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Assessing the relationship between smoking and abdominal obesity in a National Survey of Adolescents in Brazil

Neilane Bertoni[a,*], Liz Maria de Almeida[a], Moysés Szklo[b], Valeska C. Figueiredo[c], André S. Szklo[a]

[a] Division of Epidemiology, Brazilian National Cancer Institute (INCA), Rio de Janeiro, Brazil
[b] Division of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, USA
[c] Center for Studies on Tobacco and Health, Oswaldo Cruz Foundation, Rio de Janeiro, Brazil

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ABSTRACT

Abdominal obesity is even a stronger risk factor than overall obesity for noncommunicable chronic diseases. We examined the association between smoking and abdominal obesity among adolescents. Analyses were based on 38,813 subjects aged 15–17 years from the Study of Cardiovascular Risks in Adolescents (ERICA), a Brazilian school-based national survey. Abdominal obesity was defined considering waist circumference (WC) percentiles. Statistical analyses, stratified by sex, considered the sample complex design. Poisson regression with robust variance was used to estimate smoker-to-nonsmoker abdominal obesity prevalence ratio (PR), adjusting by sociodemographic and lifestyle variables. Higher prevalence of abdominal obesity was observed among adolescents who consumed > 1 cigarettes/day, comparing to nonsmokers: considering WC > 80th percentile, adjusted-PR for boys was 1.27 [95%CI:1.05,1.52] and, for girls, 1.09 [95%CI:1.00,1.19]; using the 90th percentile, adjusted-PR were 2.24 [95%CI:1.70,2.94] and 1.27 [95%CI:1.12,1.46], respectively for male and female adolescents. Our findings suggest a positive association between cigarette consumption and the prevalence of abdominal obesity, for both boys and girls. Although other studies had found this association in adults, our study contributes to this discussion by assessing it in adolescents using a nationwide representative sample of medium and large municipalities.

1. Introduction

Smoking and obesity are associated with incidence and mortality of several chronic diseases (World Health Organization, 2004; Office of the Surgeon General (US), and Office of Disease Prevention and Health Promotion (US), Centers for Disease Control and Prevention (US), National Institutes of Health (US), 2001). Abdominal obesity is even a stronger risk factor than overall obesity for noncommunicable chronic diseases (Fox et al., 2009) and is a better predictor of diabetes (Freemantle et al., 2008) and metabolic syndrome (Phillips and Prins, 2008).

A marked reduction in adult smoking prevalence was observed in Brazil between 1989 and 2013 (34.6% and 14.7%, respectively) (Szklo et al., 2016); however, prevalence rates of overweight and obesity are still very high (Malta et al., 2014). Prevalence of abdominal obesity for women and men in 2013 was 52.1% and 21.8%, respectively (Vieira, n.d.). Recent population-based surveys estimated cigarette use and elevated waist circumference to be present in around 5–7% and 13%%, respectively, of Brazilian adolescents (Figueiredo et al., 2016; Kuschnir et al., 2016; BRASIL, 2016).

Previous studies in the adult population have shown a positive association between cigarette consumption and measures of central adiposity (Akbartabartoori et al., 2005; Clair et al., 2011; Morris et al., 2015; Kim et al., 2012). Indeed, higher cortisol levels in smokers, which are related to fat depots, may explain its association with abdominal fat (Direk et al., 2011). Studies in youth/adolescents evaluating the association between tobacco consumption and increased abdominal obesity are scarce and inconclusive (Akbartabartoori et al., 2005; de Moraes and Falcão, 2013), perhaps because metabolic and hormonal changes in adolescence influence abdominal fat accumulation (Cediel et al., 2016; Medina-Bravo et al., 2011). Additional problems in past studies included difficulties in accurately measuring adolescent nicotine exposure and recruiting a large number of young smokers. It is worth mentioning that, although tobacco consumption in adults generally reduces body mass index (BMI) (Tian et al., 2015), the findings of studies that attempted to investigate the relationship between cigarette smoking and BMI among adolescents have also been inconclusive (Cooper et al., 2003; Pasch et al., 2012; Saarni et al., 2009), probably because of the same above-mentioned reasons.

The present study examined the association between smoking and

* Corresponding author at: Rua Marquês de Pombal 125/7° andar, 20230-240, Centro, Rio de Janeiro, Brazil.
E-mail address: neilane.bertoni@inca.gov.br (N. Bertoni).

