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Obesogenic behavior clusters associated with weight status among Brazilian students: a latent class analysis

Agrupamentos de comportamentos obesogênicos associados com *status* de peso em estudantes brasileiros: uma análise de classe latente

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Abstract *This study aimed to examine the association between clusters of physical activity (PA), diet, and television viewing (TV) with weight status among a representative sample of Brazilian students. Data from the National Health School-based Survey (PeNSE) 2015 were analyzed (n = 16,521; mean age 14.8, standard deviation 0.03 year). PA (minutes/week spent in leisure-time, and commuting to/from school), TV (hours/day), and weekly consumption of deep-fried empanadas, candies, sodas, ultra-processed foods, fast foods, green salads or vegetables, and fruits were self-reported on the validated PeNSE questionnaire. Latent class analysis defined behavior classes, and binary logistic regression assessed the association between clustering and weight status. Six classes' types with positive and negative behaviors were identified. Adolescents belonging to the "low TV time and high healthy diet" class had higher chances of being overweight (including obesity) compared to their peers in the "moderate PA and mixed diet" class. No associations were found in the other clusters. Mixed classes with healthy and unhealthy behaviors characterized adolescents' lifestyles and these profiles were related to weight status.*

Key words *Adolescent health, Cluster analysis, Diet, Exercise, Sedentary behavior*

Resumo *O estudo objetivou examinar a associação entre agrupamentos de atividade física (AF), dieta e tempo de televisão (TV) com o status do peso em uma amostra representativa de estudantes brasileiros. Foram analisados dados da Pesquisa Nacional de Saúde do Escolar (PeNSE) 2015 (n = 16.521; idade média 14,8, desvio padrão de 0,03 ano). AF (minutos/semana no lazer e deslocamento para/da escola), assistir televisão (TV) (horas/dia), consumo semanal de doces, refrigerantes, alimentos ultraprocessados/fast-foods, saladas/vegetais e frutas foram coletadas por questionário validado. Análise de classes latentes definiu os perfis de comportamento e a regressão logística binária a associação entre agrupamento e status de peso. Foram identificadas seis classes com comportamentos positivos e negativos. Adolescentes pertencentes à classe "baixo tempo de TV e alta alimentação saudável" apresentaram maior probabilidade de ter sobrepeso/obesidade em comparação com seus pares na classe "AF moderada e dieta mista". Não foram encontradas associações nos outros perfis. Classes com comportamentos saudáveis e não saudáveis caracterizaram o estilo de vida dos adolescentes e estiveram relacionadas com o status de peso.*

Palavras-chave *Saúde do adolescente, Análise de agrupamentos, Dieta, Exercício, Comportamento sedentário*

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Introduction

In the past three decades, based on data from 195 countries, the prevalence of childhood obesity increased globally[1]. In Brazil, three million school children are overweight or obesity[2]. An increase in body mass index (BMI) can potentiate mortality rates and the development of chronic non-communicable diseases (e.g., hypertension, dyslipidemia, obstructive sleep apnea, and depression)[3]. Moreover, the obesity etiology is multifactorial, being essential to investigate factors that can contribute to BMI modification[4]. It was also observed that adolescents with overweight and obesity tend to maintain this weight status in adulthood[5,6].

Physical activity (PA), diet, and sedentary behavior (SB) are determinants of BMI[3]. Recently, these behaviors have been studied in co-occurrence form[7,8]. The coexistence of these, results in different profiles related to cumulative harmful effects on health among adolescents, including adiposity, cardiometabolic biomarkers, psychological distress, and self-esteem[9,10]. A scoping review found that adolescents were allocated in clusters characterized by high time spent in PA and high time in SB co-occurred with an intake of harmful food items (e.g., soft beverages and junk food)[7]. Brazilian studies identified adolescents into two (56.2% "high time in SB, low levels of PA, and low quality of diet"; and 43.8% "high SB, high PA, and healthier diet")[8] mainly in low- and middle-income countries, remains unclear. This study aimed to examine the association between profiles of physical activity (PA, and four clusters (the "active," the "all-day sitters," the "inactive 1" with moderate consumption of fruit and vegetables, and the "inactive 2" with low consumption of fruit, vegetables, snacks, salt and beverages)[11].

