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Family income per capita, age, and smoking status are predictors of low fiber intake in residents of São Paulo, Brazil

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ABSTRACT

We hypothesized that dietary total fiber intake may be less than recommendations and that the intake of total, soluble, and insoluble fiber may be associated with demographic, lifestyle, and socioeconomic factors. Data were drawn from the Health Survey of São Paulo, a cross-sectional population-based study. Adolescents, adults, and elderly persons living in São Paulo city were included. Demographic, lifestyle, and anthropometric data were collected from households. Dietary intake was measured using two 24-hour dietary recalls. All analyses were conducted based on the sample design of the study. The proportion of individuals who met the adequate intake (AI) for total fiber intake was examined, and foods that contributed to the intake of fiber and fractions were evaluated. The relationship of total, soluble, and insoluble fiber intake with demographic, socioeconomic, and lifestyle characteristics was determined using multiple linear regression models. A low proportion of individuals met the AI for dietary fiber. The foods that most contributed to total fiber intake were beans, French bread, and rice. Total fiber intake was negatively associated with former and current smokers and positively associated with family income per capita and age. Soluble fiber intake was negatively associated with current smokers and positively associated with female sex, age, and family income per capita. Insoluble fiber intake was negatively associated with former or current smokers and positively associated with age. In summary, residents in the city of São Paulo had a low fiber intake, and demographic, socioeconomic, and lifestyle factors were associated with dietary fiber and intake of its fractions.

Abbreviations: 24HR, 24-hour dietary recall; AI, adequate intake; BMI, body mass index; HBS, Brazilian House Budget Survey; NDSR, Nutrition Data System for Research.

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1. Introduction

Dietary fiber intake exhibits numerous health benefits, including reduced risk of diabetes [1], metabolic syndrome [2], cardiovascular events and diseases [3,4], and some types of cancer [5]. A recent systematic review and meta-analyses of cohort studies [6] found that for every 10-g/d increase in dietary fiber, there was a concomitant reduction of 11% for all-cause mortality, 9% for cancer mortality, 20% for cardiovascular disease mortality, and 34% for ischemic heart disease mortality, which are the leading causes of death worldwide [7].

However, these beneficial effects are dependent on the fraction of fiber consumed and the food sources of this nutrient [2,8]. Historically, dietary fiber was classified into soluble and insoluble based on its solubility. The solubility of soluble fiber is attributed to the hypocholesterolemic effect, which occurs via the association of the soluble fraction with bile salts and cholesterol in the aqueous environment of the small intestine, which decreases its absorption. The soluble fraction promotes the formation of short-chain fatty acids in the large intestine, which reduces cholesterol synthesis [9,10]. Insoluble fiber decreases the transit time in the large intestine and contributes to the control of postprandial glucose by delaying gastric emptying and the absorption process [11].

The *Codex Alimentarius* defines *dietary fiber* as "carbohydrate polymers with ten or more monomeric units not hydrolyzed by the endogenous enzymes in the small intestine of humans" [12]. However, there is no consensus between countries on the definition of fiber. Some authorities consider the physiological effects of fiber to establishing its definition, but other authorities consider analytical methods [11].

The lack of consensus on the definition of dietary fiber and differences between analytical methods to evaluate fiber contribute to discrepancies in the recommendations for fiber intakes between countries [13]. Brazil adopts the recommendation of the Food and Agriculture Organization and World Health Organization for fiber intake, which is a daily consumption of ≥25 g [14]. However, data from a cross-sectional study involving a probabilistic sample of the entire country performed in 2008-2009, the Brazilian Household Budget Survey (HBS), suggest that the population consumes much less fiber than recommended [15]. This scenario was also observed in the populations of other countries, such as England [13], the United States [16], France, Sweden [17], and Germany [18].

Low fiber intake is one feature of the modern lifestyle and eating patterns that have been known for decades [19]. However, reversing this trend remains a public health challenge [20]. Studies suggest that some factors, such as income, education, and place of residence, are critical determinants for the consumption of dietary fiber in high-, middle-, and low-income countries [21–23]. Understanding these relationships becomes fundamental for the planning of public policies with a focus on vulnerable population groups.

We hypothesized that subjects living in São Paulo have low dietary fiber intake and that demographic, socioeconomic, and lifestyle factors may be associated with decreased intake of this nutrient. The present study investigated total, soluble, and insoluble fiber intake in adolescents, adults, and elderly persons living in the city of São Paulo, Brazil; the demographic, lifestyle, and socioeconomic factors that are associated with these nutrients; and foods that contribute to the intake of fiber and its fractions.

