

The association between multiple cardiovascular risk factors and overweight in Brazilian adolescents: an analysis based on the grade of membership

A associação entre múltiplos fatores de risco cardiovascular e o excesso de peso em adolescentes brasileiros: uma análise baseada no *grade of membership*

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Abstract *The aim of the current research is to analyze the coexistence of modifiable risk behaviors for cardiovascular disease (CVD) in 12- to 17-year-old adolescents living in Brazil and their influence on overweight. National, cross-sectional, school-based epidemiological study focused on estimating the prevalence of cardiovascular risk factors and metabolic syndrome in 12 to 17 year old adolescents enrolled in public and private schools in Brazilian counties accounting for more than 100 thousand inhabitants. The grade of membership method was used to identify the coexistence of risk factors among adolescents. The analytical sample comprised 71,552 adolescents. According to the two herein generated profiles, adolescents classified under Profile 2 have shown behaviors such as smoking, alcohol consumption and diet rich in Ultra-processed food intake \geq 80% of the percentage of total caloric value. In addition, adolescents presenting CVD risk profile have shown increased likelihood of being overweight. The study has found coexistence of risk factors for CVD in Brazilian adolescents, with emphasis on tobacco smoking and alcoholic beverage intake. In addition, it heads towards the analysis of the association between CVD risk factors and health outcomes, such as overweight.*

Key words *Adolescents, Cardiovascular disease, Alcohol, Smoking, Physical activity, Ultra-processed food*

Resumo *O objetivo desta pesquisa é analisar a coexistência de comportamentos de risco modificáveis para doenças cardiovasculares (DCV) em adolescentes de 12 a 17 anos residentes no Brasil e sua influência no excesso de peso. Estudo epidemiológico nacional, transversal, de base escolar, com foco em estimar a prevalência de fatores de risco cardiovascular e síndrome metabólica em adolescentes de 12 a 17 anos matriculados em escolas públicas e privadas de municípios brasileiros que somam mais de 100 mil habitantes. O grade of membership foi utilizado para identificar a coexistência de fatores de risco entre os adolescentes. A amostra analítica foi composta por 71.552 adolescentes. De acordo com os dois perfis gerados, os adolescentes classificados no Perfil 2 mostraram comportamentos como fumar, consumo de álcool e dieta rica em alimentos ultraprocessados \geq 80% da porcentagem do valor calórico total. Além disso, adolescentes com perfil de risco para DCV mostraram maior probabilidade de apresentar excesso de peso. O estudo encontrou coexistência de fatores de risco para DCV em adolescentes brasileiros, com destaque para tabagismo e consumo de bebidas alcoólicas. Além disso, demonstra associação entre fatores de risco para DCV e desfechos de saúde, como o excesso de peso.*

Palavras-chave *Adolescentes, Doença cardiovascular, Álcool, Tabagismo, Atividade física, Alimentos ultraprocessados*

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Introduction

Obesity and overweight rates in adolescents have been increasing worldwide^{1,2}; therefore these conditions became a severe public health issue³. Overweight prevalence in adolescents has significantly increased in recent years, mainly in developing countries^{1,4} such as Brazil⁴.

It is known that overweight during adolescence has important short- and long-term consequences, such as increased risk and early onset of Chronic Non-Transmissible Diseases^{5,6}, such as some types of cancer and cardiovascular diseases^{7,8} and premature death⁹. Added to this are problems in the psychological realm, due to its potential risk for social and emotional changes experienced by adolescents, causing diseases such as depression, anxiety, low self-esteem, in addition to emotional and behavioral disorders - due to the social stigma associated with overweight¹⁰.

The NCD Risk Factor Collaboration (NCD-RisC) study demonstrated that the age-standardized overall prevalence of obesity in children and adolescents increased from 0.7% in 1975 to 5.6% in 2016 in girls, and from 0.9% in 1975 to 7.8% in 2016 in boys¹¹. In the 42 years of analyses, the increase was eightfold in the global estimate, and was fastest in children aged 5 to 19 years².

In Brazil, a study from the Study of Cardiovascular Risks in Adolescents (ERICA) showed that the prevalence of overweight was 17.1% and obesity was 8.4%, with obesity being higher in males (9.2%) than in females (7.6%)¹². The prevalence of overweight and obesity in a study with data from the National School Health Survey (PeNSE) showed that 23.7% of adolescents were overweight and 7.8% were obese¹³.