Regarding the association between clusters` types and weight status, there are inconsistent findings. Several studies did not find any association[8,12] some found a positive association[13-16] whereas others found an inverse association[13,14], where adolescents in unhealthy cluster behaviors had the lowest BMI when compared with adolescents in the healthiest cluster. Adolescent clusters associated with correlates are not well understood in countries with upper-middle-income such as Brazil[7] and clarifying this question can contribute to the development of strategies to decrease SB, increase PA, and improve the quality of diet and at the same time, improving healthy behaviors (e.g. adequate weight status) among adolescents[7]. Therefore, this study aimed to: (1) identify how obesogenic behaviors cluster together among a representative sample of Brazilian students; and (2) verify the association of these clusters with weight status.

Materials and methods

Study population, sampling, and data collection

Data from National Health School-based Survey (PeNSE) conducted in 2015 were used. Research aims, methods, samples, and ethics procedures have been described in detail previously[17]. PeNSE was conducted in private and public schools and is part of the Brazilian Surveillance of Risk and Protective Factors for Chronic Diseases. This study was approved by the National Committee of Ethics in Research (protocol number 1.006.467/2015).

Students' data enrolled from the sixth grade of elementary school to the third grade of high school were analyzed in this study. Each Brazilian geographic microregion were one stratum (five macro-regions) and schools and classrooms were selected after. The sample size was calculated to provide estimates for each geographical stratum. Further details regarding the sampling design and weighting can be found elsewhere[17]. All students who completed the free informed consent form answered the questionnaire on a smartphone during regular school hours and underwent anthropometric measurements. All procedures were performed by previously trained technicians of Brazilian Institute of Geography and Statistics. A pilot test was conducted to ensure the adequacy of the questionnaire and the anthropometric measures.

Variables

Body mass index

Height and weight were measured barefoot and with light clothing. A portable stadiometer measured height to the nearest 0.1 cm with the participant standing upright with feet together, head in the Frankfort plane, and arms hanging freely. Weight was measured using an electronic scale to the nearest 0.1 kg. BMI was calculated as weight (kg)/height (m^2). Age-and sex-specific BMI z-scores were calculated according to the guidelines of the World Health Organization[18]. Weight status was categorized as overweight (including obesity) and non-overweight (including

thinness and normal weight). The prevalence of overweight and obesity in this sample was 18.3% and 9.5%, respectively.

Physical activities

Three PA domains (leisure time, school, and commuting) were assessed using previously validated[19] questions. Adolescents answered the following questions: (1) In the last seven days, excluding the physical education (PE) classes at school, how many days did you engage in any PA, including sports, dance, gymnastics, weight training, wrestling, or other activities (response range 0-7)?; (2) Other than PE classes, how much time per day did you do those activities (such as sports, dancing, gymnastics, resistance training, wrestling, or other activities) (response range from less than 10 minutes to 1 hour or more)? Leisure time PA was obtained by multiplying the weekly frequency with the daily duration and was categorized as "does not practice" (does not practice, 1-299 min/week, and ≥ 300 min/week).

PA volume in PE was assessed using two questions: (1) In the last seven days, how many days did you have PE classes at school (response range from 0-5)?; (2) In the last seven days, how much time per day did you engage in PA or sports during PE classes at school (response range from less than 10 minutes to 1 hour or more)? The volume of PE classes was obtained by multiplying the weekly frequency by the daily duration of these PA, and was categorized as "does not practice," "1-50 min/week" (one PE class per week), "51-100 min/week" (two PE classes per week), and "≥ 101 min/week" (three or more PE classes per week)[20].

Four questions were used to measure commuting to and from school: (1) In the last seven days, how many days did you walk or cycle to/from school? (2) When you walk or cycle to/from school, how much time do you spend? Responses to frequency questions ranged from none to 7 days, and duration questions ranged from less than 10 minutes to 1 hour or more per day. The volume of active commutes to and from school (calculated separately) was obtained by multiplying the frequency (to/from) to school. Thus, total commuting PA volume was categorized as "does not perform active commuting," "1-149 min/week," and "≥ 150 min/week"[21].