2. Methods and materials

2.1. Study design and population

Data were collected from the Health Survey of São Paulo (ISA-Capital 2008). This study was a cross-sectional population-based study using a complex multistage sampling design to collect health and nutrition information and life conditions of a representative sample of residents of the city of São Paulo, Southeastern Brazil, between 2008 and 2009.

A 2-stage cluster sampling of census tracts and households was performed. A total of 70 census tracts were randomly selected from the 267 urban census tracts in the city of São Paulo as the primary sampling units in the first stage. A total of 16,607 households were randomly selected within census tracts in the second stage. This sampling was drawn from the following domains: infants (<1 year old), children (1-11 years), male adolescents (12-19 years), female adolescents (12-19 years), male adults (20-59 years), female adults (20-59 years), male elderly (≥60 years), and female elderly (≥60 years). Nutrition information was collected in a subsample of adolescents, adults, and elderly persons of both sexes. Different sampling fractions were used based on the participation of age groups in the population of the urban area of São Paulo to preserve the representativeness of each domain. The sample size was calculated for to estimate proportions of 0.5 with a sample error of 0.07 at a 5% significance level and design effect of 1.5.

The study sample comprised 1662 individuals: 560 adolescents, 585 adults, and 517 elderly adults. Demographic, socioeconomic, and lifestyle data were collected from households using a structured questionnaire administered by trained interviewers (Figure).

Age was measured in years calculated as the difference between the date of data collection and date of birth of the respondent, and participants were classified into age groups. Self-reported skin color was classified as white, black, brown, and others. Family income per capita was calculated by summing the monetary income reported by all family members and dividing by the number of family members, and the results were classified as ≤1 minimum wage or >1 minimum wage (minimum wage in 2008 = US $260.00 per month). The educational level of the household head was measured in years of schooling and categorized as ≤9 (until complete elementary school) or ≥10 years of study (since high school). The smoking status was classified as current, former, or never smoker.

The Ethics Committee of the Public Health School of University of São Paulo approved the study protocol (CAAE no. 26800414.1.0000.5421), and all participants provided written informed consent.

2.2. Dietary intake

Dietary intake was assessed using two 24-hour dietary recalls (24HRs). Trained interviewers administered the first 24HRs (n =

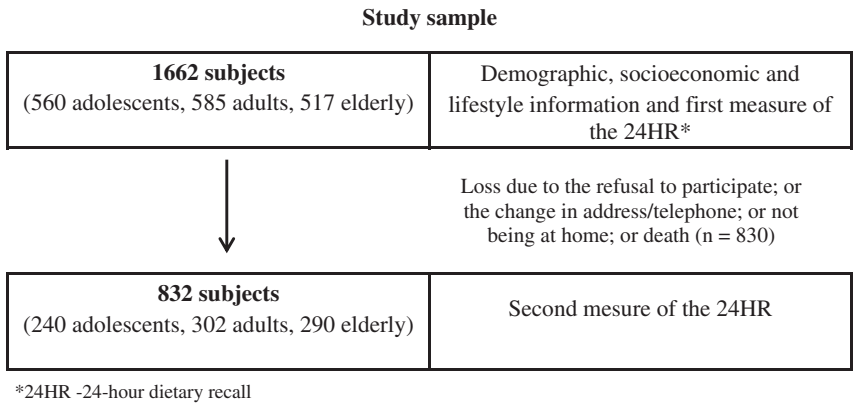

Figure – Flowchart of ISA-Capital sample used in this study. São Paulo, 2008.

1662) in the households using the Multiple Pass Method. The respondent in this process is guided through 5 steps (quick listing, quick listing review, naming meals, detail cycle, and general review) using a standardized process that keeps individuals interested and engaged in the interview, which helps them recall all items consumed [24].

Trained interviewers performed the second measure of the 24HRs (n = 832) on the telephone using the interview system of the Nutrition Data System for Research software (NDSR) version 2007, which was developed by the Nutrition Coordinating Center at the University of Minnesota, Minneapolis, MN, USA. This system resembles the Automated Multiple Pass Method because it uses the same structure for the collection of dietary data in 5 steps [25,26]. Both 24HRs were collected on nonconsecutive days and represented each day of the week (70% of 24HRs were performed on weekdays, and 30% were performed on weekends) and every season.

The NDSR software uses the American food composition database developed by the United States Department of Agriculture. The adequacy of the nutritional values of foods included in the software was checked using the Brazilian Table of Food Composition [27]. A consistency analysis of dietary data was performed to identify possible errors in data collection and processing.