Increased risk of early cardiovascular disease (CVD) development stands out¹⁴ among several issues associated with overweight during adolescence; overweight is a key factor for increased CVD-related morbidity and mortality rates¹⁵.

CVDs account for approximately 50% of deaths caused by noncommunicable diseases (NCDs); most CVD-associated deaths are observed in low- and middle-income countries¹⁶. According to estimates, 17.8 million people have died from CVD in 2017^{17,18}. Although the most severe manifestations, such as acute myocardial infarction and stroke, have higher prevalence in adult individuals, CVD risk factors have been often observed in children and adolescents¹⁹⁻²².

Epidemiological studies have shown that risk factors acquired in adolescence tend to persist in adulthood²³⁻²⁵. In addition, the incidence of

two, or more, risk factors during adolescence is enough to predict cardiovascular events within the next ten years, since the combination of factors increases the extent and severity of vascular lesions that prevail in adulthood²⁶.

Since the combination of two, or more, risk factors can be associated with increased risk of CVD development²⁷, studies focused on investigating simultaneous risk factors play key role in measuring the dimension of the current epidemiological issue, as well as provide better guidance for public health interventions. The idea that risk and protection factors for a given outcome coexist in groups (clusters) is highly beneficial²⁷, mainly at the time to develop public policies.

In addition, identifying risk behaviors for CVD and their influence on overweight may help substantiating more effective prevention strategies - based on multiple components - aimed at reducing risk factors for overweight among adolescents and, consequently, at avoiding the most severe CVD-associated outcomes. In light of the foregoing, the aim of the current study was to analyze the coexistence of modifiable risk behaviors for CVDs in 12 to 17 year old adolescents living in Brazil, as well as their association with overweight.

Ethics approval and consent to participate

The study was approved by the Research Ethics Committees of the institution coordinating the study (IESC / UFRJ) and of each Brazilian state. Adolescents who agreed to participate in the study have signed the written informed consents form; parents or legal guardians provided written informed consents form for all participants younger than 18. Participants' identification remained confidential.

Methods

Study population

The current research is part of the Study of Cardiovascular Risks in Adolescents (ERICA), which is a national, cross-sectional, school-based epidemiological study aimed at estimating the prevalence of CVD risk factors and metabolic syndrome in 12 to 17 year old adolescents enrolled in public and private schools in Brazilian counties that account for more than 100 thousand inhabitants²⁸.

The sample was stratified into 32 strata comprising 27 state capitals and five sets of counties

with more than 100 thousand inhabitants, in each of the five geographical regions in the country. Schools were selected in each geographic stratum based on probability proportional to school size and inversely proportional to the distance from the capital. Three classes per school were selected, based on different combinations of shift (morning and afternoon) and grade (seventh, eighth, and ninth grades of elementary school and first, second, and third years of high school). All students in the selected classes were invited to participate in the study²⁸.

The herein adopted sample was representative of mid- and large-sized counties (≥ 100 thousand inhabitants) at national, regional and metropolitan level. Adolescents who were not in the age group of 12 to 17 years, who had some disability level capable of impairing the anthropometric assessment and questionnaire completion were excluded from the study, as well as pregnant women²⁸. Data collection took place between February 2013 and November 2014. Further details on the sampling process can be found in Block et al.²⁹ and Vasconcellos et al.²⁸

Teenagers participating in ERICA have completed the self-administered questionnaire about different topics associated with health and lifestyle by using Personal Digital Assistants (PDA)^{28,29}. ERICA was approved by the Research Ethics Committees of the Institute of Studies in Collective Health of Federal University of Rio de Janeiro and of each participant state and Federal District unit. All participants have signed the informed consent form and a copy of it was properly filed by the research team in charge of the current study.

Dependent variable

Overweight incidence in adolescents was adopted as dependent variable. Participants' body mass index (BMI) was calculated based on their weight and height; reference curves set by the World Health Organization (WHO) for adolescents³⁰ were also adopted. The cutoff points adopted for overweight corresponded to Z-score $> +1$ ³⁰.

Anthropometric measurements of all participants were taken by trained researchers. Participants' weight was measured with the aid of Leader electronic scale (capacity = 200 kg and variation = 50 g). Portable Altarexata stadiometer (1-mm resolution and field of use of up to 213 cm) was used to measure adolescents' height¹².

