DOI: 10.1590/1413-812320212611.26362020

Quality of life and adiposity in adolescents: direct and indirect effects

Isabelle Arruda Barbosa (http://orcid.org/0000-0003-3121-0505) [1]
Marise Fagundes Silveira (https://orcid.org/0000-0002-8821-3160) [2]
Adélia Dayane Guimarães Fonseca (https://orcid.org/0000-0002-1168-7106) [3]
Maria Fernanda Santos Figueiredo Brito (https://orcid.org/0000-0001-5395-9491) [2]
Lucinéia de Pinho (https://orcid.org/0000-0002-2947-5806) [2]
Carla Silvana de Oliveira e Silva (https://orcid.org/0000-0002-2752-1557) [2]

Abstract *This paper aimed to analyze the direct and indirect effects of adiposity and factors related to adolescents' quality of life. This is a cross-sectional study with 635 adolescents (10-16 years) from public schools in Montes Claros-MG, Brazil. Anthropometric data, physical activity (PA), inadequate dietary habits, body image, and quality of life (QoL) of adolescents were collected. A structural equation modeling was performed. The variables addressed as constructs were adiposity and inadequate dietary habits, the exploratory variables were PA and body image, and the outcome variable was QoL. The total effect of PA-mediated adiposity on QoL was positive and significant (β=0.213; $p<0.05$), in contrast to the total effect mediated by inadequate dietary habits on QoL, which was negative and significant (β=-0.150; $p<0.05$). The direct effect of PA on QoL was positive and significant (β=0.209; $p<0.001$). No body image-related effects were observed. The effects of adiposity on adolescents' QoL tend to improve when mediated by PA, and they worsen when mediated by inadequate dietary habits. The effects of PA tend to improve the QoL of adolescents.*

Key words *Adolescents, Multivariate analysis, Quality of life, Adiposity, Risk factors*

[1] Instituto Federal do Norte de Minas Gerais. Rodovia BR 367, km 07, s/n, Zona Rural. 39900-000 Almenara MG Brasil. isabelleab3@gmail.com
[2] Universidade Estadual de Montes Claros. Montes Claros MG Brasil.
[3] Universidade Federal de Juiz de Fora. Juiz de Fora MG Brasil.

Introduction

With the reduction of infectious diseases, excess body weight has become one of the leading public health problems worldwide, increasing its prevalence in recent years[1]. However, this event's concern at younger ages deserves emphasis, since obesity obtained during childhood and adolescence tends to continue into adulthood[2].

Studies warn that individuals simultaneously acquire several unhealthy behaviors or lifestyles in adolescence and adulthood, highlighting physical inactivity and inadequate consumption of fruits and vegetables[3,4].

Although much of the scientific and health interest is focused on assessing the physiological implications of overweight on health, chronic deterioration in functional, social, and psychological capacities have also been perceived, affecting people's quality of life (QoL)[5-7]. Obese children and adolescents display worse QoL and greater dissatisfaction with their body image than healthy children and adolescents[8]. Obesity-related psychosocial disorders also include anxiety, depression, distress, low self-esteem, feelings of guilt, social adjustment difficulties, and behavioral disorders. Such conditions can culminate in the cause or effect of the weight gain process, with possible adverse repercussions on QoL[9,10].

The number of studies that seek to study the associations between QoL and overweight is notorious[6-8,11]. However, this study aims to discuss the relationships that underpin the event directly and indirectly and through the clinical risk factors, lifestyle, and body image, which has not yet been described in the literature. Understanding these relationships that directly or indirectly influence QoL may make the study of this relevant public health issue more comprehensive.

Therefore, the hypotheses tested in this study were that adiposity had a direct and adverse effect on adolescents' QoL and produced indirect and adverse effects, mediated by lifestyle and body image, on the QoL of adolescents. Thus, this study aimed to analyze the direct and indirect effects of adiposity and risk factors on adolescents' QoL.

Methods

This is a cross-sectional study conducted with adolescents aged 10-16 years, from elementary school (5th to 9th grade) and high school (1st and 2nd year), from urban public schools in Montes Claros, Minas Gerais, Brazil, in 2016.

The sample size was defined to estimate population parameters with a prevalence of 0.50 to ensure a larger sample size. The levels of confidence and margin of error adopted were 95% and 5%, respectively. Adjustment for the finite population and for the effect of design were performed, assuming a deff equal to 1.5. An increase of 10% was established to offset possible non-responses and losses[12]. The calculations showed the need to examine and interview at least 634 adolescents.

The adolescents were selected by two-stage conglomerate probabilistic sampling. In the first stage, five schools representing the four regions of the city (north, south, east, and west) were selected by sampling proportional to size. The schools' eligibility criteria were: (i) state public schools, (ii) elementary and high school level, and (iii) not participating in any scientific research involving regular physical activity (PA) at the time of the research. In the second stage, adolescents were selected by systematic random sampling, in all selected school classes, based on the attendance list.