Television viewing

Television (TV) viewing time was obtained by a previously validated question[19] on an average weekday, how many hours a day do you watch TV (not counting Saturday, Sunday, and public holidays) (response range from one hour to more than 8 hours)? TV viewing time was categorized into < 2 hours/day, 2-4 hours/day, and > 4 hours/day[22].

Dietary patterns

Diet was assessed using the question "How often do you eat?" for the seven food groups: greens or vegetables, fruits, deep-fried *empanadas*, candies, sodas, fast food, and ultra-processed food. Possible answers ranged from one to seven days a week. Principal component analysis was used to identify dietary patterns. The weekly average number of days of intake for each of the seven identified food groups was used. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin test of sampling adequacy were used, and values of $p < 0.05$ and $p > 0.60$ were acceptable respectively[23]. No rotation was required once the components were independently identified. The number of components was determined using the Kaiser criterion and a screen plot (eigenvalues > 1)[23]. Two components were extracted based on factor loadings > 0.30 to characterize the dietary pattern[23]. The factor loading is shown in the supplementary material Table S1 (available at: https://doi.org/10.48331/scielodata.UW9L3K). The two food groups were: (1) deep-fried empanadas, candies, soda, ultra-processed food, and fast food ("unhealthy diet"); and (2) green salads or vegetables and fruits ("healthy diet"). To better interpret the data, after identifying the components, we categorized unhealthy diet into < 1, 1-2, and > 2 days/week, and healthy diet into < 2, 2-4, and > 4 days/week. Categories were created considering the Dietary Guidelines for the Brazilian Population, which recommend lower consumption of unhealthy food and high consumption of less processed food.

Sociodemographic variables

Variables considered for analysis were sex (male and female), age (continuous), and maternal education level. Maternal education level was categorized as Low (did not studied, incomplete elementary school, and complete elementary school), Medium (incomplete high school and complete high school), High (incomplete higher education and complete higher education), and Unknown (do not know).

Statistical analysis

Latent class analysis (LCA) was procedure to identify the number of behaviors profiles considering the six behaviors: leisure PA; school PA; commuting PA; television viewing; unhealthy diet; and healthy diet. The treat of each variable is available aforementioned. The number of classes was based on the best combination of maximum low log-likelihood, Akaike information criteria (AIC), Bayesian information criteria (BIC), adjusted BIC (aBIC), and consistent AIC (CAIC). LCA was performed using the 'poLCA' package version 1.4.1 of R statistical language 4.0.1.

Participants' characteristics were described using means and standard deviations for quantitative variables, and relative and absolute frequencies for qualitative variables. Binary logistic regression models adjusted for sex, age, and maternal education were used to verify the association between classes and weight status categories (non-overweight *vs*. overweight [including obesity]). Values were expressed as odds ratio and 95% confidence intervals. Methods for complex analyses were used to incorporate strata, conglomerates, and sample weights. A significance level of 0.05 was assumed.

Results

Of the total sample of 16,521 participants, 50.8% were boys with a mean age of 14.8 ± 0.03 years old. About a third of the sample had mothers with low education levels and were overweight or obese (Table 1).

The model fit for two to six latent classes is presented in supplementary material S2 (available at: https://doi.org/10.48331/scielodata.UW9L3K). The six-class model was selected as the best-fitting model because it was conceptually more meaningful than the others, and had the lowest BIC, aBIC, and CAIC values. The classes characteristics and item-response probabilities are shown in supplementary material S3 and Figure 1.

Class 1 – low PA, and mixed diet (17.9%) was characterized by high probabilities to practice leisure and school PA 0 min/week, consumption of unhealthy diet 1-2 days/week, and consumption of healthy diet 2-4 days/week. Class 2 – low PA, low TV time, and unhealthy diet (5.1%) was characterized by a high probability to did not practice leisure PA, watched TV < 2 hours/day, and consumption of unhealthy foods < 1 day/week. Class 3 – moderate PA, high TV time, and mixed diet (11.5%) was characterized by high probabilities to practice leisure PA 1-299 min/week, spending > 4 hours/day watching TV, consumption of unhealthy diet > 2 days/week, and

Table 1. Sample characteristics of the Brazilian students. PeNSE, 2015.

