (1991) as follows: 1) low body mass = BMI < percentile 5 specific to sex and age, 2) regular body mass = BMI ≥ percentile 5 and < percentile 85 specific to sex and age, 3) overweight = BMI≥ percentile 85 specific to sex and age and 4) obesity =BMI ≥ percentile 95 specific to sex and age 28. The percentile distribution and median standard deviation curves published by the Centres for Disease Control 2000 were used as a reference for classifying the sample (Kuczmarski et al., 2002). Based on this diagnosis, the prevalence of obesity in the sample was determined.

The use of self-reported dietary and physical activity records may be subject to recall bias and reporting errors, particularly in pediatric populations. Therefore, the results related to energy intake, energy expenditure, and energy balance should be interpreted with caution.

Additionally, only a subset of the total sample completed all records, which may limit the generalizability of the energy balance analyses.

Statistical analysis

Data distribution was assessed for normality using the Shapiro–Wilk test. Prevalence data were compared using the chi-square test. Pearson's correlation analysis was used to assess associations between continuous variables. Comparisons between public and private schoolchildren for continuous variables (energy intake, energy expenditure, and energy balance) were performed using independent-samples t-tests when normality assumptions were met. In addition to p-values, effect sizes were calculated for group comparisons (Cohen's d) and for associations involving categorical variables (Cramér's V). Effect sizes were interpreted according to conventional thresholds (Cohen's d: 0.2 = small, 0.5 = moderate, 0.8 = large; Cramér's V: 0.1 = small, 0.3 = moderate, 0.5 = large). The significance level was set at 5%.

Results

Table 1 presents the characterisation of the sample, including the sample size of students from public and private schools, the subdivision between genders in both education systems, the total number of students who also participated in the assessment of the energy balance by filling the recalls, the average age, height and body mass of the sample, in addition to the average BMI presented among the students, besides the body mass at birth of the participating individuals.

Table 1. Sample characterization (mean ± standard deviation).

	Public (n = 84)	Private (n = 48)
Gender (boys/girls)	35/49	31/17
Record (boys/girls)	6/13	14/3
Age (years)	8.2 ± 0.1	8.1 ± 0.1
Height (m)	1.33 ± 0.01	1.33 ± 0.01
Body mass (kg)	32.4 ± 1.0	32.8 ± 1.4
BMI (kg/m²)	17.8 ± 0.3	18.2 ± 0.5
Body mass at birth (kg)	3.08 ± 0.05	3.08 ± 0.08

Figure 1 shows the prevalence of obesity among schoolchildren. The overall prevalence of obesity was 28%. In public schools, the prevalence was 29.75%, while in private schools it was 25%, with no significant difference observed between groups ($\chi^2(1) = 0.35$, $p = 0.55$; Cramér's $V = 0.05$). When analysed by sex, obesity prevalence in public schools was 22% among boys and 34% among girls, whereas in private schools it was 25% among boys and 23% among girls.

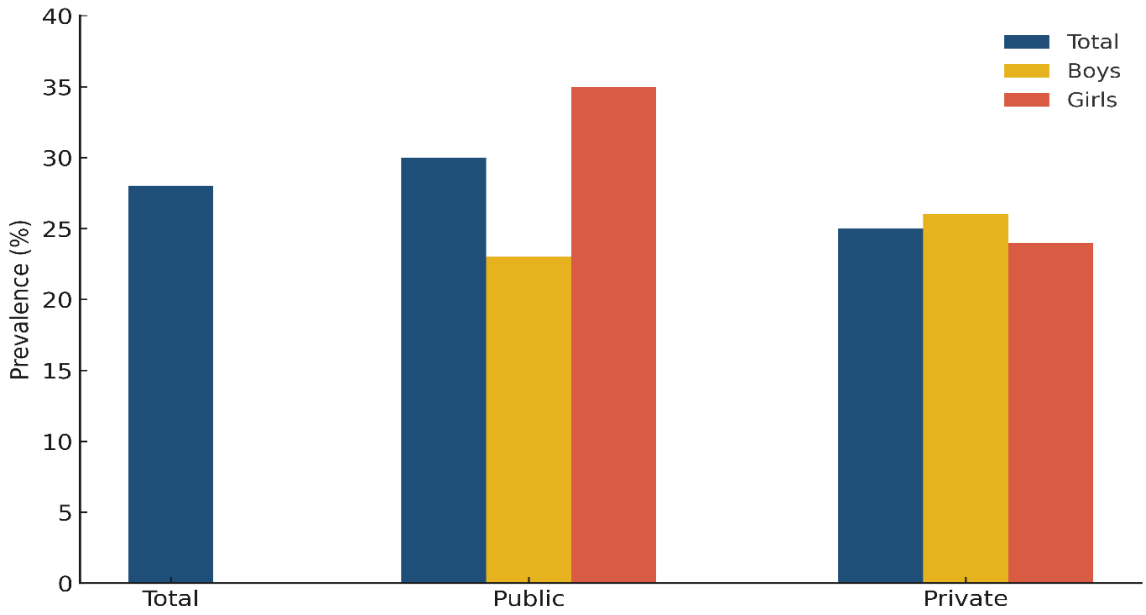

Figure 1. Prevalence of obesity among children from public and private schools.

