

# Sedentary behavior, physical activity and body composition in adults

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## SUMMARY

**OBJECTIVE:** We investigated the associations between objectively assessed sedentary behavior (SB) and moderate-to-vigorous physical activity (MVPA) and body composition variables among a representative sample of Brazilian adults.

**METHODS:** Using an accelerometer, SB and MVPA were monitored for at least 5 days in 524 participants (261 men; age, 18-65 years). Each minute epoch was classified as sedentary or spent in light, moderate, or vigorous physical activity (LPA, MPA, and VPA, respectively). The measured body composition variables included abdominal perimeter (AP) and neck circumference (NC).

**RESULTS:** Men accumulated significantly more min/day of MPA (37.82 versus 27.28), VPA (1.10 versus 0.31), MVPA (39.02 versus 27.61), and steps/day (14,978 versus 13,443) than women ( $p < .001$ ). In men, MPA, VPA, MVPA, and steps/day were negatively associated with AP ( $p < .05$ ) independently of SB. Only VPA was significantly associated with NC ( $\beta = 0.113$ ;  $p = .002$ ). In women, only SB was significantly associated with AP ( $\beta = 0.003$ ;  $p = .031$ ). There were no significant associations between physical activity intensities and body composition in women.

**CONCLUSIONS:** Our findings on the unequal association of physical activity with body composition variables between sexes can help inform future intervention strategies in Brasil.

**KEYWORDS:** Accelerometry. Obesity. Anthropometry.

## INTRODUCTION

Physical activity (PA), a pillar in the prevention and treatment of obesity and cardiovascular diseases (CVD), is inversely associated with excess weight<sup>1</sup>. Whereas a high level of sedentary behavior (SB) probably favors obesity<sup>2</sup>. In general, 50.1% of Brazilian

men and 48% of women have excess weight, and 12.4% and 16.9%, respectively, are obese<sup>3</sup>. In addition, only 60.2% of men and 51.5% of the women follow the recommendations of moderate to vigorous physical activity (MVPA)<sup>4,5</sup>. Although population studies have

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revealed that the association between PA and obesity varies according to sex, the relationships between the intensities of PA and health outcomes have not been sufficiently studied. The understanding of these associations is important for the development of public policies and interventions aimed at behavioral changes.

Objective measures of time spent in SB, in different intensities of PA, and the number of steps/day may help to understand the human movement behavior related to obesity. Objective evaluations using accelerometers are commonly included in studies from high-income countries<sup>6</sup>. In contrast, relatively few studies have applied this technology to research in low- and middle-income countries, such as Brasil<sup>6</sup>. The present study investigated the association between SB and MVPA, both objectively assessed, with body composition variables in Brazilian adults according to the intensity of the PA.

## METHODS

### Brazilian Study on Nutrition and Health

The present study was part of the Latin American study on Nutrition and Health (*Estudio Latinoamericano de Nutrición y Salud*, Elans)<sup>7</sup>, conducted in eight countries of Latin America: Argentina, Brasil, Chile, Colombia, Costa Rica, Ecuador, Peru, and Venezuela. The study included data of the Brazilian Study on Nutrition and Health (Ebans)<sup>8</sup>. The Ebans is a cross-sectional, populational, household-based survey. The participants were stratified by geographic location (urban areas only), sex, age, and socioeconomic level (SEL). The data were collected between November 2014 and August 2015. The sample included subjects of both genders, aged between 15 and 65 years, who belonged to various regions and cities<sup>8</sup>. All participants signed the Informed Consent Form, and the comprehensive Elans protocol (60953716.4.0000.5505) was approved by the Federal University of São Paulo, Brasil.

### Participants

In total, 1,436 people who participated in the Ebans did not use an accelerometer or had less than five days of valid data, yielding a final sample of 524 participants. In general, we found no significant differences between the participants who did not use accelerometers and those who had valid data in groups stratified by sex ( $p=0.644$ ), level of formal education ( $p=0.110$ ), and body mass index (BMI) ( $p=0.813$ ).

