Original Article

Smoking and abdominal fat in blood donors*,**

Tabagismo e obesidade abdominal em doadores de sangue

Cássia da Silva Faria, Clovis Botelho,
Regina Maria Veras Gonçalves da Silva, Márcia Gonçalves Ferreira

Abstract

Objective: To assess the association between smoking and abdominal fat among male blood donors. **Methods:** This was a cross-sectional study involving 1,235 adult male blood donors (age, 20-59 years) in the city of Cuiabá, Brazil. Socioeconomic, demographic, and anthropometric data, as well as information on the lifestyle of the participants, were collected. In this study, waist circumference and waist-to-hip ratio were used as markers of abdominal fat. The association between these two markers and smoking was analyzed by multiple linear regression in separate models, adjusted for potential confounders. **Results:** Of the 1,235 respondents, 273 (22.1%) reported being smokers, and, of those, 99 (36.3%) reported smoking more than 15 cigarettes per day. The average body mass index was lower among smokers than among nonsmokers ($p < 0.001$). In the multiple linear regression analyses, smoking was associated with waist circumference and waist-to-hip ratio for smokers of 6-10 cigarettes/day and of ≥ 11 cigarettes/day. **Conclusions:** In our sample, smoking was positively associated with indicators of abdominal fat, regardless of potential confounding factors, including the consumption of alcoholic beverages.

Keywords: Smoking; Obesity; Abdominal fat.

Resumo

Objetivo: Analisar a associação entre tabagismo e obesidade abdominal em doadores de sangue. **Métodos:** Estudo de corte transversal com 1.235 homens adultos doadores de sangue (idade: 20-59 anos) em Cuiabá, MT. Foram coletados dados socioeconômicos, demográficos e antropométricos, bem como informações sobre o estilo de vida dos participantes. Neste estudo, a circunferência da cintura e a relação cintura/quadril foram utilizadas como marcadores de obesidade abdominal. A associação desses dois marcadores com tabagismo foi analisada por meio da regressão linear múltipla em modelos distintos, ajustados para potenciais fatores de confusão. **Resultados:** Dos 1.235 entrevistados, 273 (22,1%) declararam ser fumantes e, desses, 99 (36,3%) relataram fumar mais de 15 cigarros por dia. A média do índice de massa corpórea nos fumantes foi menor que nos não fumantes ($p < 0,001$). Nas análises de regressão linear múltipla, o tabagismo mostrou-se associado à circunferência da cintura e à relação cintura/quadril em fumantes de 6-10 cigarros/dia e de ≥ 11 cigarros/dia. **Conclusões:** Nesta amostra, o tabagismo associou-se positivamente com os indicadores da obesidade abdominal, independentemente de potenciais fatores de confusão, inclusive o consumo de bebidas alcoólicas.

Descritores: Tabagismo; Obesidade; Gordura abdominal.

* Study carried out at the Collective Health Institute, Federal University of Mato Grosso, Cuiabá, Brazil.
Correspondence to: Clóvis Botelho. Rua Dr. Jonas Correa da Costa, 210, CEP 78030-365, Cuiabá, MT, Brasil.
Tel. 55 65 3537-1471. Fax: 55 65 3023-0408. E-mail: fbotelho@terra.com.br
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Introduction

Smoking is currently the single most important public health problem worldwide, being a modifiable risk factor[1] for the development of numerous morbidities, including cardiovascular disease.[2-4] The relationship between smoking and nutritional status has been widely studied. Clinical and epidemiological research has demonstrated that smokers weigh less than do nonsmokers and gain weight when they quit smoking, which is actually one of the factors that impede smoking cessation, especially in women.[5] However, obesity is an epidemic disease worldwide.[1] In Brazil, the proportion of overweight men almost tripled between 1974 and 2009, having increased from 18.5% to 50.1%. During the same period, the proportion of overweight women increased from 28.7% to 48.0%.[6]

Obesity, particularly central obesity, is a major risk factor for cardiovascular diseases,[1,2] mainly affecting adults and the elderly.[7] Abdominal fat is an indicator of the presence of visceral fat, which has an atherogenic profile,[8] causing metabolic complications[2,3,9] and increasing the risk of death.