The 955 foods consumed in the first 24HR were classified into 270 food groups based on the frequency of consumption and similarity in dietary fiber content to determine the foods that contribute to the fiber intake of residents in São Paulo city. Foods that were consumed fewer than 8 times were grouped with other food items based on the similarity of dietary fiber content and considering the food group, for example, sandwich cookies and butter cookies. The organizational contribution of each item to the total, soluble, and insoluble fiber intake was determined using the method proposed by Block et al [28], considering the study sampling design. This method estimates the corresponding percentage to foods or food groups consumed by the population from the total intake of the nutrient in question.

2.3. *Anthropometric data*

Self-reported weight and height data were used. These data were validated by Carvalho et al [29], who observed a high sensitivity (>91%) and specificity (>83%) in all age and sex groups for body mass index (BMI) calculated based on these data. BMI was calculated using the Quetelet equation (BMI = weight [kg]/height [m]^2), and the results were classified as follows: (1) adolescents—underweight, BMI <3rd percentile; normal weight, BMI >3rd percentile and <85th percentile; overweight, BMI >85th percentile and <97th percentile; obese, BMI >97th percentile [30]; (2) adults—underweight, BMI <18.5 kg/m^2; normal weight, BMI between 18.5 and 24.9 kg/m^2; overweight, BMI between 25 and 29.9 kg/m^2; obese, BMI ≥30 kg/m^2 [31]; and (3) elderly—underweight, BMI <23 kg/m^2; normal weight, BMI between 23 and 27.9 kg/m^2; overweight, BMI between 28 and 29.9 kg/m^2; obese, BMI ≥30 kg/m^2 [32].

2.4. *Physical activity*

Physical activity was defined as physical activity practiced for at least 30 minutes daily, 5 days per week, at a moderate intensity or at least 20 minutes daily, 3 days per week, at a vigorous intensity using the questions for leisure time from the International Physical Activity Questionnaire long version [33]. Physical activity status was classified as sufficiently or insufficiently active.

2.5. *Statistical analyses*

All analyses were conducted using the appropriate sample weights using the survey module commands in Stata version 11.0 to account for the complex survey design. A significance level 2-sided of .05 was adopted.

The usual total, soluble, and insoluble fiber intake was estimated using statistical modeling techniques incorporated in the Multiple Source Method software [34], which is an online platform that estimates the usual intake of nutrients and foods collected from each individual of the sample or a part of the sample. The software considers the combination of the probability and the amount of intake to estimate the distribution of usual intake. These nutrients were energy-adjusted using the residual method [35]. No substantial difference was found in the distribution of total, soluble, and insoluble fiber intakes with and without energy adjustment, and the adjusted data were retained.

Total, soluble, and insoluble fiber intakes are described as medians and the interquartile range based on demographic,

socioeconomic, and lifestyle variables. The Theil-Sen median test for complex survey was used to examine the difference between these characteristics based on life stage group and sex [36].

The proportion of individuals who met the adequate intake (AI) for total fiber intake was examined using the method proposed by the Institute of Medicine of the United States [37] for nutrients with AI.

The relationship of total, soluble, and insoluble fiber intake with demographic, socioeconomic, and lifestyle characteristics was determined using multiple linear regression models. The following 3 regression models were made: (1) dependent variable: energy-adjusted total fiber; (2) dependent variable: energy-adjusted soluble fiber; and (3) dependent variable: energy-adjusted insoluble fiber. All of the models had the following factors as independent variables: sex, age, physical activity, smoking status, family income per capita, BMI, and self-reported skin color. The final model was accepted after residual analysis.

3. Results

The sample studied included subjects that were predominantly female (53.5%); were predominantly adult (71.0%); and had a self-reported skin color of white (58.5%), a family income per capita ≥1 minimum wage (61.4%), and >10 years of education (53.2%). The sample studied included nonsmokers (64.2%) as well as subjects who were insufficiently active (85.6%) and of normal weight (57.1%).

The median intake of total dietary fiber was 13.1 g daily. Male adolescents consumed 12.6 g daily, and female adolescents consumed 12.7 g daily. Male adults ingested 12.9 g daily, and female adults consumed 13.1 g daily. Elderly men consumed 14.1 g daily, and elderly women consumed 14.1 g daily. The proportion of individuals who met the AI for total fiber intake was 2.0% for the total population, 2.2% for male adolescents, 2.2% for female adolescents, 3.1% for male adults, 1.0% for female adults, 3.2% for elderly men, and 0.8% for elderly women.