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Table 1
Weighted estimates of selected variables in adolescents aged 15 to 17 Years, according to smoking status and sex, ERICA, Brazil, 2014.

	BOYS								GIRLS							
	TOTAL		Did not smoke		< 1 cigarette/day		≥1 cigarettes/day		TOTAL		Did not smoke		< 1 cigarette/day		≥1 cigarettes/day	
	n = 17,142		*n* = 15,783		*n* = 902		*n* = 236		*n* = 21,671		*n* = 20,280		*n* = 972		*n* = 191	
	(N = 2,398,123)[a]		(N = 2,170,009)[a]		(*N* = 143,391)[a]		(*N* = 40,120)[a]		(N = 2,401,376)[a]		(N = 2,219,577)[a]		(*N* = 121,152)[a]		(*N* = 28,970)[a]	
	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI
Abdominal obesity (≥80th weighted percentile)	**19.9**	*18.5, 21.3*	**19.8**	*18.4, 21.1*	**20.8**	*13.7, 27.8*	**26.5**	*13.8, 39.3*	**20.2**	*18.3, 22.2*	**20.0**	*17.8,*	*22.2*	**23.4** *17.0,*	*29.8*	**24.3** *14.4, 34.1*
Abdominal obesity (≥90th weighted percentile)	**10.0**	*9.0, 11.0*	**9.8**	*8.9, 10.8*	**10.9**	*5.0, 16.8*	**22.7**	*9.9, 35.6*	**10.0**	*8.8, 11.2*	**9.8**	*8.3,*	*11.2*	**12.5** *6.7,*	*18.2*	**15.3** *6.9, 23.7*
Nutritional Status[1]																
Low/normal weight	**77.0**	*75.5, 78.6*	**77.3**	*75.6, 79.0*	**77.5**	*70.5, 84.4*	**64.9**	*52.2, 77.5*	**77.7**	*75.8, 79.5*	**78.0**	*75.8,*	*80.1*	**75.2** *68.8,*	*81.6*	**68.0** *56.5, 79.5*
Overweight	**15.7**	*14.1, 17.2*	**15.6**	*13.8, 17.3*	**14.2**	*8.4, 20.0*	**17.7**	*9.4, 25.9*	**15.7**	*14.3, 17.0*	**15.5**	*13.9,*	*17.0*	**17.0** *11.1,*	*22.9*	**22.4** *11.4, 33.4*
Obesity	**7.3**	*6.5, 8.1*	**7.2**	*6.4, 7.9*	**8.4**	*3.7, 13.0*	**17.5**	*8.0, 26.9*	**6.6**	*5.7, 7.6*	**6.5**	*5.5,*	*7.6*	**7.8** *4.1,*	*11.5*	**9.6** *4.0, 15.2*
Alcoholic drinks (past 30 days)																
Did not drink	**68.6**	*66.4, 70.9*	**73.1**	*71.1, 75.2*	**21.4**	*15.8, 27.0*	**19.1**	*8.4, 29.9*	**67.3**	*65.2, 69.4*	**70.8**	*68.9,*	*72.7*	**21.8** *14.9,*	*28.6*	**22.4** *8.5, 36.3*
Consumed < 1 drink/day	**27.1**	*25.0, 29.2*	**23.7**	*21.9, 25.6*	**65.2**	*58.1, 72.2*	**52.0**	*40.8, 63.1*	**29.3**	*27.3, 31.3*	**26.9**	*25.1,*	*28.7*	**63.8** *57.2,*	*70.5*	**46.4** *31.5, 61.3*
1 or more drinks/day	**4.3**	*3.6, 4.9*	**3.1**	*2.6, 3.7*	**13.4**	*9.5, 17.3*	**28.9**	*18.6, 39.2*	**3.4**	*2.9, 3.9*	**2.3**	*1.9,*	*2.7*	**14.4** *10.3,*	*18.5*	**31.2** *18.2, 44.1*
Healthy eating habits[2]	**50.0**	*47.5, 52.5*	**51.1**	*48.4, 53.8*	**38.7**	*31.0, 46.4*	**38.4**	*26.3, 50.4*	**40.2**	*37.5, 42.9*	**41.2**	*38.3,*	*44.1*	**30.0** *23.6,*	*36.4*	**28.9** *16.6, 41.1*
Self reported morbidity[3]	**12.0**	*11.1, 12.9*	**11.8**	*10.9, 12.6*	**13.7**	*8.7, 18.7*	**10.9**	*5.4, 16.5*	**13.8**	*12.5, 15.0*	**13.3**	*12.0,*	*14.6*	**19.8** *12.9,*	*26.7*	**19.0** *10.3, 27.6*
Lower socioeconomic status[4]	**16.3**	*14.5, 18.1*	**16.7**	*14.8, 18.5*	**13.5**	*9.1, 17.9*	**7.7**	*3.6, 11.9*	**17.5**	*15.9, 19.1*	**17.5**	*15.8,*	*19.2*	**18.0** *13.8,*	*22.3*	**11.5** *2.5, 20.6*