We excluded from the study: pregnant women and infants, individuals with major physical or cognitive disabilities, which could affect food intake and physical activity, individuals aged <18 or >65 years, who lived in any residential environment that was not a household, and those unable to read.

### Accelerometer

To monitor SB and MVPA objectively, participants were asked to wear a triaxial accelerometer (model GT3X+, ActiGraph, Pensacola) on an elastic band at hip-height, on the right midaxillary line, for seven days. In addition, they were asked to put on the device as soon as they woke up and removed it when sleeping, bathing, or swimming. Verbal and written instructions on how to use the accelerometer were provided. Participants completed a diary indicating the start and end time of use of the device and were encouraged to wear it for 12 hours/day, including on both weekend days. Data from at least five days (including at least one weekend day) from the use of the accelerometer were considered acceptable, with at least 10 hours/day of use after excluding sleep time<sup>9,10</sup>. After removing the nocturnal sleep period, the time of non-use was defined as any period of at least 60 consecutive minutes in a zero-count activity.

On the eighth day of data collection, the research team visited the homes of participants to collect the accelerometers. Data were compiled using the latest version of ActiLife (version 6.0; ActiGraph), collected at a sampling rate of 30 Hz, and downloaded in periods of 60 seconds<sup>11</sup>.

Based on the time accumulated, SB was defined as  $\leq 100$  counts/min, mild PA (MIPA) as  $\geq 101$ -1951 counts/min, moderate PA (MOPA) as  $\geq 1,952$ -5,724 counts/min, vigorous PA (VPA) as  $\geq 5,725$  counts/min, and MVPA as  $\geq 1,952$  counts/min<sup>12</sup>. The participants were classified as having fulfilled or not the recommendations of MVPA<sup>5</sup>.

### Body Composition

Bodyweight was measured with a precision of 0.1 kg using a portable scale (Seca®, Hamburg, Germany) up to 200 kg after removing all heavy clothing items, items in pockets, and shoes<sup>13</sup>. Two measurements were obtained, and the mean was calculated for analysis.

The body height was measured using a portable stadiometer (Seca 213®, Hamburg, Germany) with a measuring range of 0 to 205 cm. After assembling the

stadiometer, the subject's height was measured without shoes on<sup>13</sup>. The subject was positioned under the stadiometer, standing in an upright position with their backs against the wall and their heads positioned on the Frankfurt plane<sup>13</sup>. The measurement, taken while inhaling, was repeated, and the average was used for analysis. The BMI (kg/m<sup>2</sup>) was calculated based on reference data for adults<sup>14,15</sup>.

The abdominal perimeter (AC) was measured to the nearest centimeter, between the last rib and the iliac crest after exhaling, with participants standing up, in accordance with the recommendations by the World Health Organization (WHO)<sup>15,16</sup>. The measurement was taken on exposed skin with non-elastic tape after removing accessories such as belts and girdles in the abdominal region. Each individual stood with their feet together, and arms relaxed on the side of their bodies. The AC (kg/m<sup>2</sup>) was classified based on reference data for adults<sup>17</sup>.

The NC has recently been used to identify obesity and is correlated with age, weight, and BMI in both sexes<sup>18</sup>. The NC (cm) was measured using a non-elastic tape placed right below the larynx, perpendicular to the long axis of the neck, with the tape, on the front and back of the neck, at the same height<sup>19</sup>. The adults were categorized as NC >39 cm for men and NC >5 cm for women<sup>20</sup>. Each measurement was taken twice to ensure accuracy, and the average was used for the analyses.

### Sociodemographic variables

A questionnaire was used to collect demographic information such as age, gender, years of education, race, and marital status. The SEL was also assessed using a questionnaire whose format was based on the national indices used in Brasil<sup>7</sup>. The SEL data were divided into three strata (high, medium, and low).