Cardiovascular disease-risk variables

ERICA questionnaire covered specific questions distributed in 11 thematic blocks (socio-demographic features, work and employment, physical activity, eating habits, smoking, alcohol intake, reproductive health, oral health, referred morbidity, sleep duration and common mental health disorder). This study focused on the analysis of thematic blocks referring to alcohol intake, eating habits, smoking and physical activity.

Alcohol intake

This questionnaire block comprised information about the age at which participants drank at least one alcoholic drink for the first time, as well as about drinking days, number of drinks and drink types. The classification "alcohol intake" was defined based on these variables. The following classifications were used: 0 "never drank alcohol"; 1 "only once", which corresponded to "do not drink"; 2 "1 or 2 days", 3 "3 to 5 days", 4 "6 to 9 days", 5 "10 to 19 days", 6 "20 to 29 days", or 7 ">29 days", which corresponded to "every day"¹⁹.

Tobacco smoking

Current cigarette smokers comprised individuals who had smoked cigarettes for at least 1 day in the previous 30 days. Both variables have followed definitions adopted by WHO and by the Center for Disease Control and Prevention in the United States (CDC) in the Global Youth Tobacco Surveillance (GYTS)³¹. The following information was used as indicator of frequent tobacco smoking: having smoked cigarettes for at least seven consecutive days²⁰.

Ultra-processed food (UPF) intake

Food intake was assessed based on a 24-hour dietary recall (R24h) during face-to-face interview performed by trained interviewers. Participants were interviewed by using Brasil Nutri software (<http://nebin.com.br/novosite/contedo.php?id=4>), which was specifically designed for food intake data, which were directly recorded in netbooks.

The adopted interview technique lied on the multiple pass method³², which consists in a five-stage guided interview capable of reducing errors in food intake reports. The software used in this procedure has a list of 1,626 food items

deriving from the food and beverage database of the 2002-2003 Household Budget Survey (POF, acronym in Portuguese), which was carried out by the Brazilian Institute of Geography and Statistics (IBGE)³³, and developed by the Ministry of Health in partnership with the Institute of Social Medicine (Universidade do Estado do Rio de Janeiro). Database used in the National Dietary Survey (INA, acronym in Portuguese) was developed by the Brazilian Institute of Geography and Statistics in 2008-2009^{34,35}.

Food and beverage intake data were transformed into weight (in grams) and volume (mL) units; then, they were associated with the respective information on nutritional composition, based on the methodology proposed by IBGE to process food intake data extracted from the Family Budget Survey (2008/2009)^{34,35}.

Caloric and food intake data were analyzed and classified as fresh or minimally processed, processed and ultra-processed food, based on NOVA classification system³⁵, by taking into consideration the extent and purpose of food processing. Information about the contribution rate of the UPF intake group to total daily energy (% of total caloric value – TCV) was taken into consideration in the present study. UPF ingredients often include different substances and additives, such as sugar, oil, fat, salt, antioxidants, stabilizers and preservatives³⁶. Excessive UPF intake was classified as UPF intake higher than, or equal, to the 80th percentile of UPF intake distribution (45.60% of TCV). Large quintile of UPF intake distribution (P80) had been associated with poor food intake profile and with high risk of obesity in previous studies³⁷.

Physical activity

The total physical activity time was calculated by summing up the time of each activity, including the low-intensity ones, such as walking dogs and taking care of children, commuting and walking to school, home or work. Adolescents who did not accumulate at least 300 min/week of physical activity were classified as inactive at leisure^{21,38}.

Main effect

The *Grade of membership* (GoM)^{39,40} method was used to identify the coexistence of risk and protective factors among adolescents. This method allows fuzzy membership, i.e., individuals do not need to organize themselves in well-defined

sets, as in traditional crisp cluster methods, although they may partly belong to more than one group⁴⁰.

The aforementioned method estimates the pertinence degree score of each individual based on different, crisp, well-defined sets. It is applied to a dataset composed of i individuals ($i = 1, 2, \dots, I$), with j categorical variables ($j = 1, 2, \dots, J$). There are L_j response levels for each j -th variable. Discrete response variable X_{ijl} is predicted by two sets of estimated coefficients, namely: λ_{kjl} and g_{ik} . The λ_{kjl} coefficient corresponds to the likely incidence of the L_j -th response level in the k -th profile among i -th individuals who are pure types of these profiles; it can assume any value between 0 and 1. The model estimates the pertinence degree score (g_{ik}) of each individual; this score represents the degree to which element i belongs to the extreme profile k , and it ranges from 0 to 1. Model identification process imposes two restrictions: (1) the sum of λ_{kjl} over L for the same k equals 1, and (2) the sum of g_{ik} over k for the same i equals 1^{39,40}.