[a] Estimated population.
[1] Classified according to Body Mass Index (BMI), based on reference curves from WHO, using the BMI-for-age chart for each sex.
[2] Based on reported breakfast consumption (always/often).
[3] Reported at least one of the following chronic diseases: Diabetes, Hypertension and altered levels of cholesterol.
[4] Assessed by the information on the number of people sharing the same bedroom with the adolescent (lower = three or more persons per bedroom.

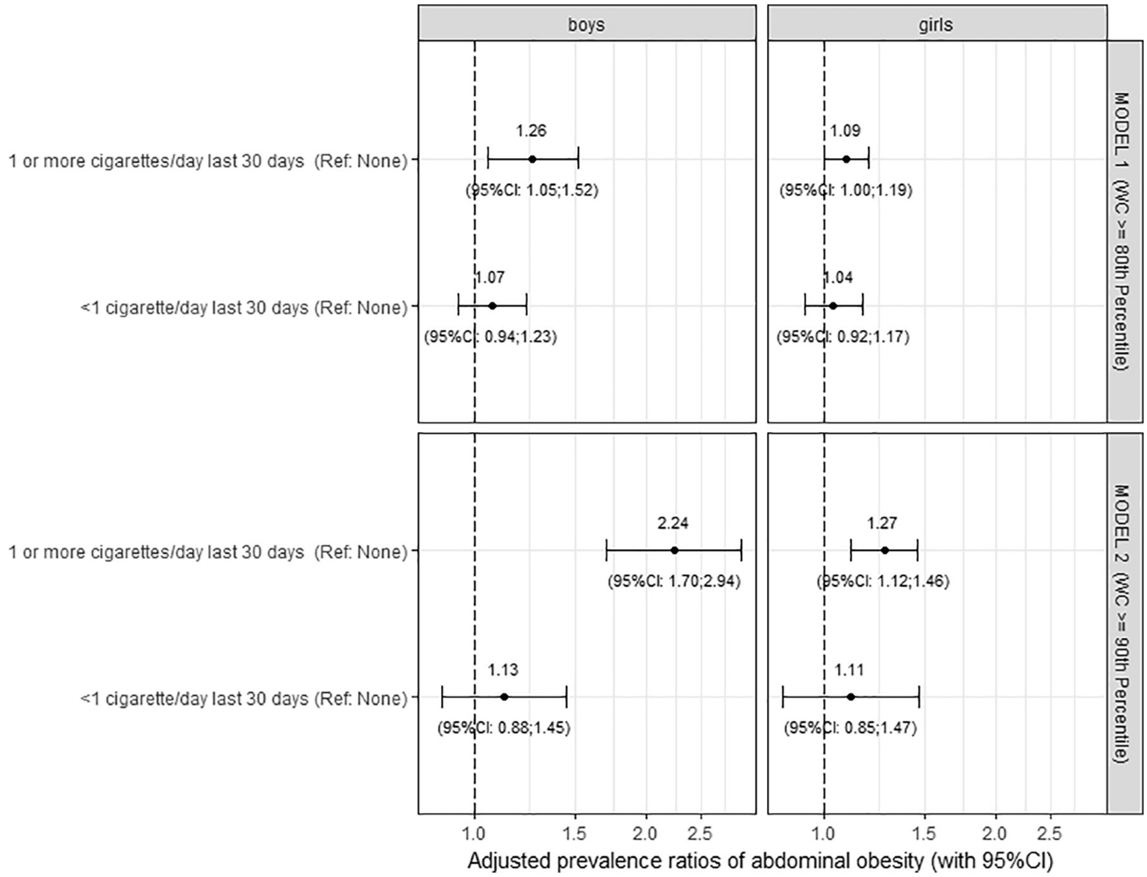

Fig. 1. Adjusted Prevalence Ratios[1] of Abdominal Obesity[2] in Adolescents Aged 15 to 17 Years, According to Smoking Status and Sex. ERICA, Brazil, 2014
[1]Each model was adjusted by age, alcohol consumption, healthy eating habits, self-reported morbidity, and socioeconomic status.
[2]Based on the waist circumference (WC) cutoffs used to classify abdominal obesity: 80th weighted percentile and 90th weighted percentile from the ERICA study population.

abdominal obesity in Brazilian adolescents in a nationwide representative sample of medium and large municipalities. To the best of our knowledge, this is the first population-based study on this topic conducted in a low-and-middle-income country that has made great progress in reducing prevalence of adult smoking.