### Statistical analysis

Descriptive statistics included averages, standard deviations, and frequencies, as appropriate. The Kolmogorov-Smirnov tests were applied to evaluate data distributions. To check for differences between sexes, we used the t-test for independent samples and the chi-square test. The Pearson correlation test was used to evaluate the association between SB, different intensities of PA, steps/day, and body composition variables.

Multiple linear regression models were used to examine the independent associations between SB, PA, steps/day, and body composition variables. Our

first model was adjusted by region (to allow the grouping of the regional level), age, race, educational level, marital status, and employment situation. The second model was added to the MVPA as an adjustment. When considering PA as a dependent variable, we also made adjustments for SB. The calculations were done using SPSS, version 20.0, with a level of significance of  $p < 0.05$ .

## RESULTS

There were significant differences between men and women regarding race, marital status, and employment situation, but not in age and educational level. Men used the accelerometer for significantly more time than women; however, there was no significant difference in the number of valid days of monitoring between the sexes. There were no significant differences between the sexes regarding SB and MIPA. Men accumulated significantly more minutes of MOPA (10.5 min/day), VPA (0.8 min/day), MVPA (11.4 min/day), and steps (1,535 steps/day) than women. In general, 60.9% of the participants met the guidelines for MVPA (Table 1).

There were significant differences between men and women in body weight and height, BMI (kg/m<sup>2</sup>), AC (categorical), and NC (cm); however, there were no significant differences in the classification of the BMI, AC (cm), or NC (categorical) between them (Table 1).

Tables 2 and 3 show the results of the multiple linear regression analysis describing the independent association between variables from the accelerometer with body composition (AC and NC) according to sex. There were no significant associations of the SB and MIPA with the AC in men. MOPA, VPA, MVPA, and steps/day were significantly negatively associated with the AC. In women, only SB was significantly associated with the AC, regardless of region, age, race, educational level, marital status, employment situation, and MVPA. On the other hand, MIPA, MOPA, VPA, MVPA, and steps/day were not associated with the AC (Table 2).

In men, there were no significant associations between SB, MIPA, MOPA, MVPA, and steps/day with the NC. Only VPA was negatively associated with the NC, regardless of region, age, race, educational level, marital status, employment situation, and MVPA. In women, there were no significant associations between any variables from the accelerometer and the NC (Table 3).

## DISCUSSION

This study investigated the association between SB and PA, both objectively assessed, with body composition variables in Brazilian adults. In men, VPA proved to have the greatest potential to influence

body composition (mainly regarding AC) than MPA, even after adjusting for SB. In contrast, we found no significant association between SB and body composition variables. In women, only SB was significantly associated with the AC.

**TABLE 1.** DESCRIPTIVE ANALYSIS (MEAN AND STANDARD DEVIATION, OR FREQUENCY AND PERCENTAGE) OF THE VARIABLES FROM THE ACCELEROMETER AND BODY COMPOSITION IN BRAZILIAN ADULTS