Nineteen adolescents who reported important inflammatory and infectious diseases, used drugs that affect the metabolic and hemodynamic profile, pregnant adolescents, and those who did not show up on the day of the collection were excluded from the study. These adolescents were replaced by others who, when present, preceded them in the school attendance list and agreed to participate in the research. According to the criteria mentioned above, observing the proportionality for gender and age, the final sample consisted of 635 adolescents with population representation (from a total of 77,833 students).

Principals from participating schools and parents or legal guardians allowed adolescents to participate in the study through informed consent. Likewise, the adolescents themselves agreed to participate through an assent term, after receiving related information.

A multidisciplinary team collected data in the respective schools of adolescents in the second half of 2016. This team consisted of medical professionals, nurses, nutritionists, physical education professionals, and physiotherapists, assisted by undergraduate health students, after training and calibration. The professionals considered fit for data collection showed that they developed standardized criteria of measurement of the investigated anthropometric data (Kappa>0.60), beyond random.

Ciência & Saúde Coletiva, 26(11):5661-5670, 2021

The adolescents' weight was measured by a portable digital scale, with a capacity of 150 kg and precision of 0.1 kg (Body complete model, with eight electrodes and model interface. BF 100 - Beurer, Ulm, Germany). Height was measured by a portable stadiometer with a folding measuring rod and support tripod, 115 cm to 210 cm measuring capacity, tolerance +/- 2 mm in 210 cm, and resolution in millimeters (Sanny® professional model, São Paulo, Brazil). Height (cm) and weight (kg) data were used to calculate the Body Mass Index (BMI) (weight (kg)/height (m^2))[13]. Waist circumference (WC) was assessed with an anthropometric, inelastic, and flexible measuring tape, without a lock, with a limit of 2 m and precision of 0.1 cm, was measured in the narrowest part of the trunk, between the lower costal margin and the crest iliac[13]. The waist-to-height ratio (WHR) was calculated using WC and height (WC (cm)/height (cm)) data[13].

The following questionnaires were applied to collect information from adolescents: a questionnaire to collect demographic information; the KIDSCREEN-27[14], for assessing the QoL of adolescents; the International Physical Activity Questionnaire (IPAQ) - short version[15], to identify the duration and frequency of PA; the Test: How is your diet?[16], from the Ministry of Health, for information on inadequate dietary habits; and the Silhouettes Scale[17], to identify self-perceived body image. The adolescents were adequately instructed on how to correctly complete the questionnaires, with a mean estimated completion time of 20 minutes.

The (continuous numeric) QoL variable is the outcome of this study and was used as an observed variable. It was investigated through the KIDSCREEN-27[14]. This instrument assesses the QoL related to the health of children and adolescents and consists of five dimensions: Physical well-being (5 items), Psychological well-being (7 items), Autonomy and relationship with parents (7 items), Peers and social support (4 items), and School environment (4 items). All items were on a Likert scale and aimed to identify the frequency of behaviors/feelings or, in some instances, the intensity of specific attitudes, with a recall period of the week before the application of the questionnaire. The scores for each dimension (ranging from 1 to 5) were computed using simple arithmetic mean and the final score equivalent to each dimension. The higher the value, the greater the perception of the QoL indicator of the dimension in question[14], except for item 1 of Physical well-being and items 4, 5, and 6 of Psychological well-being, which initially had inverted scores.

The (continuous numeric variable) PA variable was addressed as an observed variable and investigated using the IPAQ - short version[15]. This questionnaire consists of seven open-ended questions, and its information allows estimating the weekly duration and frequency in different PA intensities (domestic, moderate, and vigorous intensities) and physical inactivity (sitting position). The final score was presented in metabolic equivalents (MET) in weekly minutes and was calculated by the product of frequency and duration of PA for each PA intensity, followed by the sum of the result of all PA intensities. The longer the duration and frequency of weekly PA, the better the PA level (hiking=3 METs/min; moderate activities=4 METs/min; vigorous activities=8 METs/min)[18].

Body image (discrete numerical variable) was addressed as an observed variable and investigated using the scale of silhouettes[17], with profiles ranging from thinness (silhouette 1) to severe obesity (silhouette 9). On this scale, the individual chose the number of the silhouette that he judged to be similar to his actual body appearance and his ideal body appearance. The final score was calculated by the difference between the real and the ideal appearance, which was shown in absolute values, ranging from -8 to 8, where an individual is classified as satisfied if equal to zero, and dissatisfied, if different from zero. Dissatisfaction with overweight was considered with positive difference, and dissatisfaction with thinness, when negative.