2. Methods

This study used data from the Study of Cardiovascular Risks in Adolescents (ERICA), a national survey conducted in 2013/2014 in adolescents aged 12 to 17 years, selected from schools of Brazilian municipalities with > 100,000 inhabitants. Detailed methods have been published elsewhere (de Vasconcellos et al., 2015). Briefly, ERICA used a complex design sample composed of 32 geographical strata. Private and public schools were selected with probability proportional to size and, in each school, classes were selected considering both shifts and grades. In the selected classes, all students were invited to participate and the response rate was 72.9% (da Silva et al., 2016). Both students and parents/caregivers signed a consent form. This study was approved by the Ethics Committee of the Federal University of Rio de Janeiro and by local Ethics Committees (Bloch et al., 2015).

Sociodemographic, behavioral and health-related information was obtained by a self-administered electronic questionnaire. In the present analyses, we considered only information from 21,671 male and 17,142 female adolescents aged 15 to 17 years, in order to minimize the influence of childhood hormonal changes on abdominal obesity (Golub et al., 2008; Riestra et al., 2013).

Anthropometric measurements were performed by trained staff. Two abdominal obesity outcomes were considered in this paper. They refer to values higher than the age- and sex-specific waist circumference (WC) cutoff point of the 80th or the 90th percentiles (Monzani et al., 2016; Taylor et al., 2000). WC was measured twice and the mean value was used. Measurements were done at one-half the distance between the iliac crest and the lower costal margin, using a Sanny® fiber glass anthropometric tape. Nutritional status was defined considering BMI separately by age and sex, as recommended by the World Health Organization (Bloch et al., 2015). Body weight was measured using a Lider® digital scale. Height was the average of two measurements taken using an Alturexata® portable stadiometer.

Based on the average number of cigarettes smoked in the past 30 days and the number of days individuals smoked in the past month, smoking was categorized as never, < 1 cigarette per day, or 1 or more cigarettes per day. Alcohol consumption was categorized as no consumption, average of < 1 dose or 1 or more doses in the previous 30 days 'Daily' or 'almost daily breakfast' consumption was used as a proxy of healthy eating habits (Barufaldi et al., 2016; Rampersaud, 2009). Pre-existing chronic disease included those who reported diabetes, hypertension or hypercholesterolemia. Socioeconomic status was categorized as low or median-to-high based on reporting living with three or more individuals (low), or < 3 individuals (high) per bedroom in the household (de Bittencourt et al., 2013).

Statistical analyses were stratified by sex. In addition to descriptive analyses, a multivariate Poisson regression with robust variance (Zou, 2004) was used to estimate smoker-to-nonsmoker abdominal obesity prevalence ratio. Analyses included age and the above mentioned variables as covariates, but not BMI in order to avoid overadjustment (Clair et al., 2011; Ananth and Schisterman, 2017; Schisterman et al., 2009). All analyses considered the sample design (de Vasconcellos et al., 2015) using the 'survey' package in software R v.3.2.4.

3. Results

The estimated prevalence of abdominal obesity, defined as > 80th percentile of WC, was 19.9% for male and 20.2% for female adolescents. For the definition based on > 90th percentile, the estimated prevalence was 10.0% for both boys and girls. Classified by BMI, 15.7% of both boys and girls were overweight, and 7.3% of boys and 6.6% of girls, obese (Table 1).

Approximately one-third of adolescents reported consumption of alcoholic drinks in the past 30 days. Healthy eating habits was less prevalent in girls (40.2%) than in boys (50%) (Table 1). At least one chronic disease was present in 12.0% of boys and 13.8% of girls. Low SES was observed in 16.3% of boys and 17.5% in girls.

One or more, and less than one cigarette per day in the past 30 days were observed in 1.7% [95%CI:1.3,2.1] and 6.1% [95%CI:5.1,7.1] of boys, respectively. In girls, these proportions were, respectively, 1.2% [95%CI:0.8,1.6] and 5.1 [95%CI:4.5,5.7] (data not shown in table).