Tables 1, 2, and 3 show the medians and interquartile range for total, soluble, and insoluble fiber intake based on sex and life stage group. Total fiber intake was increased in elderly men and women with a household head education of 10 years or more and elderly men with sufficient leisure time physical activity. Soluble fiber intake was increased in the following groups: male adolescents, adults, and elderly women with a family income per capita more than minimum wage; male and female adults and the elderly with a household head education of 10 or more years; female adults and the elderly never smokers; female adolescents and elderly men with sufficient leisure time physical activity; and female adults with obesity. Insoluble fiber intake was increased in elderly men with sufficient leisure time physical activity and male adolescents with a household head education up to 9 years, but it was also increased in elderly men and women with a household head education of 10 years or more.

Table 4 shows 3 multiple linear regression models in which total, soluble, and insoluble fiber intakes were dependent variables. A higher family income per capita (β = 0.04; 95% confidence interval [CI], 0.01-0.06) and age (β = 0.36; 95% CI, 0.25-0.47) were associated with increased total fiber intake, and being a former (β = –0.88; 95% CI, –1.58 to –0.19) and current smoker (β = –1.03; 95% CI, –1.74 to –0.33) was associated with decreased total fiber intake (model 1). A higher family income per capita (β = 0.02; 95% CI, 0.01-0.03), higher age (β = 0.09; 95% CI, 0.05-0.13), and being female (β = 0.38; 95% CI, 0.16-0.58) were associated with increased soluble fiber intake, and being a current smoker (β = –0.38; 95% CI, –0.60 to –0.09) was associated with decreased soluble fiber intake (model 2). A higher age (β = 0.29; 95% CI, 0.20-0.38) was associated with increased insoluble fiber intake, and being a former (β = –0.64; 95% CI, –1.15 and –0.14) and current smoker (β = –0.79; 95% CI, –1.31 to –0.27) was associated with decreased insoluble fiber intake (model 3).

Table 5 describes 15 food items that collectively accounted for more than 50% of the dietary total, soluble, and insoluble fiber intake. Beans were the main source of total fiber intake, followed by French bread, rice, oranges, and bananas. French bread was highest in soluble fiber ranking, followed by oranges, yogurt with high fiber content, French fries, and bananas. The greatest contributors to insoluble fiber intake were beans followed by French bread, rice, bananas, and tomatoes.

4. Discussion

The results demonstrated that a low proportion of individuals met the AI for total fiber intake, which confirms the hypothesis of the study. There are no specific recommendations for soluble and insoluble fiber, but an insufficient intake of the fiber fractions is possible. The intake of total, soluble, and insoluble fiber was associated with sex, age, income, and smoking status. The main foods that contributed to fiber intake are generally not considered good sources of fiber.

Foods that most contributed to total fiber intake were beans, followed by French bread and rice. These foods are typical Brazilian foods, and the frequency of their consumption renders them important contributors to total fiber intake for the study population. For example, 100 g of French bread contains 2.3 g of dietary fiber, and boiled rice contains 1.6 g of dietary fiber. These amounts are low compared with other foods that are available to the population, such as guava (10.5 g per 1 unit) and persimmon (7.2 g per 1 unit) [27].

Data on the most consumed foods from the HBS 2008-2009 survey suggest that the dietary intake of Brazilians is derived from a combination of a traditional diet based on rice and beans (foods considered of good nutritional quality and contributors to total fiber intake) concomitant with the consumption of high-calorie, low-nutrient foods, such as soft drinks, candies, and fried and baked snacks [38].

Residents in the city of São Paulo had a similar total fiber intake to the adult population of the United States, whose average total fiber intake ranged from 13 to 14 g daily [39]. However, the intake observed in the current study population differed from the levels observed in Germany, whose mean fiber intake in adolescent, adult, and elderly populations was approximately 18 g daily [18]. Similar results were observed for France, with an average of 19.2 g daily for men and 16 g

Table 1 – Total, soluble, and insoluble fiber intake according to sex in adolescents [a] (São Paulo, Brazil, 2008)