Variables	Total (n = 16,521)
Sex	n (%)
Girls	8,258 (49.2)
Boys	8,263 (50.8)
Age, mean (SD)	14.8 (0.03)
Maternal education level	
Low	4,475 (32.7)
Medium	3,851 (24.1)
High	4,028 (17.9)
Unknown	4,168 (25.3)
Weight status (BMI)	
Non-overweight	11,495 (72.3)
Overweight (including obesity)	5,096 (27.7)
Leisure time PA (min/week)	
Do not practice	5,507 (36.9)
1 to 299	8,291 (47.8)
≥ 300	2,665 (15.3)
Commuting PA to and from school (min/week)	
Do not practice	6,507 (35.0)
1 to 149	7,538 (48.3)
≥ 150	2,478 (16.7)
Physical education classes (min/week)	
Do not practice	5,145 (37.2)
1 to 50	4,978 (29.0)
51 to 100	3,857 (20.9)
≥ 101	2,492 (12.9)
TV viewing time (hours/day)	
< 2	6,106 (37.4)
2 to 4	4,112 (24.0)
> 4	6,254 (38.6)
Healthy diet (days/week)	
< 2	2,594 (15.3)
2 to 4	8,937 (55.8)
> 4	4,949 (28.9)
Unhealthy diet (days/week)	
< 1	2,276 (13.4)
1 to 2	8,137 (49.1)
> 2	6,030 (37.5)

Note: BMI – body mass index; SD – standard deviation; TV – Television; PA – physical activity.

Source: Authors.

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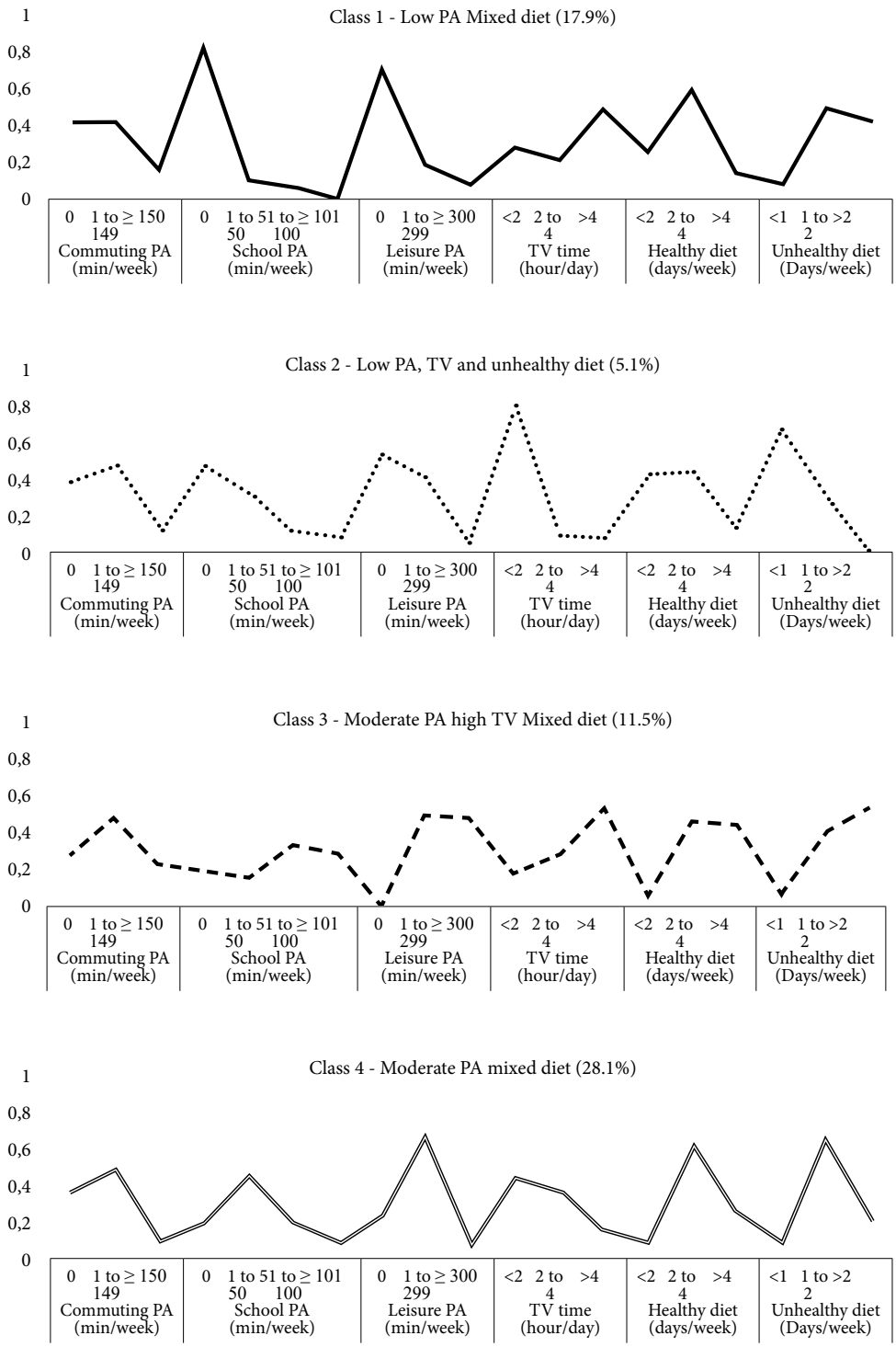