Figure 2 shows the analysis of the association between children's BMI and mothers' BMI (A) and fathers' BMI (B). The children's BMI presents a weak correlation with the mothers' BMI ($r = 0.434$; $p < 0.05$), while children's BMI is not correlated with parents' BMI ($r = 0.249$; $p > 0.05$).

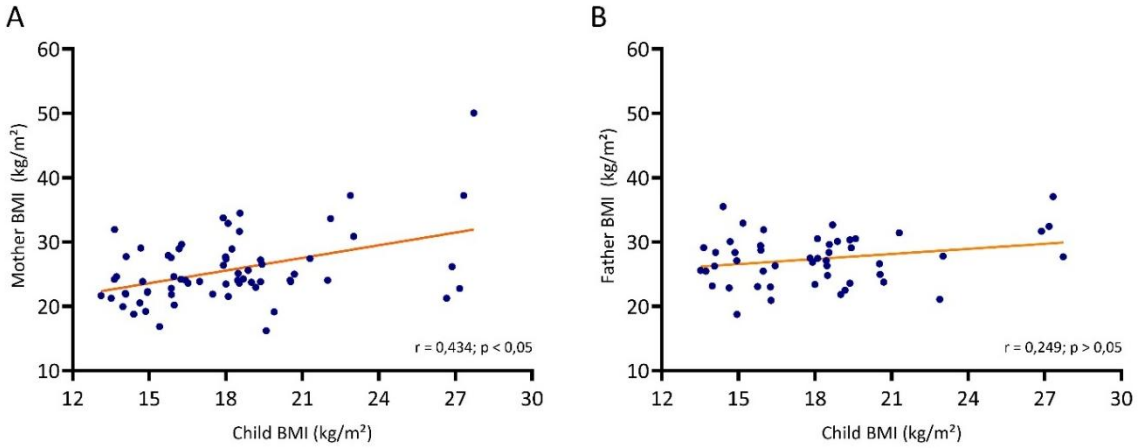

Figure 2. Correlation between children's BMI and parents' body mass index. (A) Correlation between child and mother body mass index. (B) Correlation between child and father body mass index.

Figure 3 presents the results of energy intake and also presents the results of energy expenditure in schoolchildren from Divinópolis. Energy intake was similar between students from public and private schools (public: 1239 ± 67 kcal vs private: 1387 ± 99 kcal; $p > 0.05$; Cohen's $d = 0.23$). In contrast, energy expenditure was significantly higher in public school students compared with those from private schools (public: 1258 ± 109 kcal vs private: 765 ± 92 kcal; $p < 0.05$; Cohen's $d = 0.56$).

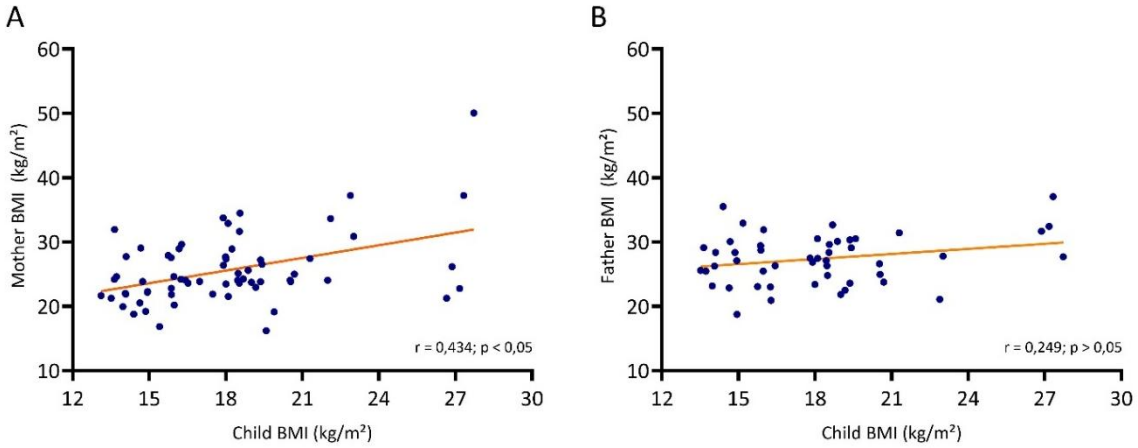

Figure 3. Energy expenditure and energy intake in children from public and private schools. (A) Average energy intake by school type. (B) Average energy expenditure by school type. Bars represent mean ± standard deviation.