Although λ_{kjl} directly describes the extreme profiles in probabilistic terms, the λ_{kjl} /marginal frequency ratio (expected/observed ratio) is more often used, since it sets an objective criterion for profile featuring based on the prevalence of attributes. Marginal frequency can be understood as the likely incidence of a particular feature in the total population. Cutoff value of 1.2, which was recorded for the Expected/Observed ratio, means that the likely incidence of an l -th response to a j -th variable in a k -th profile among pure types of that profile must be at least 20% higher than the observed marginal likelihood^{39,40}. Risk factors coexisted in the current study when there were at least two risk factors for CVD in the generated profile⁴¹.

GoM parameters in the current study (g_{ik} and λ_{kjl}) were estimated in the GoMRcpp.R software for R⁴². Created profiles and the G_{ik} found for each teenager were separated based on the highest degree of belonging to the profile. They were categorized as belonging to profile 1 when G_{ik} was ≤ 0.5 and as belonging to profile 2, when G_{ik} was > 0.5 .

Statistical analysis

Population featuring was based on descriptive analysis. Collected data were analyzed in Stata software, version 16.0.

Multilevel logistic regression was used to estimate the odds ratio (OR) adjusted based on so-

ciodemographic and school variables in order to check the significance of the association between the coexistence profile of CVD risk factors and overweight.

The modeling process has followed the steps suggested by Laros and Marciano⁴³ and it was carried out in 3 different stages. The first stage is called the Null Model (M0).

Stage 2 consisted in analyzing the model based on variables at individual level such as participants' age, sex, race/color, whether, or not, they live with their parents, and maternal education. Subsequently, stage 3 took into consideration variables at school level such as managerial dependency - public or private; sale of snacks at school and macro-region where the school is located in. Variance reduction was calculated at the end of the modeling process, based on the introduction of variables at individual and school level in the models in order to check their fit⁴³. Akaike information criterion (AIC) was used to calculate model fit - the best model was the one recording the lowest value for this criterion⁴⁴.

The *gllamm* command - which enables performing statistical analysis by taking into consideration the multilevel structure of data, as well as including the necessary weighting at the time to analyze complex samples - was used to perform the multilevel model. Adolescents' school was the herein adopted cluster unit.

All analyses were performed at 5% significance level.

Results

In total, 71,552 adolescents were analyzed in the current study. Based on participants' BMI, 26.17% (95%CI 25.03%-27.34%) of them were classified as overweight. Among overweight adolescents, 53.96% were girls, and aged between 14 and 15 years (35.91%), 50.19% declared themselves to be brown and 6.40% lived alone. With respect to the place of study, 73.53% of overweight adolescents studied in public schools and 52.00% of them studied in more economically favored regions such as Southern, Southeastern and Midwestern Brazil (Table 1).

Table 2 shows the λ_{kjl} estimates (alcohol intake, tobacco smoking, UPF intake, and exercising) performed for each extreme profile of the investigated adolescents. Adolescents belonging to Profile 2 for Brazil (pure types, $g_{ik} = 1$) have shown behavioral features such as smoking, alcohol intake, and diet rich in UPF $\geq 45.60\%$ of

TCV. This profile can be categorized as CVD risk profile because it comprises three simultaneous risk factors (Table 1).

The null model is shown in Table 3. The M0 intercept variance (0.29; 95%CI 0.28-0.30) has shown overweight rates differed among schools ($p < 0.001$). Coefficient of variance partition (CVP) reached 0.051, or approximately 5.10% of total variance was attributed to adolescents' school features.

Figure 1 shows the multilevel logistic regression model for overweight and its association with CVD risk profile. Model 1, which only comprised adolescent-level variables, has shown that participants belonging to the CVD risk profile presented significantly high likelihood of being overweight (Figure 1).

After school-level variables were included in the model (Figure 1 - Model 2), it was possible observing that adolescents presenting CVD risk profile have shown 1.067 times the likelihood of being overweight in comparison to adolescents who did not have this profile.