Irrespective of the cutoff point used, for both boys and girls, smokers had higher unadjusted abdominal obesity prevalence rate than non-smokers (Table 1).

Multivariate-adjusted smoker-to-nonsmoker abdominal obesity prevalence ratio using either the 80th or the 90th percentile cutoff points are presented in Fig. 1. No differences were found in abdominal obesity prevalence between adolescents who consumed on average less than one cigarette per day and those who did not smoke. However, for both boys and girls, higher prevalence of abdominal obesity was observed among adolescents who consumed one or more cigarettes per day than in nonsmokers. This association was stronger for boys (p for heterogeneity for sex, < 0.05) (Fig. 1).

4. Discussion

Our findings suggest a positive relationship between smoking at least 1 cigarette per day and abdominal obesity, consistently with previous studies conducted in adults.(Clair et al., 2011; Kim et al., 2012).

A consensus has not yet been reached in the scientific community about the best cutoff point in adolescents to define abdominal obesity based on WC (Gómez-Campos et al., 2015). Usually, each country constructs reference curves for WC and defines cutoff points based on their own population anthropometric and demographic characteristics (Supplementary Fig. 1). In Brazil, such curves have not been produced before our study and, therefore, we used either the 80th or the 90th percentiles based on the age-specific WC distribution of ERICA study's subjects. Even when we used different cutoff points based on previous studies conducted among adolescents in other countries, the main conclusions about the positive association between smoking and abdominal obesity remained unaltered (Supplementary Fig. 1).

Previous studies have shown that smoking in adolescence is also associated with sustained abdominal obesity in adult life (Saarni et al., 2009). Furthermore, smoking and obesity are major risk factors for noncommunicable diseases (de Bittencourt et al., 2013) and, therefore, their combined effects at young ages may also contribute to increase early morbidity and mortality (Bauer et al., 2014). In addition, other studies have demonstrated the cumulative effects of nicotine on body weight in adults, which could lead to insulin resistance and the resulting fat accumulation in abdominal region (Chiolero et al., 2008).

We found heterogeneity by sex in the association of smoking with abdominal obesity, which may be explained by either misclassification of smoking data, the fact that boys smoke more heavily than girls and/or by sex differences in nicotine metabolism (Piper et al., 2010).

Intentions for cigarette use have not been measured in this study. It is worth mentioning though that the tobacco industry often uses the information that smoking helps in controlling body weight to market/sell its products, particularly to girls/women (Same and Yoon, n.d.), which may increase smoking initiation and reduce cessation (Fulkerson and French, 2003). On the other hand, the negative association between body weight and smoking, among adolescents, is controversial in the literature (Cooper et al., 2003; Pasch et al., 2012; Saarni et al., 2009; Patel et al., 2017). Indeed, ERICA's data show that the prevalence of overall obesity (based on BMI) was higher among smoker adolescents than in nonsmokers (See Supplementary Fig. 2).

Our study's strengths include the population-wide nature of our sample and the quality control procedures conducted during the study's field work. However, as the study was cross-sectional, temporal bias may have occurred if adolescents with unhealthy lifestyles may have started smoking to reduce their increased abdominal fat depots (Fulkerson and French, 2003). Another limitation is that we had to consider only the information on smoking that was available in the study's database, namely, cigarette consumption in the past 30 days. Unfortunately, any form of tobacco product other than manufactured cigarettes, such as smokeless tobacco and electronic cigarettes, has not been investigated in ERICA. In Brazil, the prevalence of any form of tobacco product other than cigarette among adolescents is around 7% (BRASIL, 2016), and is similar to the prevalence of cigarette use; thus, future studies should also consider evaluating the association between the consumption of different forms of tobacco products and anthropometric measures. Moreover, the small proportion of adolescents who consumed one cigarette per day or more did not allow us evaluating more than one category of daily cigarette consumption. Finally, as with all single observational studies, residual confounding may have occurred (e.g., we were unable to control for other behavioral variables, such as physical activity).

In summary, our results indicated a positive association between consumption of one or more cigarettes per day and the prevalence of abdominal obesity, which was present in both boys and girls, although stronger in boys. Our findings may contribute to support prevention programs aimed at reducing both smoking initiation and childhood obesity through encouraging healthier lifestyles and, as a consequence, reducing future mortality and morbidity associated with these risk factors.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2018.02.017.

Conflict of interest

The authors declare no conflict of interest.

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