Variables	Men (n=231)	Women (n=293)	p-value*
Age (years)	38.44 (13.08)	39.68 (13.44)	0.269
Ethnicity			
White	87 (38.8)	125 (44.6)	0.014
Black	47 (21.0)	56 (20.0)	
Mixed	37 (16.5)	59 (21.1)	
Others	60 (23.7)	53 (14.3)	
Educational level			
Basic/Primary Education	96 (41.6)	122 (41.6)	0.683
Secondary Education	117 (50.6)	142 (48.5)	
Higher Education	18 (7.8)	29 (9.9)	
Marital status			
Single	83 (35.9)	91 (31.1)	<0.001
Married	133 (57.6)	157 (53.6)	
Widow(er)	1 (0.4)	22 (7.5)	
Divorced	14 (6.1)	23 (7.8)	
Employment Status			
Does not work	120 (51.9)	232 (79.1)	<0.001
Active Worker	111 (48.1)	61 (20.9)	
Time of Vigil (min/day)	925.59 (123.05)	902.32 (116.76)	0.028
Number of days	6.43 (0.66)	6.36 (0.67)	0.205
SB (min/day)	565.84 (130.70)	550.59 (119.87)	0.166
MIPA (min/day)	322.72 (95.89)	324.73 (91.76)	0.116
MOPA (min/day)	37.82 (14.18)	27.28 (19.20)	<0.001
VPA (min/day)	1.10 (0.18)	0.31 (0.14)	<0.001
MVPA (min/day)	39.02 (16.29)	27.61 (19.31)	<0.001
Steps/day	14.978 (5.721)	13.443 (4.610)	<0.001
Meet the recommendations for MVPA	160 (69.3)	159 (54.3)	<0.001
Bodyweight (kg)	79.26 (16.53)	70.87 (14.94)	<0.001
Height (cm)	171.67 (7.00)	159.28 (7.07)	<0.001
BMI (Kg/m <sup>2</sup> )	26.91 (5.43)	27.95 (5.63)	0.003
BMI Classification			
Underweight	7 (3.0)	7 (2.4)	0.380
Normal weight	81 (35.1)	84 (28.7)	
Excess weight	85 (36.8)	108 (36.9)	
Obesity	58 (25.1)	94 (32.0)	
Abdominal circumference (cm)	90.21 (14.07)	88.02 (13.79)	0.590
Bellow the threshold	196 (84.8)	154 (52.6)	<0.001
Neck circumference (cm)	36.88 (4.18)	32.99 (4.23)	<0.001
Bellow the threshold	171 (74.0)	210 (71.7)	0.548

\*Significance value of the Student t-test.

All measurements were calculated from the time of vigil.

SB: sedentary behavior; MIPA: mild physical activity; MOPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate to vigorous physical activity; Min: minutes; BMI: Body Mass Index.

Our results corroborate previous studies that showed a negative relationship between MVPA and body composition variables and risk factors, regardless of SB<sup>21</sup>. The study by Van Dyck et al.<sup>21</sup> showed a curvilinear relationship of MVPA with the BMI and a probability of excess weight/obesity in adults. In men, MOPA and VPA seem to be worthy of behavioral

targets associated with body composition variables. In the present study, VPA was the best predictor of body fat estimates. Similar to the previous findings, our results support the hypothesis that VPA has a potentially greater influence in the AC and NC than MOPA, even after adjusting for SB. Regarding public health, it is suggested that efforts should focus more

**TABLE 2.** ADJUSTED ANALYSES BETWEEN THE ACCELEROMETER VARIABLES AND THE ABDOMINAL CIRCUMFERENCE IN BRAZILIAN ADULTS

Accelerometer variables	Men			Women		
	β coefficient	95% IC	p-value	β coefficient	95% IC	p-value
SB (min/day) <sup>a</sup>	0.002	-0.024, 0.075	0.353	0.002	0.011, 0.038	0.031
SB (min/day) <sup>b</sup>	0.095	0.064, 0.188	0.257	0.003	0.002, 0.006	0.042
MIPA (min/day) <sup>a</sup>	-0.032	-0.021, 0.014	0.609	0.043	-0.011, 0.026	0.456
MIPA (min/day) <sup>c</sup>	-0.058	-0.027, 0.010	0.351	-0.006	-0.020, 0.018	0.913
MOPA (min/day) <sup>a</sup>	-0.047	-0.087, -0.018	0.032	-0.002	-0.038, 0.041	0.951
MOPA (min/day) <sup>c</sup>	-0.005	-0.112, -0.020	0.039	-0.002	-0.048, 0.055	0.398
VPA (min/day) <sup>a</sup>	-0.114	-0.358, -0.104	<0.001	-0.079	-0.379, 0.371	0.074
VPA (min/day) <sup>c</sup>	-0.126	-0.373, -0.107	<0.001	-0.074	-0.425, 0.299	0.083
AFMV (min/day) <sup>a</sup>	-0.055	-0.067, -0.045	0.035	-0.036	-0.074, 0.058	0.914
AFMV (min/day) <sup>c</sup>	-0.076	-0.094, -0.059	0.021	-0.047	-0.086, 0.042	0.377
Steps/day <sup>a</sup>	-0.002	-0.006, -0.001	<0.001	-0.001	-0.001, 0.002	0.465
Steps/day <sup>c</sup>	-0.005	-0.011 -0.005	0.035	-0.002	-0.006, 0.004	0.062