Discussion

The current study has shown that Brazilian adolescents presented more than one simultaneous risk factor for CVD. These concomitant risk factors were represented by profile comprising behavioral patterns such as smoking, alcohol intake, and UPF intake $\geq 45.60\%$ of TCV, with weighted prevalence of 30.46% for girls and of 28.35%, for boys. It has also shown that the CVD risk profile was associated with higher likelihood of overweight in adolescence.

The understanding that risk factors for CVD coexist in adolescents remains recent, which is the reason why only few risk factors were analyzed, so far^{45,46}. A study carried out in 2019, with sample representative of Brazilian adolescents, recorded the highest prevalence (79%) of smoking and alcohol intake in clusters of risk factors for chronic noncommunicable diseases (NCDs)⁴⁶; this rate was higher than that found in the current study. Another study investigated this very same national sample and found that 2.9% of adolescents did not present any risk factor, whereas 38.0%, 32.9%, 9.4% and 1.8% of them accumulated two, three, four and five risk factors, respectively⁴⁷; this outcome was similar to results found in the present study.

Another study has shown that 68.9% of adolescents presented at least two risk factors,

whereas more than 10% of them had more than four risk factors⁴⁸. According to most generated profiles, CVD-protective and risk behaviors existed in simultaneous way - this finding that was also observed in other studies^{49,50}. Furthermore, 65% of adolescents in Canada presented two, or

Table 1. Features of Brazilian adolescents evaluated through ERICA study. Brazil, 2013-2014 (n = 71,552).

Variable	Adolescents	
	Overall	Overweight
	Absolute frequency (relative frequency - %)	Absolute frequency (relative frequency - %)
Gender		
Female	39,690 (55.47)	9,451 (53.96)
Male	31,862 (44.53)	8,065 (46.04)
Race/ethnicity		
White	25,425 (36.50)	6,693 (39.31)
Black	5,409 (7.77)	1,330 (7.81)
Brown	36,476 (52.37)	8,544 (50.19)
Yellow	1,805 (2.59)	326 (1.91)
Indigenous	535 (0.77)	132 (0.78)
Age (years)		
12 - 13	19,832 (27.72)	5,906 (33.72)
14 - 15	26,670 (37.27)	6,290 (35.91)
16-17	25,050 (35.01)	5,320 (30.37)
School management type		
Public	56,168 (78.50)	12,880 (73.53)
Private	15,384 (21.50)	4,636 (26.47)
Residence		
Living with both parents	39,231 (54.83)	10,060 (47.43)
Living with at least one parent	27,402 (38.30)	6,335 (36.17)
Living alone	4,919 (6.87)	1,121 (6.40)
Economically favored Brazilian region		
No (Northern and Northeastern)	36,699 (51.29)	8,407 (48.00)
Yes (Southern, Southeastern and Midwestern)	34,853 (48.71)	9,109 (52.00)

Source: Authors.

Table 2. Distribution of lambda coefficients (λ_{kjl}) of internal variables for each extreme profile of Brazilian adolescents' behavioral patterns - ERICA, Brazil, 2013-2014

	N (%)	Profile 1 (λ_{1j})	Profile 2 (λ_{2j})	Profile 1 (E/O ratio)	Profile 2 (E/O ratio)
Smoking					
No	70,064 (97.92)	1.0000	0.9274	1.0212	0.9471
Yes	1,488 (2.08)	0.0000	0.0726	0.0000	3.4910
Alcohol intake					
No	54,131 (75.65)	1.0000	0.0000	1.3218	0.0000
Yes	14,905 (20.83)	0.0000	0.8741	0.0000	4.1961
No information	2,516 (3.52)	0.0000	0.1259	0.0000	3.5804
UPF intake					
< 45.60% of TCV	57,242 (80.00)	1.0000	0.4489	1.2500	0.5611
≥ 45.60% of TCV	14,310 (20.00)	0.0000	0.5511	0.0000	2.7556
Practice of physical activity					
Active (≥ 300 min/week)	31,770 (44.40)	0.4137	0.5112	0.9317	1.1513
Inactive (< 300 min/week)	39,782 (55.60)	0.5863	0.4888	1.0545	0.8792

Source: Authors.

more, risk factors for NCDs, namely: insufficient exercising levels, alcohol intake, tobacco smoking, sedentary lifestyle and high body mass rate⁵⁰.

Table 3. Multilevel logistic regression model (OR and p-value) without explanatory variables for overweight – Null model.