The variables BMI, WC, and WHR, were also addressed as observed variables. The WHO parameters (score $Z \geq 1$) for age and gender were used[19] to classify adolescents according to BMI. The 75th percentile of the sample was considered according to gender and age[18] to classify WC values and fat percentage in the central region. WHR was calculated by measuring the waist circumference (cm) and height (cm), considering values >0.5[19] as increased risk.

The following variables were addressed as a construct, variables measured by the shared variance of other variables directly observed: (a) adiposity, measured by three continuous numeric variables: BMI, WC, and WHR; (b) inadequate dietary habits, measured using two questions from the Ministry of Health's Test instrument: how is your diet?[16]. This test consists of 18 questions, with answer options ranging from 2 to 5 alternatives, regarding the regular consumption

in portions, of items in the food pyramid groups: oils, vegetables, fruits and legumes, protein, carbohydrates, and water; alcohol, and salt consumption; and physical activity[16]. Questions 10 and 11 of this test were used in this study and entitled "ultra-processed foods" and "sweets", respectively. They are: (10) "Think of the following foods: fried foods, fried or packaged snacks, salty meats, hamburgers, hams, and sausages (sausage, bologna, and salami). How often do you eat any of them?"[16], in this study called "ultra-processed foods"; and (11) "Think of the following foods: sweets of any kind, filled cakes with icing, sweet cookies, soft drinks, and processed juices. How often do you eat any of them?"[16], in this study called "Sweets". Both questions are presented on a Likert scale (Daily=0; 4-5 times a week=1; 2-3 times a week=2; Less than twice a week=3; Rarely or never=4), and the lower the response option score, the greater the frequency of inadequate dietary habits reported by the adolescent.

A theoretical model was developed to identify the interrelationships between the outcome variable QoL and the other variables involved in this study. It contains the observed variables as rectangles, the constructs as ellipses, and the associations as arrows or trajectories (starting from the independent variable to the dependent one)[20] (Figure 1).

The ordinal observed variables were described by their frequency distributions (absolute and relative) and the observed numerical variables, by the measures of central tendency and dispersion (mean and standard deviation), adjusted by the effect of design (*deff.*). The variables' normality was analyzed by the skew (Sk) and kurtosis (Ku) coefficients, whose absolute values greater than three and seven, respectively, indicated severe deviation from this assumption[20]. The PA variable showed severe deviations from normality and was submitted to logarithmic transformation. It had missing data above 10%, which were imputed by linear regression for this reason.

The model was adjusted in two stages. Firstly, the adiposity and inadequate dietary habits construct measurement models were adjusted through confirmatory factor analysis, in which the factor weight above 0.4 was adequate[20]. The multivariate model was then adjusted based on the structural equation modeling (SEM) (Figure 2). Direct effects were estimated through standardized coefficients (SC), whose significance was analyzed by the relationship between the value of the coefficient and its standard error (critical ratio - CR), at the 5% level. The indirect effects mediated by intermediate variables were calculated by multiplying all indirect routes' coefficients in the model. The percentages of variances were also calculated (explained and manifested by the constructs). SC were interpreted according to Kline[21] recommendations, where values close to 0.10 indicated a small effect, values close to 0.30 indicated a medium effect, and values greater than 0.50, a large effect.

To verify the model's quality, indices were used to ascertain the intensity or degree with which the model predicts the covariance matrix, allowing the comparison of the proposed model with the null model. These indices can be subdivided into general adjustment indices: chi-square over degrees of freedom (χ^2/df) and; and comparative indices: Bentler (CFI), the goodness of fit (GFI), Tucker-Lewis (TLI), and the root mean square error approximation (RMSEA). The fit of the model to the data was adequate when weights of factorial items $\lambda \geq 0.50$ were obtained; $\chi^2/df \leq 4.0$; GFI, CFI and TLI$\geq$0.90, and RMSEA$\leq$0.10[20].

The descriptive analyses of the variables were obtained through the Software Package for the Social Sciences (IBM SPSS 22.0) and the model's graphic construction, through the Analysis of Moment Structures program (IBM SPSS AMOS 22.0), created specifically to perform MEE.

The study adopted the criteria of Resolution N° 466/2012 of the National Health Council and its complementary resolutions. The Research Ethics Committee approved the project of the State University of Montes Claros.

Results

A total of 635 adolescents from public schools in the urban area participated in the study. The mean age was 13.8 (+1.7) years, consisting mostly of females (60.2%; n=382).

Concerning inadequate dietary habits, 32% (n=203) of the adolescents answered that they consume "ultraprocessed foods" 2-3 times/week, and 29.1% (n=185) consume "sweets" less than twice a week (Table 1). Table 1 shows the descriptive data for the other study variables.

Figure 2 shows the adjusted structural model, which revealed a good fit quality: χ^2/df=1.901; CFI=0.995; GFI=0.990; TLI=0.989; RMSEA= 0.038 (90%CI: 0.013-0.060).