Figure 1. Prevalence and item-response probabilities of each obesogenic behavior for each class in Brazilian adolescents. PeNSE 2015.

PA: physical activity; TV: television; healthy diet: fruits and vegetable consumption; unhealthy diet: deep-fried empanadas, candies, soda, fast foods, and ultra-processed food consumption; days/week: days per week; min/week: minutes per week; hour/day: hours per day.

Source: Authors.

consumption of unhealthy diet 2-4 days/week. Class 4 – moderate PA and mixed diet (28.1%) was characterized by high probabilities to practice leisure PA 1–299 min/week, commuting PA 1-149 min/week, consumption of unhealthy diet 1–2 days/week, and consumption of healthy diet 2-4 days/week. Class 5 – moderate PA, high TV time, and unhealthy diet (25.7%) was characterized by high probabilities to practice leisure PA 1-299 min/week, to watch TV > 4 hours/day, consumption of unhealthy foods > 2 days/week and consumption of healthy foods 2-4 days/week of healthy foods. Finally, Class 6 – low TV time and high healthy diet (11.7%) was characterized by low probabilities to practice commuting, school and leisure PA, high probabilities to watch TV < 2 hours/day and consumption of healthy foods > 4 days/week. In addition, prevalence of non-overweight and overweight (including obese) adolescents according to classes are in supplementary material S4 (available at: https://doi.org/10.48331/scielodata.UW9L3K).

The association between classes and overweight (including obesity) is presented in Table 2. Adolescents allocated to in Class 6 – low TV time, and high healthy diet had 29% higher chances of being overweight (including obesity) than their peers in Class 4 – moderate PA and mixed diet. No other latent classes were associated with being overweight (including obesity) when compared to their peers in Class 4 – moderate PA and mixed diet (Table 3).