Figure 4 presents the results of energy balance in schoolchildren from Divinópolis. Energy balance was significantly higher in private school students compared with those from public schools (public: 34 ± 104 kcal vs private: 621 ± 141 kcal; $p < 0.05$; Cohen's $d = 0.61$).

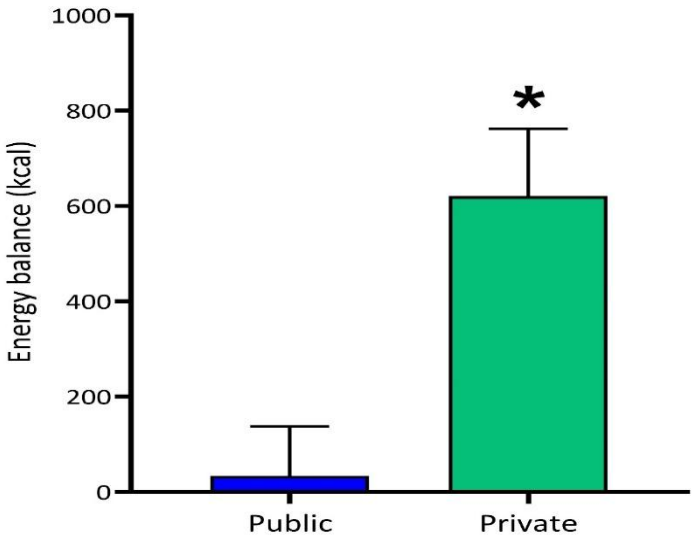

Figure 4. Energy balance in children from public and private schools. Bars represent mean ± standard deviation.

It is important to emphasise that despite the high prevalence of obesity in school children (~30%), most mothers are not worried about their child's body mass. This can be seen by analysing the answers to the following question: "Are you concerned or have you ever been concerned about your child's weight? ( ) Yes ( )No?". When analysing the answers, it was observed that in public schools, 50% of the mothers are concerned about their children's weight, while in private schools, 41.9% of the mothers say they are concerned about their children's weight.

Discussion

The study aimed to evaluate the prevalence of obesity and to quantify energy intake, energy expenditure, and energy balance in children attending public and private schools. Also, factors that may be associated with obesity in these children, such as their body mass index (BMI) percentile and parents' body mass, as well as physical activity and food recalls,

were used to calculate energy expenditure and consumption. Based on the results, it can be observed that the prevalence of obesity among schoolchildren in Divinópolis was 28%. More specifically, the prevalence in public schools was 29.75%, and in private schools it was 25%. It was also observed that energy expenditure is significantly higher in children from public schools, energy intake is similar between the two groups, and energy balance is significantly higher in children from private schools.

This high prevalence contrasts with the concern of parents about their child's body mass; while in public schools 50% of mothers say they are not concerned about their child's weight, in private schools 58.1% say they are not concerned. Taking into account that most mothers in the private network (48%) compared to the public network (38%) authorised their children to participate in the research, it makes sense not to worry, because they believe that their children are being guided when they participate in certain research projects, thus agreeing with statements of Vieira and Sichieri (2008) that the socioeconomic character has influenced the high rates of obesity, according to occupation, education and income.

Another important risk factor for the appearance of obesity in children is the presence of obesity in their parents, due to the sum of genetic and environmental influences (Oliveira, 2000). In our study, children's BMI is weakly associated with mothers' BMI and not associated with fathers' BMI. Therefore, other factors may be associated with obesity in these children.

The percentage of children with obesity highlighted in the results (28%) is a high value compared to the figures from the Ministry of Health, which indicate in recent surveys that 12.9% of Brazilian children between 5 and 9 years of age are obese, demonstrating the need to implement strategies that draw attention to childhood overweight and obesity as a serious public health problem (Ministério da Saúde, 2019). The global obesity rate has skyrocketed over the past 41 years, with expectations of a steady increase over the years; therefore, there is a need for urgency in methods that fight obesity (Abarca-Gómez et al., 2017).

In view of the results presented, it is possible to observe that parents of students from private schools showed a greater interest in the participation of their children in the research project, since 48% allowed the participation of their children, while in public schools 38% allowed the participation of their children. participation. Obesity levels in the schools

surveyed were high, a worrying finding given the worsening levels of obesity already reported. An increase in information and lectures in schools about obesity in general can reduce numbers in the medium and long term.