Abdominal fat deposition is influenced by several factors, some of which are well known, including age, gender,[10-12] and alcohol consumption.[13,14] The protective effect of physical activity seems more evident in individuals who engage in regular physical activities over a long period of time.[15] The association between smoking and indicators of fat distribution has been little explored, and few studies have consistently shown this association when potential confounders are controlled.

Biological mechanisms play a role in the association between smoking and body fat distribution. Higher levels of cortisol increase lipogenesis, adipocyte differentiation, and abdominal fat deposition,[16] which is accelerated by a change in the activity of lipoprotein lipase in the abdominal and gluteal regions.[8]

The prevalence of smoking remains high and the occurrence of obesity in the population is increasing, contributing to a significant increase in the incidence of cardiovascular disease.[17] The objective of the present study was to assess the independent association between smoking and anthropometric indicators of abdominal obesity, the association having been controlled for potential confounding factors.

Methods

The present study was based on a previous analysis of a cross-sectional study involving blood donors and conducted between August of 1999 and January of 2000. The study sample comprised 1,235 adult male blood donors aged 20-59 years and recruited from the Cuiabá Blood Bank, located in the city of Cuiabá, Brazil. Details on the sampling process for that study have been published elsewhere.[13]

Socioeconomic and demographic data, as well as information on the lifestyle of the participants, were collected by administering a questionnaire in the form of an interview. Trained interviewers collected the data on anthropometric measurements and body composition.

With regard to smoking, the participants who reported never having smoked were classified as nonsmokers; those who reported having smoked in the past but not currently were classified as former smokers; and those who reported smoking at least one cigarette per day were classified as current smokers.[13] Smoking history was calculated by dividing the number of cigarettes smoked per day by 20 (the number of cigarettes in a pack) and multiplying the result by the number of years of tobacco use (pack-years). Regarding physical activity, the participants were classified as physically active or physically inactive on the basis of self-reported physical activity during leisure time in the month prior to the interview.

Alcohol consumption was assessed on the basis of the type of alcoholic beverage consumed, the frequency of consumption, and the amount consumed in the week preceding the interview. The amount of alcohol consumed was calculated on the basis of the average alcohol content of the most common alcohol beverages available, including beer (5%), wine (12.5%), and spirits (39%). Alcohol consumption was expressed in units per week, each unit of alcohol amounting to 10 g of alcohol consumed per week.

All anthropometric measurements were taken prior to blood donation. Waist circumference (WC) was taken at the natural waistline, given that this more accurately reflects visceral adipose tissue.[18] Hip circumference was measured at the level of the maximum extension of the buttocks, at the largest prominence of the gluteal muscle. A flexible, inextensible 200-cm tape measure with 0.1-cm precision was used. Circumference measures were taken in duplicate, in accordance with the recommendations by Callaway et al.[19] In order to calculate the waist-to-hip ratio (WHR), we used the mean WC and the mean hip circumference.

Weight and body composition were assessed with a bioelectrical impedance device (TBF-305; Tanita Inc., Tokyo, Japan) with a low-frequency (50-kHz) 500-μA current and 0.2-kg precision. Height was measured with a self-retracting tape measure attached to a wooden pole and mounted to a wall with no baseboard. Details on the techniques used in order to take the anthropometric measurements have been described elsewhere.[13]

Categorical variables were described as absolute frequencies and 95% CIs. The means of variables with non-normal distribution were compared by the nonparametric Mann-Whitney test and the nonparametric Kruskal-Wallis test. Multiple linear regression analysis was performed to assess the association between smoking and abdominal fat, adjusted for potential confounders. The level of significance required in order to reject the null hypothesis was set at 5% ($p \leq 0.05$).

The dependent variable was abdominal fat, represented by WC or WHR in separate models. Neither WC nor WHR showed normal distribution, both therefore requiring a logarithmic transformation in order to meet the required assumption of normal distribution in the linear regression models.

Because the results of the analysis using models with and without logarithmic transformation were similar, we chose to present the results obtained with non-log-transformed dependent variables to facilitate their interpretation. The main independent variable of the study was smoking, which was treated as a dummy variable to test its effect on abdominal adiposity at different exposure levels, comparing smokers with never smokers.