Variables	Total fiber						Soluble fiber						Insoluble fiber					
	Male			Female			Male			Female			Male			Female		
	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P
Self-reported skin color																		
White	12.5	4.2	.270	12.6	3.8	.508	2.8	1.6	.563	3.0	1.4	.620	9.4	3.7	.078	9.1	3.2	.386
Black and brown	12.8	3.4		12.8	3.9		2.7	1.6		3.0	1.2		10.0	3.0		9.2	2.9	
Others	12.2	0.7		11.6	4.8		2.9	0.3		3.5	2.1		9.3	1.0		8.7	2.7	
Income category																		
≤1 minimum wage	12.7	3.4	.702	12.8	3.7	.708	2.5	1.6	.017	3.0	1.2	.478	9.9	3.4	.235	9.4	3.4	.278
>1 minimum wage	12.3	3.5		12.3	4.6		2.9	1.6		3.0	2.0		9.5	3.3		9.1	3.0	
Household head education																		
≤9 y	13.0	3.6	.075	12.6	4.0	.963	2.7	1.6	.420	2.9	1.4	.065	10.2	3.2	.019	9.5	3.4	.166
≥10 y	12.1	3.7		12.9	4.2		2.8	1.5		3.0	1.6		9.4	3.2		9.1	3.0	
Smoking status																		
Never smoker	12.7	3.8	.089	12.7	4.1	.640	2.8	1.5	.201	3.0	1.2	.190	9.7	3.6	.158	9.1	3.1	.687
Former smoker	11.6	4.4		12.0	3.2		2.7	2.6		3.7	1.5		9.4	2.5		9.2	2.2	
Current smoker	9.6	4.2		13.2	5.2		2.7	1.1		3.3	2.4		7.2	2.5		9.9	3.5	
Physical activity																		
Sufficient	12.7	4.5	.413	12.8	3.0	.876	2.8	1.7	.820	3.4	1.1	.035	10.1	4.4	.244	9.1	2.6	.502
Insufficient	12.5	3.3		12.7	4.1		2.7	1.5		2.9	1.3		9.5	3.1		9.2	3.1	
BMI																		
Underweight	12.2	2.5	.208	15.7	–	.383	2.4	2.1	.574	4.9	–	.100	9.9	1.6	.183	10.2	–	.371
Normal weight	12.6	3.8		12.8	3.8		2.7	1.5		3.0	1.4		9.8	3.8		9.2	2.9	
Overweight	12.0	3.3		11.7	4.8		2.7	1.3		2.6	1.4		9.4	3.2		9.1	3.6	
Obese	12.3	1.6		13.3	4.3		2.9	1.6		3.1	0.9		9.4	1.8		8.2	3.9	

Theil-Sen medians test for complex survey; –: insufficient number of individuals to estimate the IQR. Abbreviation: IQR, interquartile range.
[a] Adolescents: 12-19 years.

daily for women, and Sweden, with an average of 18.1 g daily for men and 16.4 g daily for women [17]. The results in the present study also differed from the data collected in the HBS 2008-2009 survey, which registered a mean total fiber intake of 20.4-23.5 g daily for men and 17.6-18.8 g daily for women [15]. Dietary intake in the national survey was measured using 2 food records, which may explain the observed differences [40].

Recommendations for daily dietary fiber intake are not established, and therefore, this intake was evaluated based on AI. The total fiber intake of residents of São Paulo, Brazil, as a whole and the other countries cited appears to be far less than recommended levels.

Increasing the intake of dietary fiber remains a public health challenge [20]. Therefore, the identification of factors that are associated to the intake of this nutrient remains an important step to guide nutrition policies. Higher age was associated with increased total, soluble, and insoluble fiber intake in this study. Andrade [41] found that the elderly had a better diet quality compared with adults and adolescents when the diet quality of the same study population was examined using the Brazilian Eating Index. Elderly people present a higher risk of developing chronic disease, and the fiber intake may represent an attempt to remedy this condition. The same study also found the worst diet quality in adolescents because of the lower intake of dark green and orange vegetable, legumes, and total grains, which are important sources of dietary fiber.

Smoking status was also associated with fiber intake. Current smokers exhibited decreased total, soluble, and insoluble fiber intake, which corroborates the results observed in previous studies [42,43]. The adoption of unhealthy habits may occur simultaneously with a lower intake of sources of dietary fiber, such as fruits and vegetables, which provides a possible explanation for this finding [44].

Storey and Anderson [45] identified that lower income was associated with lower total fiber intake in the North American population, which is consistent with the present study. A systematic review performed by Mayén et al [21] demonstrated that fruit and vegetable intake was associated with higher socioeconomic status in low- and middle-income countries. These findings are consistent with food price trends in the United States. Fruit and vegetable prices rose between 1950 and 2007, whereas the prices for other foods fell [46]. This trend was also observed in São Paulo between 1939 and 2010,

Table 2 – Total, soluble, and insoluble fiber intake according to sex in adults [a] (São Paulo, Brazil, 2008)