The paths of the constructs with the highest (>0.50) and significant SC were: WC ← adiposity (β=0.97; p<0.001) with 94% of the WC variabili-

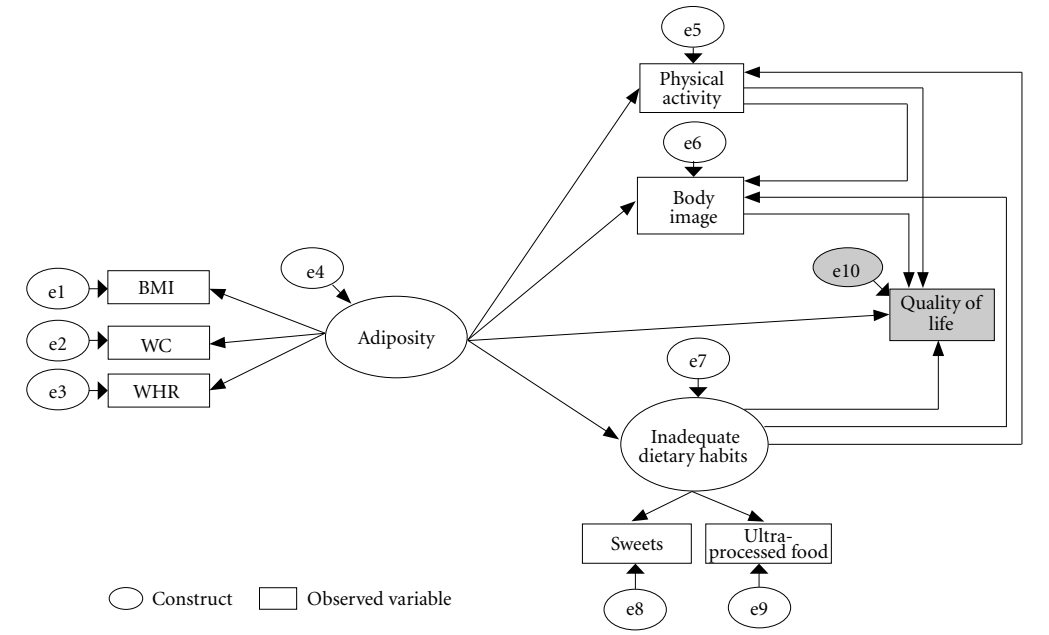

Figure 1. Theoretical model tested to assess the direct and indirect effects of adiposity and related factors on adolescents' quality of life aged 10 to 16 years. Montes Claros, Minas Gerais, Brazil, 2016.

BMI - Body Mass Index (Z-score); WC - Waist Circumference (cm); WHR - Waist-to-height Ratio (cm).

Source: Elaborated by the authors.

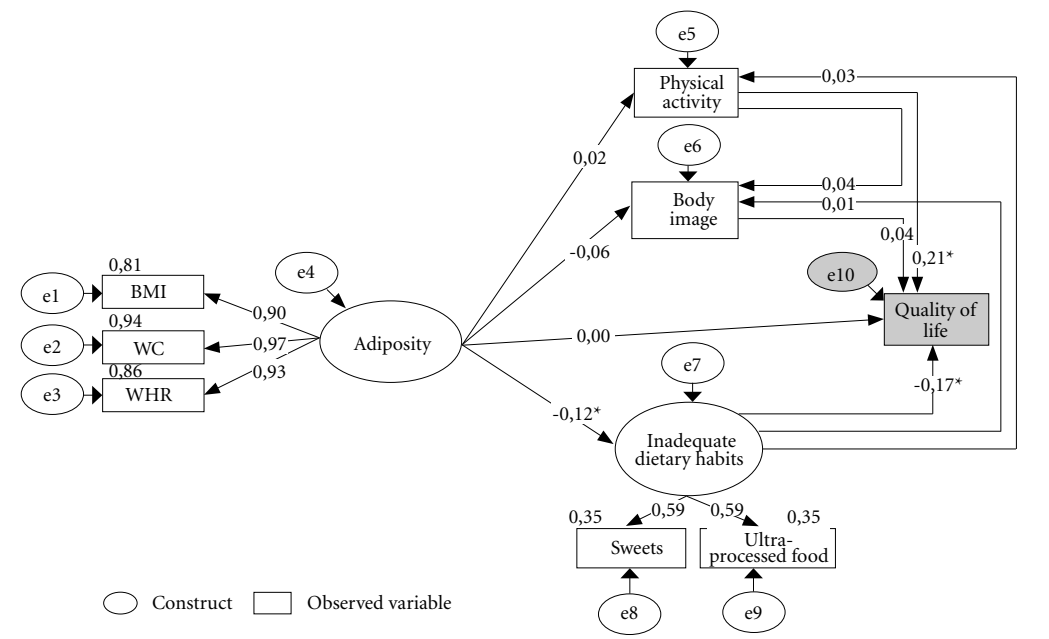

Figure 2. Adjusted model with structural equations to assess the direct and indirect effects of adiposity and related factors on adolescents' quality of life aged 10 to 16 years. Montes Claros, Minas Gerais, Brazil, 2016.