The marginal probabilities of being overweight (including obesity) adjusted by binary logistic regression for each latent class are presented in Figure 2. Students in Class 1 –low PA, and mixed diet had a 28.7% (95%CI: 26.5; 31.0) probability of being overweight (including obesity), while adolescents in Class 2 – low PA, TV time, and unhealthy diet had 29.5% (95%CI: 24.9; 34.1) probability of being overweight (including obesity). Members of Class 3 – moderate PA, high TV time, and mixed diet had a 27.7% (95%CI: 25.0; 30.4) probability of being overweight (including obesity) in this sample of Brazilian students. Adolescents in Class 4 – moderate PA and mixed diet and Class 5 – moderate PA, high TV time, and unhealthy diet had a 26.5% (95%CI: 24.8; 28.3) and 26.2% (95%CI: 24.5; 28.0) probability of being overweight (including obesity), respectively. Finally, students in Class 6 (low TV time and high healthy diet) had the highest (31.7%; 95%CI: 28.8; 34.7) probability of being overweight (including obesity).

Discussion

This study examined patterns of PA, diet, and TV viewing time and their associations with weight status in a national school-based sample of Brazilian adolescents. Six mixed classes with positive and negative behaviors were identified, and adolescents belonging to a lifestyle with the moderate practice of leisure PA, low time spent watching TV, and high consumption of healthy food (Class 6) had higher chances of being overweight (including obesity) compared to those with an active lifestyle in three domains of PA (commuting, school, and leisure), low time watching TV

Table 2. Prevalence of non-overweight and overweight (including obese) adolescents according to latent classes (PeNSE, 2015).

Classes	Weight status	
	Non-overweight (n = 11,495)	Overweight (including obesity) (n = 5,026)
	n (% [95%CI])	n (% [95%CI])
1 (n = 2,961)	2,130 (22.2 [21.2; 23.4])	831 (21.5 [19.8; 23.3])
2 (n = 838)	585 (5.5 [4.9; 6.1])	253 (5.7 [4.7; 6.8])
3 (n = 1,904)	1,318 (11.1 [10.3; 11.9])	586 (11.4 [10.3; 12.7])
4 (n = 4,634)	3,225 (27.4 [26.3; 28.5])	1,409 (26.1 [24.5; 27.9])
5 (n = 4,244)	2,979 (24.5 [23.4; 25.6])	1,265 (23.3 [21.7; 24.9])
6 (n = 1,940)	1,258 (9.3 [8.7; 10.1])	682 (12.0 [10.8; 13.3])

Note: n – absolute frequency; % relative frequency; 95%CI – 95% confidence interval. Class 1 – Low PA, mixed diet; Class 2 – Low PA, TV, and unhealthy diet; Class 3 – Moderate PA, high TV mixed diet; Class 4 – Moderate PA, mixed diet; Class 5 – Moderate PA, high TV and unhealthy diet; Class 6 – Low TV, high healthy diet.

Source: Authors.

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Table 3. Association between latent classes with overweight (including obesity) among Brazilian students (n = 16,521). PeNSE, 2015.

Variables	Weight status			
Classes	Crude		Adjusted	
	OR (95%CI)	P-value	OR (95%CI)	P-value
1	1.01 (0.88; 1.17)	0.862	1.12 (0.97; 1.29)	0.136
2	1.09 (0.87; 1.38)	0.456	1.16 (0.91; 1.48)	0.225
3	1.08 (0.92; 1.27)	0.336	1.06 (0.90; 1.25)	0.461
4	Ref.		Ref.	
5	1.00 (0.88; 1.13)	0.964	0.98 (0.87; 1.12)	0.807
6	1.35 (1.15; 1.58)	< 0.001	1.29 (1.10; 1.52)	0.002

Note: OR – odds ratio; 95%CI – 95% confidence interval; Ref. – Reference category. Class 1 – Low PA mixed diet; Class 2 – Low PA, TV, and unhealthy diet; Class 3 – Moderate PA high TV mixed diet; Class 4 – Moderate PA mixed diet; Class 5 – Moderate PA high TV and unhealthy diet; Class 6 – Low TV high healthy diet. Model adjusted by sex, age, and maternal education level.

Source: Authors.