Note: All measurements were calculated from the time of vigil.

SB: sedentary behavior; MIPA: mild physical activity; MOPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate to vigorous physical activity; min: minutes; 95% IC: 95% confidence intervals, p<0.05.

a Basic adjustment: region, age, ethnicity, level of education, marital status, and employment status.

b Full adjustment: region, age, ethnicity, level of education, marital status, employment status, and moderate to vigorous physical activity.

c Total adjustment: region, age, ethnicity, level of education, marital status, employment status, and sedentary behavior.

**TABLE 3.** ADJUSTED ANALYSES BETWEEN THE ACCELEROMETER VARIABLES AND THE NECK CIRCUMFERENCE IN BRAZILIAN ADULTS

Accelerometer variables	Men			Women		
	β coefficient	95% IC	p-value	β coefficient	95% IC	p-value
SB (min/day) <sup>a</sup>	-0.093	-0.006, 0.003	0.123	-0.079	-0.007, 0.001	0.146
SB (min/day) <sup>b</sup>	-0.117	-0.007, 0.002	0.062	-0.095	-0.008, 0.002	0.134
MIPA (min/day) <sup>a</sup>	0.061	-0.003, 0.021	0.331	-0.024	-0.002, 0.008	0.746
MIPA (min/day) <sup>c</sup>	0.205	-0.005, 0.317	0.518	-0.023	-0.007, 0.004	0.735
MOPA (min/day) <sup>a</sup>	-0.082	-0.016, 0.012	0.280	-0.018	-0.028, 0.022	0.163
MOPA (min/day) <sup>c</sup>	-0.083	-0.012, 0.005	0.174	-0.048	-0.067, 0.016	0.101
VPA (min/day) <sup>a</sup>	-0.116	-0.260, -0.041	<0.001	-0.109	-0.382, 0.072	0.054
VPA (min/day) <sup>c</sup>	-0.113	-0.273, -0.032	0.002	-0.074	-0.422, 0.008	0.052
AFMV (min/day) <sup>a</sup>	-0.057	-0.030, 0.014	0.131	-0.280	-0.029, 0.022	0.290
AFMV (min/day) <sup>c</sup>	-0.083	-0.031, 0.008	0.090	-0.043	-0.036, 0.017	0.113
Steps/day <sup>a</sup>	-0.036	0.000, 0.001	0.581	-0.046	0.000, 0.001	0.425
Steps/day <sup>c</sup>	-0.073	0.000, 0.001	0.235	-0.090	0.001, 0.002	0.143

Note: All measurements were calculated from the time of vigil.

SB: sedentary behavior; MIPA: mild physical activity; MOPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate to vigorous physical activity; min: minutes; 95% IC: 95% confidence intervals, p<0.05.

a Basic adjustment: region, age, ethnicity, level of education, marital status, and employment status.

b Full adjustment: region, age, ethnicity, level of education, marital status, employment status, and moderate to vigorous physical activity.

c Total adjustment: region, age, ethnicity, level of education, marital status, employment status, and sedentary behavior.



on the promotion of MOPA than in VPA since MOPA can be achieved by walking and is more likely to be practiced by the population through appropriate promotion strategies.