	M0 Model – Null Model	
	OR (CI95%)	p-value
Fixed effect		
Intercept	0.29 (0.28-0.30)	< 0.001
Random effect		
Variance (standard error)	0.179 (0.003)	
Coefficient of variance partition	0.051	
AIC	1,181,955	

Source: Authors.

A study²⁴ carried out with different developmental trajectories in Norwegian adolescents until adult life has found that adolescents had three likely trajectories: one of them resembled the risk profile identified in the current study, according to which adolescents presented unhealthy habits leading to CVD²⁴. Adolescents were highly likely to start smoking early in life, as well as to increase smoking levels in adult life. In addition, there was moderate-to-high lack of fruit intake on a daily basis in late adolescence and this habit persisted until early adulthood. Accordingly, these adolescents presented high alcohol intake levels, which further increased in adult life²⁴.

With respect to the association between CVD-risk profile and overweight, it is known that overweight has multiple causal factors such as the individual, school environment and community environment ones⁵¹. Studies have already shown association between overweight in adolescence and factors such as alcohol intake, tobacco smoking and ultra-processed food intake^{22,52-54}

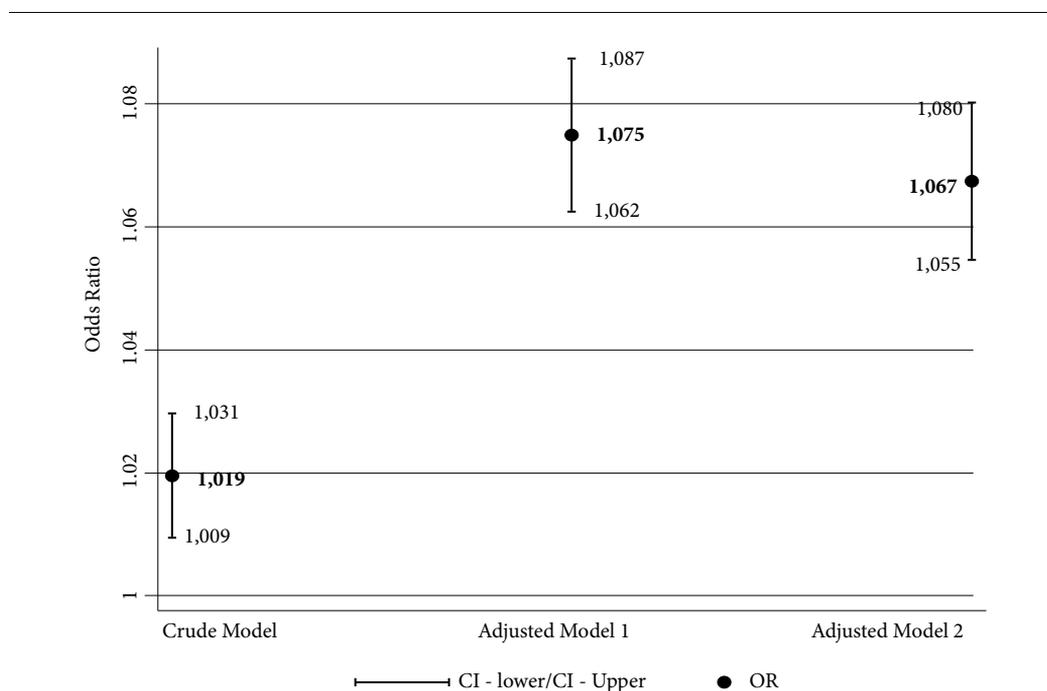


Figure 1. Adjusted multilevel logistic regression model (OR) of individual and school environment, based on profile associated with coexistence of risk factors for cardiovascular diseases and on their association with overweight in Brazilian adolescents – ERICA, Brazil.

Note: Adjusted Model 1 – Adjusted based on participants' sex, age, self-referred skin color, on whether they live with their parents, or not, and on maternal education. Adjusted Model 2 – Adjusted based on variables in model 1 and added with managerial dependency - public or private; selling snacks at school and macroregion where the school was located in.

Source: Authors.

however, they evidenced this association at individual level.

Studies have also shown the influence of multiple risk factors on overweight^{55,56}. Another study also using ERICA data, conducted with Brazilian adolescents has shown that adolescents categorized in the “unhealthy lifestyle” profile (comprising physical inactivity, long screen time, low fiber intake, excessive alcohol intake and smoking) were associated with overweight incidence in a dose-response gradient⁵⁵.