Variables	Total fiber						Soluble fiber						Insoluble fiber					
	Male			Female			Male			Female			Male			Female		
	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P
Self-reported skin color																		
White	13.4	4.4	.411	13.3	4.0	.155	2.7	1.5	.131	3.1	1.5	.149	9.9	3.4	.604	9.8	2.9	.170
Black and brown	12.7	4.6		12.6	4.1		2.6	1.4		3.0	1.3		10.0	3.4		9.4	3.1	
Others	11.8	3.0		13.0	3.7		2.0	0.8		3.8	1.6		9.2	2.5		10.4	4.1	
Income category																		
≤1 minimum wage	13.4	3.4	.653	13.3	3.3	.688	2.3	1.3	.041	2.9	1.4	.105	10.6	2.8	.154	9.9	2.5	.162
>1 minimum wage	12.5	5.1		13.0	4.3		2.7	1.5		3.2	1.4		9.7	3.4		9.4	3.3	
Household head education																		
≤9 y	12.8	3.7	.646	12.8	3.5	.486	2.4	1.4	.035	2.9	1.3	.003	10.2	3.4	.221	9.7	2.6	.653
≥10 y	13.1	5.3		13.2	4.1		2.9	1.6		3.2	1.5		9.7	3.4		9.5	3.4	
Smoking status																		
Never smoker	13.4	4.1	.088	13.0	4.1	.285	2.8	1.4	.115	3.2	1.5	.012	10.4	3.3	.047	9.6	3.0	.360
Former smoker	12.5	2.5		13.1	4.0		2.5	1.2		2.9	1.5		9.4	2.4		9.6	3.6	
Current smoker	12.2	6.1		13.1	3.8		2.4	1.5		2.9	1.1		9.4	3.7		9.4	3.2	
Physical activity																		
Sufficient	12.6	5.6	.387	13.4	4.8	.193	3.0	1.9	.931	3.3	1.4	.183	9.2	5.0	.255	10.2	3.9	.116
Insufficient	12.9	4.3		13.0	3.8		2.6	1.4		3.0	1.4		10.0	3.3		9.5	3.0	
BMI																		
Underweight	14.1	2.4	.950	13.5	3.9	.332	3.7	2.1	.078	2.9	1.7	.024	10.6	0.8	.315	9.4	3.5	.916
Normal weight	12.9	4.2		12.9	3.6		2.5	1.5		2.9	1.2		10.0	3.2		9.6	3.1	
Overweight	13.2	4.6		13.1	3.8		2.9	1.2		3.3	1.6		10.1	3.8		9.5	3.1	
Obese	13.2	5.3		13.4	4.2		3.0	1.8		3.4	1.6		9.1	4.9		10.1	3.0	

Theil-Sen medians test for complex survey.
[a] Adults: 20-59 years.

during which prices fell for some food groups, such as fats, oils, spices, sugar, processed meat and sausages, prepackaged foods, candies, and savory snacks, but rose for fruits and vegetables [47].

The accessibility of food sources of dietary fiber has attracted attention in the literature [48–50], but there is no consensus on the potential impact of the availability of fruits and vegetables on the consumption of these foods. However, promoting an environment with greater availability of healthy foods becomes an important research area in settings with a high prevalence of chronic diseases. Miller et al [51] found gaps between food provisions for the United States population and dietary guidelines of the country, wherein the supply of important sources of dietary fiber, such as fruits, vegetables, beans, and whole foods, was almost or less than half the ideal level between 1970 and 2010.

This scenario and the evidence show the potential health benefits of dietary fiber, and nutrition policies to increase dietary fiber intake should encourage the consumption of foods with higher fiber content and promote the accessibility of these foods. However, strategies that result in increased dietary fiber intake are not well established [20]. Healthy eating promotion is one way to encourage increased fiber intake, such as the "5 a day" initiative implemented in more than 30 countries, which encourages the consumption of at least 5 servings of vegetables, including high-fiber foods such as beans, fruits, and vegetables [52,53]. It would be useful to mention that relatively small differences in fiber intake were observed for the different assessed factors. As no one factor stood out as the largest predictor of low fiber intake, the city would benefit from citywide interventions to improve fiber intake.

Actions should also integrate different sectors of society to meet fiber intake recommendations, which was achieved by The Danish Wholegrain Campaign. This campaign involves partnerships between government, health organizations, and food companies, and it substantially increased the consumption of whole grains from 32 g daily in 2002-2004 to 55 g daily in 2011-2012 [54].

Some limitations of the present study should be considered. This study was a cross-sectional study, and therefore, we cannot determine causality between the factors examined and fiber intake. The dietary assessment used was a source of errors for the estimation of dietary intake because it presents recall errors, omissions, and errors in portion size estimation.