BMI - Body Mass Index (Z-score); WC - Waist Circumference (cm); WHR - Waist-to-height Ratio (cm). *p-value<0.05.

Source: Elaborated by the authors.

ty of the adolescents evaluated, explained by this construct; and both trajectories: sweets ← inadequate dietary habits and processed food ← dietary habits (β=0.59; p<0.005), each with 35% of the variability of inadequate dietary habits investigated in adolescents explained by this construct (Figure 2; Table 2).

As for the magnitude of the effects, the total effect (direct + indirect) of PA-mediated adiposity on QoL was small, positive, and significant; the total effect of adiposity on QoL, mediated by inadequate dietary habits was small, negative, and significant, but was lower than the direct effect. The direct effect of PA on QoL was small, positive, and significant, and the direct effect of inadequate dietary habits on QoL was small, negative, and significant. The other effects were not significant (Table 3).

Discussion

Given the existing complexity around excess body weight (EBW), this study aimed to analyze the direct and indirect effects of adiposity and risk factors on adolescents' QoL.

The analysis revealed that PA had a small, positive, and significant effect on the adolescents' QoL among the model's variables. Several studies investigating the QoL of adolescents related to PA corroborated these results and concluded that a higher PA level is associated with higher QoL scores[22,23]. A study that investigated, among others, the associations between the level of PA and BMI with the physical domain of the QoL of adolescents found that less active individuals were 1.7 times more likely to be at risk of having a bad physical domain than their more active peers[5]. The reverse situation is also true. Inactive adolescents (CR=1.63; p=0.05), obese (CR=3.93; p=0.05) were more likely to negatively perceive social relationships[6]. In another study, inactive adolescents (CR=1.90; 95%CI=1.16-3.10) were still likely to be dependent on alcoholic beverages (CR=4.18; 95% CI=1.04-16.84) and more likely to have a negative perception of the psychological domain of QoL[7]. Specifically, PA transcends QoL's simple physical dimension, relating, intervening, and directly transforming the social and psychological domains[24].

Inadequate dietary habits had a small, negative, and significant effect on adolescents' QoL in this study. An investigation about the role of lifestyle during childhood concerning QoL in adolescence showed that modifiable behaviors during childhood negatively interfered in the QoL of adolescents, such as inadequate dietary habits (skipping breakfast (OR=1.56, P=0.003), irregular snacks (OR=1.43, P<0.001), and frequent consumption of instant noodles (OR=1.49, P=0.007)), sleeping little (OR=1.15, P=0.061) and physical inactivity (OR=1.48, P=0.022)[25]. Other evidence points out that obesity and EBW, resulting from an inadequate diet – marked by excessive consumption, especially of carbohydrates and fats[26] –, can result in chronic

Table 1. Descriptive analysis of model variables with structural equations using quality of life as an outcome variable, among adolescents aged 10 to 16 years. Montes Claros, Minas Gerais, Brazil, 2016 (n=635).

	Mean (SD)	IC95%	Sk	Ku
Adiposity				
BMI	21.14 (4.18)	20.81-21.46	0.96	0.85
WC	71.32 (10.16)	70.53-72.11	0.95	0.85
WHR	0.44 (0.06)	0.44-0.45	1.02	0.86
Physical activity	5.06 (1.20)	4.97-5.16	-0.30[a]	-0.62[a]
Body image	0.40 (1.44)	0.28-0.51	0.42	0.47
Quality of life	3.70 (0.59)	3.66-3.75	-0.57	0.31
	Frequency of inadequate dietary habits in the last week (%)			
	0	**1**	**2**	**3**	**4**
Ultra-processed food	105(16.5)	62(9.8)	203(32.0)	154(24.3)	111(17.5)
Sweets	84(13.2)	97(15.3)	180(28.3)	185(29.1)	89(14.0)

SD - Standard Deviation; Sk - Skew coefficient; Ku - Kurtosis coefficient; aLogarithm. BMI - Body Mass Index (Z-score); WC - Waist Circumference (cm); Waist-to-height Ratio (cm). Daily =0; 4-5 times a week =1; 2-3 times a week =2; Less than 2 times a week =3; Rarely or never =4.

Source: Elaborated by the authors.

Ciência & Saúde Coletiva, 26(11):5661-5670, 2021

Table 2. Non-standardized coefficients, standard error, and standardized coefficients of the model with structural equations, using the quality of life variable as an outcome, among adolescents aged 10 to 16 years. Montes Claros, Minas Gerais, Brazil, 2016.