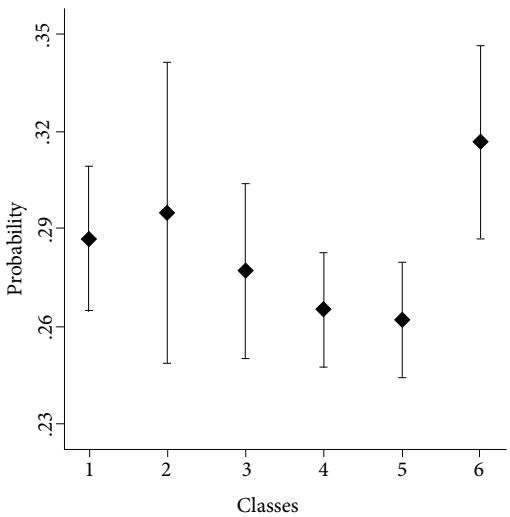

Figure 2. Probability of being overweight (including obesity) according to latent classes based on adjusted binary logistic regression on Brazilian students (n = 16.521), PeNSE 2015.

Note: Class 1 – low PA mixed diet; Class 2 – low PA, TV, and unhealthy diet; Class 3 – moderate PA high TV mixed diet; Class 4 – moderate PA mixed diet; Class 5 – moderate PA high TV and unhealthy diet; Class 6 – low TV high healthy diet. PA: physical activity; TV: television; healthy diet: fruits and vegetables consumption; unhealthy diet: deep-fried empanadas, candies, soda, fast foods and ultra-processed food consumption. Model adjusted by sex, age, and maternal education.

Source: Authors.

and high consumption of healthy and unhealthy foods (Class 4). These results support the need to create strategies focused on promoting simultaneously a healthy diet and an active lifestyle among Brazilian adolescents to stimulate adequate weight status.

We found that adolescents in all six classes were characterized by positive and negative behaviors co-occurring. These findings were consistent with a scoping review[7], evidencing the predominance of mixed cluster behaviors among youth, and also, highlighting the complexity of lifestyle in adolescents. In our study, adolescents presented classes with the co-occurrence of low time watching TV and low unhealthy food consumption (Class 2), and high time watching TV with high consumption of unhealthy food (Classes 3 and 5). It seems that screen users were likely to be exposed to a high number of advertisements that influenced their preferences and the types of food they consumed[24]. Other studies have demonstrated that eating during TV viewing promotes distractions that obstruct the feeling of fullness or satiety making individuals eat more; This reduces internal satiety due to the delay of normal mealtime satiety[25,26]. In addition, others studies have shown that youths who do not consume food while watching TV ate more fruits and vegetables, whereas those who ate during TV viewing had poor diet quality, including higher consumption of sweets, sugar-sweetened beverages, snacks, high-fat, and sugar foods[24,25].

Most classes were characterized in three domains by do not practice PA (Classes 1 and 2), and moderate practice (Classes 4 and 5). Brazilian studies have shown that adolescents mainly belong to clusters characterized by low adherence to PA[8,9,11], which is well-established worldwide[7]. A study conducted on Brazilian adolescents identified, as the most prevalent (56.16%), the class mainly characterized by low time spent practic-

ing PA and high time spent in SB per day[8]. Another study found that the most prevalent cluster "healthy promoting SB and diet" (32.6%) was characterized by one day practicing PA[9]. Moreover, Class 5 can also be characterized by high TV watching time, and Class 4 by the consumption of healthy food as much as unhealthy food. The presence of mixed classes in adolescents can be explained by a cognitive strategy that activates compensatory healthy beliefs, where a person believes that the negative effects of adopting unhealthy behaviors can be neutralized by engaging in other healthy behaviors later[27].