Table 3 – Total, soluble, and insoluble fiber intake according to sex in elderly adults [a] (São Paulo, Brazil, 2008)

Variables	Total fiber						Soluble fiber						Insoluble fiber					
	Male			Female			Male			Female			Male			Female		
	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P	Median	IQR	P
Self-reported skin color																		
White	14.3	5.3	.516	14.3	4.9	.768	3.2	1.8	.092	3.5	1.8	.248	10.8	3.6	.686	10.4	3.2	.706
Black and brown	13.9	3.8		13.6	3.5		2.8	1.7		3.2	1.5		10.8	2.5		10.1	2.6	
Others	13.3	4.6		19.6	4.2		3.0	2.1		5.7	2.5		10.7	3.6		12.7	6.0	
Income category																		
≤1 minimum wage	13.7	4.4	.100	13.5	4.1	.070	2.9	1.5	.155	3.2	1.8	.033	10.1	3.6	.087	9.9	2.9	.205
>1 minimum wage	14.3	4.3		14.8	4.5		3.3	1.8		3.6	1.8		10.9	3.5		10.8	3.2	
Household head education																		
≤9 y	13.7	3.9	.004	13.7	4.1	.001	2.9	1.7	.001	3.2	1.5	.000	10.6	3.0	.011	10.1	2.8	.032
≥10 y	15.0	5.0		15.2	6.2		3.5	2.0		4.0	1.9		11.6	3.6		11.1	4.3	
Smoking status																		
Never smoker	14.3	4.2	.139	14.3	4.5	.104	3.2	1.8	.061	3.6	1.8	.018	10.9	3.6	.279	10.4	3.3	.246
Former smoker	14.5	5.2		14.4	4.5		3.3	1.8		3.3	1.4		10.9	3.4		10.6	3.0	
Current smoker	12.5	3.4		12.5	3.6		2.4	1.2		2.8	1.1		9.8	2.7		9.3	2.4	
Physical activity																		
Sufficient	15.9	6.3	.005	13.1	7.7	.519	3.6	2.6	.005	4.2	1.9	.113	12.4	3.6	.008	9.9	5.1	.681
Insufficient	13.9	4.2		14.1	4.0		3.0	1.6		3.5	1.7		10.7	3.0		10.4	2.9	
Body mass index																		
Underweight	14.3	3.3	.649	14.1	5.2	.662	2.7	1.8	.319	3.6	1.8	.539	11.4	2.9	.285	10.6	3.4	.417
Normal weight	14.0	5.5		14.3	4.7		3.1	1.4		3.4	2.0		10.9	3.7		10.3	3.4	
Overweight	14.5	3.5		14.0	4.8		3.6	1.8		3.5	1.8		10.8	2.9		9.8	3.5	
Obesity	13.4	4.8		14.3	4.1		3.3	1.3		3.8	1.4		10.0	3.7		10.7	3.0	

Theil-Sen medians test for complex survey.
[a] Elderly adults: 60 years or more.

Total, soluble, and insoluble dietary fiber values originated from the NDSR software, which determined information for dietary fiber using chemical analysis or calculated fiber as the sum or difference between fibers types, depending on the fraction of fiber required [55]. These values could differ from the foods that were consumed by the studied population, but there is no sufficient national information available for soluble and insoluble fiber that allows for data correction. Another limitation was the use of soluble and insoluble classification. There is no consensus on the use of the terms *soluble* and *insoluble* [56], but this classification facilitates the comprehension of the role of dietary fiber and the establishment of dietary guidelines to promote the consumption of food fiber sources by the population.

The present study investigated a nutrient that remains a challenge for public health in a representative sample of São Paulo city, which is one of the most populous cities worldwide, an important financial center of South America, and the destination of migrants from different parts of Brazil and other countries [57].

In conclusion, total fiber intake in the study population was insufficient. This finding raises concerns because fiber plays an important role in the prevention of several chronic diseases with rising prevalence. There are no recommendations for soluble and insoluble fiber intake, but the low total fiber intake suggests that the intake of these fractions is similarly low. Individuals with lower family income per capita, those with lower age, and former and current smokers were identified as groups that are vulnerable to the low fiber intake. These characteristics may also be used to better target public health nutrition policies and prioritize easy access of the population to foods with higher fiber content, especially because some of the foods that contributed to fiber intake are not generally considered good sources of fiber.