The models were adjusted for age, skin color/ethnicity, number of years of schooling, income, percentage of body fat, physical activity, and alcohol consumption. The percentage of body fat was used in the models in order to remove the effect of total adiposity, because it is more effective than the body mass index (BMI) for this purpose.[20]

The present study was conducted in accordance with Brazilian National Health Council Resolution 196/96 and was approved by the Research Ethics Committee of the Júlio Muller University Hospital (Protocol no. 703/CEP-HUJM/2009).

Results

The mean age of the respondents in the present study was 30.00 ± 8.32 years. Of the 1,235 respondents, most (56.7%) were in the 20-29 year age bracket, had mixed skin color (55.2%), and had had more than eight years of schooling (73.0%). There was a high prevalence of alcohol consumption (52.0%) and physical inactivity during leisure time (44.5%). With regard to smoking, 22.1% of the respondents reported being current smokers, and 36.3% reported smoking more than 15 cigarettes/day; in addition, 16.3% of the respondents were former smokers and 61.6% were nonsmokers (Table 1). The BMI was significantly lower in the smokers than in the nonsmokers and former smokers ($p < 0.001$).

The mean smoking history was lower among younger respondents than among those older than 30 years of age ($p < 0.001$), as were the mean anthropometric indicators of body fat distribution ($p < 0.001$). Alcohol consumption

Table 1 - Sociodemographic and lifestyle characteristics of the male blood donors studied.

Variable	Participants (n = 1,235)	
	n	%
Age bracket, years		
20-29	700	56.7
30-39	363	29.4
40-59	172	13.9
Skin color/ethnicity		
White	441	35.7
Mixed	682	55.2
Black	112	9.1
Schooling, years		
≤ 8	333	27.0
> 8	902	73.0
Alcohol consumption		
Yes	641	51.9
No	594	48.1
Physical activity during leisure time		
Yes	687	55.6
No	548	44.4
Smoking status		
Nonsmokers	761	61.6
Current smokers	273	22.1
Former smokers	201	16.3

(g of alcohol/day) was higher among younger respondents ($p = 0.01$) than among those older than 30 years of age (Table 2).

We found that WC was higher among those who were older ($p < 0.001$), who were White ($p = 0.05$), and who had had fewer years of schooling ($p = 0.01$). The mean values of WHR in relation to the sociodemographic variables were similar to those of WC, showing a direct association with age and an inverse association with the level of education (Table 3).

The mean values of WC and WHR were higher in alcohol consumers, and the mean values of WHR were higher in smokers, indicators of fat deposition therefore showing a direct linear association ($p < 0.001$) with smoking history and alcohol consumption.

The mean values of WC and WHR were lower among those who reported being physically active during leisure time than among those who reported being physically inactive ($p < 0.001$; Table 3).

After the linear regression models were adjusted for confounders, smoking remained associated with WC and WHR ($p < 0.001$), having an independent effect on abdominal fat in smokers of more than 5 cigarettes/day (Table 4).

Discussion

The results of the present study showed a positive association between smoking and abdominal fat. This association was found for WC and WHR among smokers of more than 5 cigarettes per day, regardless of other factors.

Various studies have investigated the association between smoking and body weight.[21-23] Smokers typically weigh less than nonsmokers.[22-25] The present study showed that the BMI was significantly lower in the smokers than in the nonsmokers and former smokers ($p < 0.001$). Smokers, especially women,[5] have often cited this as a reason for not quitting smoking.[10,16,26] In the first year of smoking cessation, men gain 2 kg, whereas women gain 3.1 kg.[2]

It is of great importance to study the association between smoking and abdominal adiposity, given the increased risk of obesity associated with visceral fat.[8] Studies have shown that smoking can simultaneously affect lipoprotein lipase activity and increase cortisol levels, leading to accumulation of fat in the abdominal adipocytes.[8,16] In comparison with total adiposity, central adiposity is more strongly associated with outcomes such as dyslipidemia,[20] hypertension,[17] and diabetes mellitus.[27]

When the association between smoking and body fat distribution is investigated, there is a need to control potential confounders, especially alcohol consumption, which has a direct relationship with smoking[28] and has been suggested as a strong predictor of abdominal fat.[13] In our study, the bivariate analysis showed an association between the outcome measures and known risk factors, such as age, ethnicity, alcohol consumption, physical activity, and smoking. Although we also found an association between the number of years of schooling and WC/WHR, the finding might be clinically unimportant.