Positive energy balance is responsible for gradual body mass gain, both in children and adults, consequently predisposing individuals to orthopaedic disorders, respiratory disorders, diabetes, arterial hypertension, dyslipidemia, in addition to psychosocial disorders (Enes & Slater, 2010; Ribeiro Junior and Costa Ribeiro Junior, 2007). In the long term, increased mortality from all causes and from coronary heart disease has been reported in those individuals who were obese in childhood and adolescence (Must, 1996; Styne, 2001). Considering that the number of overweight children has tripled and that there are currently more overweight children than malnourished children (Instituto Brasileiro de Geografia e Estatística, 2010; World Health Organisation, 2009), intervention and prevention during the school phase is of great importance.

The effects of obesity for children will not only have consequences during childhood, but throughout their lives. The development of obesity in the early stages of life is associated with the maintenance of the pathophysiological state during adulthood (Paes et al., 2015). Obesity is a pro-inflammatory state that increases the risk of several chronic degenerative diseases. With the increasing prevalence of pediatric obesity, clinicians have begun to identify many of the same chronic degenerative diseases and risk factors that are seen in adults in pediatric age groups (Güngör, 2014). Childhood obesity can harm almost all organs and systems and often has serious consequences, including high blood pressure, dyslipidemia, insulin resistance, type 2 diabetes mellitus, fatty liver disease and psychosocial complications (Güngör, 2014).

Given the educational and social context in which eating habits and daily physical activities are part of a healthier life, preventing chronic diseases such as obesity and diabetes, for example. It is noted that the consumption of industrialised and ultra-processed foods has grown rapidly in our country and in the world (Unicamp, 2006). Ready-to-eat, practical foods that can be consumed immediately and kept for many months have gained space in the kitchens of Brazilian families (Unicamp, 2006). The increased availability of ultra-processed and ready-to-eat foods in household routines, together with the progressive decline in children's physical activity levels, has been widely described in the literature. In the present

study, the differences observed between school types may be influenced by contextual and socioeconomic factors that were not directly assessed, such as variations in daily routines, opportunities for physical activity, and access to convenience foods. Therefore, interpretations regarding the role of academic demands or purchasing power of families should be made with caution and warrant further investigation (Viuniski, 2003).

Endogenous factors (genetic, neuropsychological, endocrine, metabolic) represent 5% of cases of overweight and obesity. Exogenous factors (behavioural, dietary and/or environmental origin) represent about 95% of cases9. It is important to emphasise that the socioeconomic issue also interferes with the acquisition of electronic devices that consequently stimulate the child's intellectual learning, but not motor development and consequently causes a positive energy balance compared to children who do not use these electronics but active games such as running, jumping, swimming with other children, for example (Viuniski, 2003). Our results reinforce the importance of both physical activity in the daily routine of these children and healthy eating habits for the contribution and maintenance of health in adult life.

We can associate students with a higher socioeconomic level, students from the private school system, with an overloaded routine of studies and preparation for the next years, which indirectly can reflect on the daily practices of physical activities when the same importance of this requirement is not given in life in general. In addition to the physiological problems caused by excess or lack of body mass, psychological problems, syndromes, prejudice, discrimination, among others, are also consequences to be faced by those individuals who present this discrepancy in energy balance. The routine of these children can often be focused on moments of indoor leisure, where tablets, cell phones, computers and electronic games take the place of games that require body movement at all times, justifying the significantly more positive energy balance found in school children from private education networks.

The practice of physical activities for children presents itself as a very important ally in the fight against obesity, which shows that teachers must offer, together with the school, the best possible conditions for the student's learning and development, especially in physical education classes, in that energy expenditure is promoted, in addition to diversified

recreational activities that make up the cultural heritage and enrich the knowledge of the social and physical construction of each student.

This study has some limitations that should be acknowledged. Difficulties in recruiting schools, including the need for in-person presentations and occasional logistical constraints within the school environment, limited the number of participating institutions. In addition, incomplete information provided by parents affected the completion of dietary and physical activity records, resulting in a reduced sample size for the analyses of energy intake, expenditure, and balance, which may have limited the statistical power and generalizability of these findings.

Furthermore, due to the cross-sectional design of the study, causal relationships between school type, energy balance, and obesity cannot be established. The use of self-reported measures for dietary intake and physical activity may also be subject to recall and reporting bias. Future studies should consider using interview-based dietary recalls with parents or caregivers, including a larger number of schools, and focusing on more homogeneous age groups to enhance data quality and comparability.

Conclusions

The results of this study indicate a high prevalence of obesity among children from both public and private schools. Furthermore, they showed that children's BMI may be associated with their mothers' BMI. The identification of a positive energy balance in schoolchildren, especially among those attending private schools, highlights the need for school-based interventions aimed at raising awareness and informing teachers, students, and families about the direct importance of healthy eating habits within an active physical routine that contributes directly to health and quality of life.

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