Authorship

PVFS, CHS, DASV, and MMF were involved in data analysis and interpretation, drafting of the article, and critically revising it for important intellectual content. DMM was involved in the conception and design of the study and critically revising the manuscript for important intellectual content. RMF was involved in the conception and design of the study, data interpretation, and critically revising the manuscript for important intellectual content. All of the authors approved the version to be submitted.

Table 4 – Demographic, socioeconomic, and lifestyle variables associated with total, soluble, and insoluble fiber intake (São Paulo, Brazil, 2008)

Variables	Total fiber [a]		Soluble fiber [b]		Insoluble fiber [c]	
	β	95% CI	β	95% CI	β	95% CI
Sex (ref. male)						
Female	0.10	−0.35 to 0.55	0.38	0.16-0.58	−0.27	−0.60 to 0.07
Age	0.36	0.25-0.47	0.09	0.05-0.13	0.29	0.20-0.38
Physical activity (ref. irregular activity)						
Regular activity	−0.02	−0.97 to 0.93	0.12	−0.20 to 0.43	−0.12	−0.82 to 0.59
Smoking status (ref. nonsmoker)						
Former smoker	−0.88	−1.58 to −0.19	−0.27	−0.55 to 0.00	−0.64	−1.15 to −0.14
Current smoker	−1.03	−1.74 to −0.33	−0.38	−0.60 to −0.09	−0.79	−1.31 to −0.27
Family income per capita	0.04	0.01-0.06	0.02	0.01-0.03	0.02	−0.00 to 0.04
BMI (kg/m^2)	−0.04	−0.11 to 0.03	0.00	−0.01 to 0.03	−0.05	−0.10 to 0.00
Race (ref. white)						
Black and brown	−0.15	−0.54 to 0.23	−0.15	−0.30 to 0.00	−0.03	−0.32 to 0.26
Others	−0.68	−2.06 to 0.70	−0.26	−0.99 to 0.46	−0.61	−1.46 to 0.25

The values of family income per capita were divided per 100 USD. The values of age were divided per 10 years. Abbreviations: β, nonstandard regression coefficient; P, P value; ref., category of reference.
Multiple linear regression models: stepwise forward.
[a] Model 1 (n=1470): dependent variable: energy-adjusted total fiber; independent variables: sex, age, physical activity, smoking status, family income per capita, BMI, and race.
[b] Model 2 (n=1470): dependent variable: energy-adjusted soluble fiber; independent variables: sex, age, physical activity, smoking status, family income per capita, BMI, and race.
[c] Model 3 (n=1470): dependent variable: energy-adjusted insoluble fiber; independent variables: sex, age, physical activity, smoking status, family income per capita, BMI, and race.

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Table 5 – Foods contributing to total, soluble, and insoluble fiber intake (São Paulo, Brazil, 2008)

Rank	Food	Total fiber		Food	Soluble fiber		Food	Insoluble fiber	
		%	% Cumulative		%	% Cumulative		%	% Cumulative
1	Beans	23.35	23.35	French bread	9.02	9.02	Beans	29.97	29.97
2	French bread	7.97	31.32	Oranges	7.18	16.2	French bread	7.86	37.83
3	Rice	4.24	35.56	Yogurt with high fiber content	4.27	20.47	Rice	5.66	43.49
4	Oranges	3.20	38.76	French fries	4.02	24.49	Bananas	2.59	46.08
5	Bananas	2.88	41.64	Bananas	3.98	28.47	Tomato	2.43	48.51
6	Spaghetti with tomato sauce	2.42	44.06	Beans	3.83	32.3	Spaghetti with tomato sauce	2.34	50.85
7	Tomato	2.04	46.1	Potato without skin	3.20	35.5	Popcorn	2.07	52.92
8	French fries	1.95	48.05	Passion fruit juice	2.90	38.4	Oranges	2.04	54.96
9	Potato without skin	1.58	49.63	Other bread	2.61	41.01	Papaya	1.65	56.61
10	Cracker	1.56	51.19	Pizza	2.40	43.41	Lettuce	1.61	58.22
11	Popcorn	1.55	52.74	Cracker	2.29	45.7	Apple with skin	1.43	59.65
12	Apple with skin	1.54	54.28	Spaghetti with tomato sauce	2.26	47.96	Cracker	1.35	61
13	Pizza	1.41	55.69	Chocolate cake	2.05	50.01	French fries	1.35	62.35
14	Baked pastries	1.39	57.08	Sandwich cookies and butter cookies	2.03	52.04	Whole wheat bread and whole wheat cracker	1.29	63.64
15	Sandwich cookies and cookie butter	1.32	58.4	Apple with skin	2.01	54.05	Sandwich cookies and butter cookies	1.13	64.77

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