It is known that obesity-prevention initiatives individually aimed at adolescents do not achieve effective weight loss^{57,58}. The identification of CVD-risk profile, as well as its influence on overweight, enables making interventions in multiple modifiable behaviors and, consequently, it increases the likelihood of reducing overweight rates among adolescents⁵⁸. The current study heads towards the analysis of association between CVD-risk factors and health outcomes, such as overweight, since 80% of obese adolescents will remain obese in adulthood and approximately 70% of them will be obese at the age of 30 years³.

The study has some limitations, such as the “social desirability” bias, according to which adolescents may tend to answer the questionnaire according to previously normalized social behaviors. Furthermore, behaviors were self-reported, which may have led to information bias and to likely underestimated prevalence of risky behaviors. It is worth mentioning that participants were informed about the secrecy of the questionnaire and that their data would not be identified.

In addition, the 24-hour dietary recall may not fairly represent participants’ usual intake; therefore, it can be influenced by their memory bias. However, this limitation is addressed by sample’s representativeness, since it has external validity and allows generalizing the Brazilian population

of adolescents in the age group 12-17 years, because ERICA is a school-based study with national representativeness of the Brazilian population. It is worth emphasizing that the study design does not allow inferring causality; thus, results in the current study should be carefully evaluated.

The present study helped improving the identification of coexistence of CVD-risk factors in Brazilian adolescents; moreover, it was pioneer in using ERICA data to identify risk profiles. In addition, GoM using to assess CVD-risk profiles is unprecedented, since this method enables determining fuzzy clusters of individuals who are not organized in well-defined sets, but who partly belong to more than one group. Based on this approach, it was possible estimating a more realistic representation of simultaneous risk factor profiles and epidemiological prevalence.

Conclusion

The current study has observed coexistence of risk factors for CVD in Brazilian adolescents – tobacco smoking and alcohol intake were the most prevalent factors. CVD-risk profile was associated with increased likelihood of overweight in adolescence. These findings reinforce the need of taking specific preventive measures aimed at this population. These measures must be strategic, effective and assertive, as well as include as many CVD-risk factors as possible, since adolescents tend to simultaneously present multiple risk factors, which can be used as strategic point to reduce overweight rates in this population. Therefore, these measures are essential to help changing the behavior of young individuals, since engaging in health-risk behaviors in adolescence can have significant impact on individuals’ adult life.

Availability of data and materials

Data underlying the current study derived from ERICA (<http://www.ERICA.ufrj.br/>) and were provided by author PhD Cristiane De Freitas Cunha, who coordinates the study in Minas Gerais State (<http://www.ERICA.ufrj.br/index.php/equipe/>). Future researchers can request access to the same data by using information provided in section “Materials and Methods” of the manuscript, as well as by applying for access on ERICA’s website or by emailing projetoerica@gmail.com.

Abbreviations

Brazilian Institute of Geography and Statistics (IBGE)
 Body mass index (IMC)
 Cardiovascular disease (CVD)
 Center for Disease Control and Prevention in the United States (CDC)
 Global Youth Tobacco Surveillance (GYTS)
 Grade of membership (GoM)
 Household Budget Survey (POF, acronym in Portuguese)
 National Dietary Survey (INA, acronym in Portuguese)
 Noncommunicable diseases (NCDs)
 Personal Digital Assistants (PDA)
 Study of Cardiovascular Risks in Adolescents (ERICA)
 Total caloric value (TCV)
 Ultra-processed food (UPF)

Collaborations

Design and planning of the study: TPR Silva, FP Matozinhos, LHA Gratão, AC Silva, LL Mendes, GR Guedes. Data collection, analysis and interpretation: CFC Grillo, TRPR Oliveira, LL Mendes, TPR Silva. Drafting or proofreading of the manuscript: TPR Silva, FP Matozinhos, GR Guedes, LHA Gratão, AC Silva, LL Mendes, LA Vilela. Approval of the final version: TPR Silva, FP Matozinhos, GR Guedes, LHA Gratão, AC Silva, LL Mendes, TRPR Oliveira, CFC Grillo. Public responsibility for the contents of the article: TPR Silva, FP Matozinhos, GR Guedes, LHA Gratão, AC Silva, LL Mendes, TRPR Oliveira, CFC Grillo, LA Vilela.

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