The influence of tobacco use on abdominal fat is still unclear. In the present study, the multivariate linear regression analysis confirmed the association between anthropometric indicators of abdominal adiposity (WC and WHR) and smoking after the adjustment for a few factors, including alcohol consumption. The study results showed a dose-response effect on these associations for both WC and WHR. When compared with nonsmokers, smokers of 6-10 cigarettes/day had

Table 2 - Lifestyle characteristics and variables related to nutritional status and body composition in the male blood donors studied.

Variable	Age bracket, years						p*
	20-29		30-39		40-59		
	Mean	SD	Mean	SD	Mean	SD	
Alcohol consumption, g of alcohol/day	9.9	17.6	7.7	14.0	4.4	8.0	< 0.01
Smoking history, pack-years	5.6	5.0	13.1	8.8	21.5	12.2	< 0.001
Body mass index, kg/m^2	23.6	2.8	25.0	2.9	25.5	2.6	< 0.001
Body fat, %	17.3	5.6	20.1	5.9	21.1	5.4	< 0.001
Waist circumference, cm	78.2	7.1	82.9	7.1	86.6	7.6	< 0.001
Waist-to-hip ratio	0.860	0.05	0.890	0.05	0.919	0.04	< 0.001

*Kruskal-Wallis test.

Table 3 – Waist circumference and waist-to-hip ratio in relation to sociodemographic and lifestyle characteristics in the male blood donors studied.

Variable	Participants (n = 1,235)	WC	P	WHR	P
	n	Mean (95% CI)		Mean (95% CI)	
Age bracket, years*					
20-29	700	78.23 (77.70-78.76)	< 0.001	0.86 (0.85-0.86)	< 0.001
30-39	363	82.88 (82.14-83.61)		0.89 (0.88-0.89)	
40-59	172	86.61 (85.46-87.76)		0.91 (0.91-0.92)	
Skin color/ethnicity*					
White	441	81.44 (80.69-82.18)	0.05	0.88 (0.87-0.88)	0.23
Mixed	682	80.54 (79.95-81.12)		0.87 (0.87-0.88)	
Black	112	79.53 (78.06-80.99)		0.87 (0.86-0.88)	
Schooling, years**					
≤ 8	333	81.70 (80.85-82.54)	0.01	0.89 (0.88-0.89)	< 0.001
> 8	902	80.42 (79.91-80.93)		0.87 (0.86-0.87)	
Alcohol consumption**					
Yes	641	81.36 (80.75-81.97)	0.01	0.88 (0.87-0.88)	< 0.001
No	594	80.12 (79.50-80.75)		0.87 (0.86-0.87)	
Units of alcohol/week*					
None	594	80.12 (79.50-80.75)	0.01	0.87 (0.86-0.87)	< 0.001
0.1-21.9	565	81.23 (80.59-81.87)		0.88 (0.87-0.88)	
≥ 22	76	82.30 (80.28-84.32)		0.89 (0.87-0.89)	
Physical activity during leisure time**					
Yes	687	79.24 (78.70-79.79)	< 0.001	0.86 (0.86-0.87)	< 0.001
No	548	82.67 (81.99-83.35)		0.89 (0.88-0.89)	
Smoking status*					
Current smokers	273	82.10 (81.17-83.03)	< 0.001	0.91 (0.90-0.91)	< 0.001
Nonsmokers	761	79.68 (79.15-80.22)		0.86 (0.86-0.87)	
Former smokers	201	83.03 (81.88-84.17)		0.88 (0.87-0.88)	
Smoking history, pack-years*					
Nonsmokers	962	80.38 (79.89-80.88)	< 0.001	0.86 (0.86-0.87)	< 0.001
0.1-5.1	102	78.20 (77.05-79.35)		0.86 (0.85-0.87)	
5.2-11.9	94	82.77 (81.38-84.15)		0.91 (0.91-0.92)	
≥ 12.0	77	86.46 (84.47-88.44)		0.96 (0.95-0.97)	

WC: waist circumference; and WHR: waist-to-hip ratio. *Kruskal-Wallis test. **Mann-Whitney test.