Effects			Coefficients		p-value
			Non-standardized (SE)	Standardized	
Quality of life	←	Physical activity	0.10 (0.02)	0.21	***
Quality of life	←	Body image	0.02 (0.02)	0.04	0.330
Quality of life	←	Inadequate dietary habits	-0.14 (0.05)	-0.17	0.006
Quality of life	←	Adiposity	-0.001 (0.01)	-0.004	0.929
Physical activity	←	Inadequate dietary habits	0.05 (0.09)	0.03	0.579
Physical activity	←	Adiposity	0.01 (0.01)	0.02	0.617
Body image	←	Physical activity	0.05 (0.05)	0.04	0.346
Body image	←	Inadequate dietary habits	0.01 (0.11)	0.01	0.896
Body image	←	Adiposity	-0.03 (0.02)	-0.06	0.124
Inadequate dietary habits	←	Adiposity	-0.02 (0.01)	-0.12	0.041
Sweets	←	Inadequate dietary habits	1.00	0.59	
Processed food	←	Inadequate dietary habits	1.06 (0.38)	0.59	0.005
BMI	←	Adiposity	1.00	0.90	
WC	←	Adiposity	2.62 (0.06)	0.97	***
WHR	←	Adiposity	0.02 (0.00)	0.93	***

SE - Standard Error; BMI - Body Mass Index; WC - Waist Circumference; WHR - Waist-to-height ratio. ***p<0.001.

Source: Elaborated by the authors.

Table 3. Magnitude of the direct, indirect, and total effects of the model's adiposity independent variable with structural equations, using quality of life as the dependent variable, among adolescents aged 10 to 16 years, Montes Claros, Minas Gerais, Brazil, 2016 (n=635).

Effects			Direto	Indireto	Total
Quality of life	←	Adiposity	0.000	0.000	0.000
	←	Physical activity	0.209*	0.004	0.213*
	←	Body image	0.038	0.002	0.042
		Inadequate dietary habits	-0.174*	0.020*	-0.150*

*p<0.05.

Source: Elaborated by the authors.

noncommunicable diseases (NCDs) and significantly affect people's QoL[27]. Given these findings and the results of this study, it is consistent to say that the more frequent the inadequate dietary habits, the worse the adolescents' QoL.

It is noteworthy that the association between QoL and inadequate dietary habits among adolescents was not described in the literature. Given the relevance of this topic, investing in this type of research will allow a broad understanding of the determinants associated with this dyad, expanding the impact of promotion actions and their efficiency concerning healthy eating practices, which positively influence adolescents' QoL.

Adiposity had a small, negative, and significant effect on inadequate dietary habits. This finding contradicts the study carried out with Saudi adolescents to verify associations between measures of obesity and dietary habits, among others, which revealed that among the factors significantly associated with overweight and obesity was an emphasis on the consumption of sugar-added drinks 3-4 days per week

(OR=1.27; 95%CI=1.05-1.53) or <3 days per week (OR=1.32; 95%CI=1.08-1.62)[28]. In another study that aimed to identify the prevalence of overweight and food consumption among adolescents from public schools, a similarity was observed between genders with the prevalence of overweight (p=0.826) and obesity (p=0.276). However, 19.2% of girls and 23.4% of boys showed higher consumption than the recommended carbohydrate intake (>65% of the total energy value), and all of the adolescents consumed insufficient polyunsaturated fatty acids, in contrast to cholesterol, whose consumption was above recommended levels (48% of adolescents)[29]. This study was unable to identify the positive association between adiposity and inadequate dietary habits, possibly due to the reverse causality bias, which may occur in cross-sectional studies. Thus, it is possible to assume that recommendations regarding the change of inadequate dietary habits, including fat and carbohydrates, may have resulted in a higher concentration of overweight adolescents and less intake of these foods to improve their health condition. It is known that the consumption of ultraprocessed and ready-to-eat foods and drinks, as substitutes for traditional and healthy foods, is associated with the increased prevalence of overweight and chronic diseases already evident in the young audience[30]. Thus, identifying so-called "unhealthy" eating patterns during childhood and adolescence can be beneficial for the development of strategies to improve the dietary habits of these individuals and, consequently, decrease the prevalence of these risk factors throughout life[31].

Although this study evidenced that PA and inadequate dietary habits have more robustly determined the QoL of the adolescents investigated, adiposity seems to have an indirect impact on QoL, which is more affected as the body weight increases[11]. Thus, under the direct effect of adiposity or mediated by the adolescents' lifestyle, adiposity plays a vital role in the QoL of the investigated adolescents[6].

In this study's structural model, body image did not contribute significantly to the adolescents' QoL. Researchers point out that female adolescents (the majority in this study) modify some behavioral values over time and acquire a critical, new, and differentiated view regarding QoL, concerning issues related to body image and self-esteem[32], which may justify the non-association of body image with QoL in this study. Similar results were found in the study that analyzed, among others, the association between body image and QoL at different times of adolescent menarche (pre, post-menarche, and one year after menarche). In the mentioned study, body dissatisfaction was also not significantly related to QoL[33].