Adolescents in Class 6 (characterized as moderate practice of leisure time PA, low TV time, and high healthy diet) had higher chances of being overweight (including obesity) compared to adolescents in Class 4 (i.e., moderate practice in all PA domains with high consumption of healthy and unhealthy foods). Adolescents in this study did not represent classes that were predominantly healthy, and the presence of mixed (positive and negative) behaviors could explain this association. Within a 24-hour continuum, adolescents can participate in a variety of low-energy (i.e., sleep, sedentary behavior, and light PA) and high-energy (i.e., moderate-to-vigorous PA) expenditure behaviors[28-30] sedentary behaviour, physical activity, and time-use research has led to the recent development of time-use epidemiology. To conceptualise the emerging research field and provide a framework for its further development, this paper defines its position among the established branches of science, explains its main concepts and defines associated terms, recommends suitable data analysis methods, proposes a theoretical model for future research, and identifies key research questions. Time-use epidemiology is defined as the study of determinants, incidence, distributions, and effects of health-related time-use patterns in populations and of methods for preventing unhealthy time-use patterns and achieving the optimal distribution of time for population health. As a theoretical model for future studies, this paper proposes the Framework for Viable Integrative Research in Time-Use Epidemiology (VIRTUE framework. At any given time, an individual can only do one of these behaviors, for instance, changes in one (e.g. TV viewing) must be shifted to another movement behavior (PA or sleep)[22,28,31]. This emphasizes the co-occurrence of behaviors in positive and negative ways. Another point to consider is that jointly with movement behaviors, the diet is present. Moreover, consumption of a higher number of foods was not evaluated in this study, such as meat, grains (besides beans), and dairy products, for example. It is known that inadequate consumption of dietary fiber leads to inadequate satiety and may contribute to excessive weight gain; and diets low in calcium and dairy products have also been associated with obesity[32]. Thus, although the adolescents reported a high frequency of fruit and vegetables in Class 6, they may be consumed in smaller amounts compared to the other foods mentioned above. Another point is that, although adolescents with high consumption of healthy foods spent low time watching TV (Class 6), they could spend a high amount of time on other screen types (e.g., computers, playing videogames, and/or using smartphones/tablets) and in light PA. However, this hypothesis could not be tested.

Studies have demonstrated that adolescents in clusters considered healthier have the lowest weight status compared with adolescents in unhealthier clusters[13-16], although the opposite has been also found[13,14]. Overweight adolescents (including obesity) could restrict the consumption of unhealthy foods to control their weight, and could also under-report their dietary consumption and over-report the levels of PA[33]. In addition, it is possible that adolescents with overweight (including obesity) may have initiated a healthier lifestyle, but engaging in such behaviors has not had enough time to reflect changes in weight status. However, due to the cross-sectional design, we are not able to confirm this hypothesis. We highlight that the etiology of obesity is multifactorial and complex, stemming from genetic, biological, and environmental factors (psychosocial behaviors)[3], and this study addressed only three behaviors that potentially contribute to being overweight (including obesity).

This study has the following strengths. First, the sample was nationally representative and consisted adolescents from Brazil. Second, LCA was used to identify lifestyle behaviors that promote less arbitrary decisions in cluster formation. Nevertheless, this study has some limitations that should be considered while interpreting the results. Due to the cross-sectional design, causality could not be inferred. Therefore, caution is required in interpreting the results. Since the behaviors were captured using a questionnaire (previously tested and validated), this could involve response and memory bias. This study addressed only the weekly food consumption, volume of practicing PA, and TV viewing, while not covering portion sizes and energy food values,

intensity and types of PA, and other components of screen time. Considering these, more studies should be conducted with the goal of researching the coexistence of behaviors using self-reported and objective measures to cluster outcomes with prospective study designs in order to understand their interrelationships with obesity in this age group. In addition, such studies should explore the components of screen times, intensity, domains, and/or types of PA, the consumption of high number of food consumption, and the energy value of food consumption.

In sum, this study identified six classes with the presence of healthy and unhealthy behaviors characterized by the adolescents' lifestyles and, we observed that these mixed lifestyle classes were related to weight status. Thus, we reinforce the need to increase PA practice, the consumption of healthy foods, and reduce TV viewing, to improve adolescents' lifestyles, and help in adequate weight status.

Ethics approval

This research was approved in the Comissão Nacional de Ética em Pesquisa (CONEP) – reports no. 1.006.467/2015 –, and met the Resolution of the Conselho Nacional de Saúde (CNS) No. 466, dated December 12th 2012.

Collaborations

Writing: original draft, review and editing – GT Mello and RM Costa. Writing: review and editing – MAA Assis. Supervision: KS Siva. All authors have read and agreed to the published version of the manuscript.

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