Table 4 – Crude (β) and adjusted (β_{ADJ}) linear regression coefficients and p values (p) of the smoking habit and the indicators of fat distribution in the male blood donors studied.

Smoking habit, cigarettes/day	WC*				WHR*			
	β	p	β_{ADJ}	p	β	p	β_{ADJ}	p
1-5	−2.09	0.07	0.28	0.63	−0.004	0.60	0.007	0.22
6-10	0.79	0.04	1.86	< 0.001	0.03	< 0.001	0.03	< 0.001
≥ 11	3.44	< 0.001	3.90	< 0.001	0.07	< 0.001	0.07	< 0.001

WC: waist circumference; and WHR: waist-to-hip ratio. *Models adjusted for age, skin color/ethnicity, number of years of schooling, body fat, physical activity, income, and alcohol consumption.

a 2-cm increase in WC, whereas smokers of ≥ 11 cigarettes/day had a 4-cm increase. Some studies have failed to show this association.[10,21]

Consistent with the results of the present study, Filozof et al.[5] reported that smoking history (in pack-years) caused a linear increase in the prevalence of increased WC and WHR, suggesting a positive association.

A study involving 21,828 men and women aged 45-79 years and living in Norfolk, UK, reported that those with higher cumulative exposure to tobacco (i.e., a higher number of pack-years) had higher WHR than did nonsmokers, even after adjusting for confounders, including alcohol consumption.[8]

Metabolic changes associated with smoking are more likely to occur in individuals with a long smoking history.[29] A cohort study conducted in the USA and involving men and women aged 51-72 years found that current and former smokers with a long smoking history had a higher mortality risk. When compared with nonsmokers, current smokers with a high WC had a fivefold increase in the mortality risk.[24] However, smoking cessation can reduce morbidity and mortality risks. In patients with coronary artery disease, smoking cessation can lead to a 36% reduction in the risk for all-cause mortality, regardless of age and gender.[4]

Studies have explored the effect of tobacco on health and found a strong association between smoking and diabetes mellitus in smokers,[29] especially among heavy smokers (> 20 cigarettes/day), when compared with nonsmokers.[3] The prevalence of obesity in children of mothers who smoked during pregnancy has also been reported.[3,30]

In the present study, the mean smoking history was higher among older smokers than among younger smokers, which is most probably related to longer tobacco use among older individuals and, therefore, to a longer smoking history. A study conducted in Brazil showed similar results among men, and the frequency of heavy smoking (> 20 cigarettes/day) was twice as high in those aged 18-24 years and in those aged 55-64 years, declining thereafter.[7] Greater tobacco exposure, together with an increased risk with age, increases the health risks in this population group.

In our study, BMI and other indicators of abdominal adiposity had a lower mean among younger respondents ($p < 0.001$). These findings are consistent with those reported by Skrzypcak et al.[11] and with those reported in another study conducted in Brazil, which found a similar trend[14] pointing to age as a strong predictor of total and local fat deposition.

Despite having been adjusted for potential confounders, our analysis of the association between smoking and indicators of abdominal adiposity revealed a direct association between smoking and the outcomes studied (i.e., WC and WHR).

The present study has some limitations. Its cross-sectional design does not allow us to infer a causal relationship between smoking and the outcomes studied. In addition, our sample comprised only male blood donors, which might have introduced a selection bias, given that such individuals are usually younger and healthier than the general population. Therefore, because of the characteristics of our study, the results should be interpreted with caution.

Given the persistence of the smoking habit and the increased prevalence of abdominal obesity in the population, our results might contribute to the development of interventions for preventing and reducing smoking as a means of reducing the risk of central obesity and, consequently, the risks of chronic non-communicable diseases in the population. On the basis of our results, we conclude that smoking is associated with abdominal adiposity, regardless of alcohol consumption and other confounders.

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About the authors

Cássia da Silva Faria
Nutritionist. Collective Health Institute, Federal University of Mato Grosso, Cuiabá, Brazil.

Clovis Botelho
Full Professor. Federal University of Mato Grosso, Cuiabá, Brazil.

Regina Maria Veras Gonçalves da Silva
Adjunct Professor. Federal University of Mato Grosso, Cuiabá, Brazil.

Márcia Gonçalves Ferreira
Adjunct Professor. Federal University of Mato Grosso, Cuiabá, Brazil.