As positive aspects of this study, we emphasized modeling with structural equations, as it allows examining a series of dependence relationships simultaneously, transcending common practice in statistical analysis with classical techniques[20]. However, the investigations evaluated through questionnaires are limited to the detriment of direct measurement methods, which may underestimate or overestimate the investigated adolescents' information. Another limitation of this study is the maximum likelihood method adopted to adjust the models, which requires variables on a continuous measurement scale. However, the variables used in the composition of the construct inadequate dietary habits are in scale with five ordinal categories. That is, these variables do not, in theory, involve a parametric analysis. However, we emphasize that the maximum likelihood method is robust to the violation of the assumption of normality, as long as the skew and kurtosis of the variable distributions are not very high[20], and if the number of categories of ordinal variables is at least four[34]. The reverse causality bias inherent in cross-sectional studies also limited the analysis of this study, as it allows estimating associations between variables, but not establishing causal relationships. We stress that this theme should be better explored through longitudinal studies to better understand the risk factors involved and outline prevention strategies.

Given the above, this study showed that, while not directly affecting adolescents' QoL, the adiposity variable had small and positive PA-mediated effects, and small and adverse effects when mediated by inadequate dietary habits. Thus, it appears that the effects of adiposity on the QoL of adolescents tend to improve when mediated by physical activity and to worsen when mediated by inadequate dietary habits. On the other hand, physical activity had small and positive effects on the adolescents' QoL, tending to improve it. It is noteworthy that the effect of inadequate dietary habits on adolescents' QoL was not described in the literature.

This study provided new reflections given the complex nature of adiposity and other risk factors, with its repercussions on the QoL of adolescents. Thus, new possibilities are raised for the investigation and understanding of this event directly and indirectly.

Collaborations

IA Barbosa, ADG Fonseca and CSO Silva were the creators of the manuscript. IA Barbosa, M Fagundes, L Pinho and MFSF Brito were responsible for the methodology and data analysis. All authors contributed writing, review, approving the final version of the manuscript and are responsible for the entire study, ensuring its accuracy and integrity.

References

1. Schmidt MI, Duncan BB, Silva GA, Menezes AM, Monteiro CA, Barreto SM, Chor D, Menezes PR. Chronic non-communicable diseases in Brazil: burden and current challenges. *Lancet* 2011; 377(9781):1949-1961.
2. Biro FM, Wien M. Childhood obesity and adult morbidities. *Am J Clin Nutr* 2010; 91(5):1499S-1505S.
3. Silva DAS, Petroski ELJ. The simultaneous presence of health risk behaviors in freshman college students in Brazil. *J Community Health* 2012; 37(3):591-598.
4. Silva DA, Peres KG, Boing AF, González-Chica DA, Peres MA. Clustering of risk behaviors for chronic noncommunicable diseases: a population-based study in southern Brazil. *Prev Med* 2013; 56(1):20-24.
5. Gordia AP, Quadros TMB, Campos W, Petroski EL. Domínio físico da qualidade de vida entre adolescentes: associação com atividade física e sexo. *Rev Salud Publica* 2009; 11(1):50-61.
6. Gordia AP, Quadros TMB, Silva RCR, Campos W. Domínio social da qualidade de vida de adolescentes e sua associação com variáveis comportamentais, biológicas e sóciodemográficas. *Rev Educ Fis UEM* 2015; 26(3):451-463.
7. Gordia AP, Silva RCR, Quadros TMB, Campos W. Variáveis comportamentais e sociodemográficas estão associadas ao domínio psicológico da qualidade de vida de adolescentes. *Rev Paul Pediatr* 2010; 28(1):29-35.
8. Gouveia MJ, Frontini R, Canavarro MC, Moreira H. Imagem corporal e qualidade de vida na obesidade pediátrica. *Psic Saude Doenças* 2016; 17(1):52-59.
9. Luiz AMG, Gorayeb R, Liberatore Júnior RDR. Avaliação de depressão, problemas de comportamento e competência social em crianças obesas. *Est Psicol* 2010; 27:41-48.
10. Cataneo C, Carvalho AMP, Galindo EMC. Obesidade e aspectos psicológicos: maturidade emocional, autoconceito, locus de controle e ansiedade. *Psicol Reflex Crit* 2005; 18(1):39-46.
11. Casas AG, Guillamón AR, García-Cantó E, García PLR, Pérez-Soto JJ, Marcos LT, López PT. Estado nutricional y calidad de vida relacionada con la salud en escolares del sureste español. *Nutr Hos* 2015; 31(2):737-743.
12. Kish L. *Survey Sampling*. New York: John Wiley & Sons; 1965.
13. Brasil. Ministério da Saúde (MS). *Orientações para coleta e análise de dados antropométricos em serviços de saúde: norma técnica do sistema de Vigilância Alimentar e Nutricional - SISVAN*. Brasília: MS; 2011.
14. Ravens-Sieberer U, Gosch A, Abel T, Auquier P, Bellach BM, Bruil J, Mick Power WD, Rajmil L, the European KIDSCREEN Group. Quality of life in children and adolescents: a European public health perspective. *Soz Praventivmed* 2001; 46(5):294-302.
15. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P. International Physical Activity Questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003; 35:1381-1395.

16. Brasil. Ministério da Saúde (MS). Teste: como está a sua alimentação? In: *Guia alimentar - como ter um alimentação saudável* [Internet]. [acessado 2020 jul 17]. Disponível em: https://bvsms.saude.gov.br/bvs/publicacoes/guia_alimentar_alimentacao_saudavel.pdf.
17. Stunkard AJ, Sorensen T, Schulsinger F. Use of the Danish adoption register for the study of obesity and thinness. *Res Publ Assoc Res Nerv Ment Dis* 1983; 60:115-120.
18. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS. Compendium of physicactivities: a second update of codes and met values. *Med Sci Sports Exercal* 2011; 43:1575-1581.
19. World Health Organization (WHO). Global Database on Child Growth and Malnutrition: growth reference data for 5-19 years [Internet]. Genebra: WHO; 2007 [acessado 2020 jul 17]. Disponível em: http://www.who.int/growthref/en/.
20. Marôco J. *Análise de equações estruturais: fundamentos teóricos, software e aplicações*. Lisboa: Report Number; 2010.
21. Kline RB. *Principles and practice of structural equation modeling*. 3ª ed. New York: Guilford Press; 2011.
22. Spengler S, Woll A. The more physically active, the healthier? The relationship between physical activity and health-related quality of life in adolescents: the MoMo study. *J Phys Act Health* 2013; 10:708-715.
23. Casey MM, Harvey JT, Telford A, Eime RM, Mooney A, Payne WR1. Effectiveness of a school-community linked program on physical activity levels and health -related quality of life for adolescent girls. *BMC Public Health* 2014; 14:649.
24. Rother RL, Rempel C. Qualidade de vida de adolescentes que praticam atividade física: uma revisão sistemática. *Rev Dest Acad* 2017; 9(3):76-86.
25. Wang H, Sekine M, Chen X, Yamagami T, Kagamimori S. Lifestyle at 3 years of age and quality of life (QOL) in first-year junior high school students in Japan: results of the Toyama Birth Cohort Study. *Qual Life Res* 2008; 17(2):257-265.
26. Gulati S, Misra A. Sugar intake, obesity, and diabetes in India. *Nutrients* 2014; 6(12):5955-5974.
27. Sazlina SG, Zaiton A, Nor Afiah MZ, Hayati KS. Predictors of health related quality of life in older people with non-communicable diseases attending three primary care clinics in Malaysia. *J Nutr Health Aging* 2012; 16(5):498-502.
28. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Musaiger AO. Lifestyle factors associated with overweight and obesity among Saudi adolescents. *BMC Public Health* 2012; 12:354.
29. Pinho L, Flávio EF, Santos SHS, Botelho ACC, Caldeira AP. Excesso de peso e consumo alimentar em adolescentes de escolas públicas no norte de Minas Gerais, Brasil. *Cien Saude Colet* 2014; 19(1):67-74.
30. Sparrenberger K, Friedrich RR, Schiffner MD, Schuch I, Wagner MB. Ultra-processed food consumption in children from a Basic Health Unit. *J Pediatr* 2015; 91:535-542.
31. Ambrosini GL, Huang RC, Mori TA, Hands BP, O'Sullivan TA, Klerk NH, Beilin LJ, Oddy WH. Dietary patterns and markers for the metabolic syndrome in Australian adolescents. *Nutr Metab Cardiovasc Dis* 2010; 20:274-283.
32. Gordia AP, Quadros TMB, Campos W, Vilela Júnior GB. Qualidade de vida de adolescentes da rede particular de ensino: comparação entre gêneros. *Rev Bras Qualid Vida* 2009:1(2):16-24.
33. Santos MLB, Novaes JS, Mon teiro LAC, Fernandes HM. Insatisfação corporal e qualidade de vida durante a menarca e sua relação com a renda familiar e o índice de massa corporal: Um estudo longitudinal. *Motri* 2015; 11(2):75-84.
34. Oliveira BH, Nadanovsky P. Psychometric properties of the Brazilian version of the Oral Health Impact Profile-short form. *Community Dent Oral Epidemiol* 2005; 33:307-314.

Article submitted 16/04/2020
Approved 08/09/2020
Final version submitted 10/09/2020

Chief editors: Romeu Gomes, Antônio Augusto Moura da Silva