MIPA was not significantly associated with any body composition variable, a finding consistent with most previous findings, showing no significant associations<sup>22</sup>. It is, therefore, plausible that there is a intensity threshold in PA for body composition benefits. At least 250 min/week of MOPA ( $\geq 3$  metabolic units [METs]) are required if the primary goals are to reduce body mass and fat<sup>23</sup>. There is no recommendation regarding the time necessary of MIPA to achieve weight loss; however, the amount of MIPA necessary to improve body composition is possibly much greater than that of MVPA, given the reduced level of intensity<sup>22</sup>. In addition, evidence suggests that the total volume of PA is a key factor in achieving weight loss<sup>24</sup>. MIPA can help improve individuals' metabolic profile; however, there is a lack of evidence to support the effect of MIPA on the positive effects for CVD in adults<sup>22</sup>.

In our study, SB in women was significantly associated with the AC after adjustments for MVPA. This finding is consistent with a previous study<sup>25</sup>. Campbell et al.<sup>25</sup> found that 1 hour/day in SB causes, on average, during a period of five years, changes in body weight and AC of  $\leq 0.19$  kg, and  $\leq 0.02$  mm, respectively. In addition, previous studies that reported a significant association between sedentary time and weight used mainly questionnaires that included questions about television time as a tool to measure sedentary time and did not report findings on general sedentary time.

On average, men spent more time in MVPA, MOPA, and VPA than women, which suggests that women had a higher prevalence of physical inactivity compared to men. Although the variability was high in each sex, women spent less time in MPA, VPA, and MVPA and had fewer steps/day. Increasing women's participation in MVPA is essential not only for health and quality of life, but also for the potential positive impacts on economic development in different geographical, cultural, and political contexts. We recommend, therefore, that Brazilian policymakers develop initiatives to promote PA among women.

The strengths of this study include the objective measurement of PA using techniques and approaches that are rare in countries like Brasil, unlike most of the previous studies that used questionnaires for indirect measurement of PA<sup>4</sup>. As far as we know, this is the

first study that investigated the associations between accelerometry data with NC in Brasil. However, this study has several limitations: 1) Ebans had a cross-sectional design, preventing inferences on causality; 2) the MVPA estimates may not be representative of the total population of Brasil since participants were recruited based only on an urban residence, sex, age, and SEL; 3) only PA was examined in relation to the weight results; a more complete perspective could have been provided if measures related to diet, sleep, and more accurate measures of body fat had been included.

## CONCLUSION

The present study provided evidence for significant associations between MOPA, VPA, MVPA, and steps/day with the AC. In this study, only VPA was associated with the NC. We found a strong association between MVPA (specifically VPA) and the AC, regardless of SB. VPA had a greater influence on the AC and NC than MOPA. In women, only SB was positively associated with the AC, regardless of MVPA. Our results are informative for the development of public policies and health programs intended to reduce the levels of physical inactivity and obesity, particularly in women.

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## Author's contribution

G. L. M. Ferrari was responsible for the concept of the manuscript, conducted the statistical analyses, interpreted the data, and drafted the manuscript. E. R. Victo contributed to the drafting and critical revision of the manuscript. I. Kovalskys contributed in part to the concept of the study, provided statistical knowledge and critical review. A. V. Mello interpreted the data and drafted the discussion of the manuscript. A. N. Previdelli contributed to the data analysis and interpretation and provided critical revision of the manuscript. D. Solé provided critical revision of the manuscript. M. Fisberg contributed to the concept and design of the project and provided critical revision of the manuscript. All authors provided critical reviews, read, and approved the final manuscript.

## RESUMO

**OBJETIVO:** Investigar a associação do comportamento sedentário (CS) e da atividade física de moderada a vigorosa (AFMV), avaliados objetivamente, com variáveis de composição corporal em uma amostra de adultos brasileiros.

**MÉTODOS:** CS e AVMV foram monitorados por meio de acelerômetros no mínimo por cinco dias, em 524 participantes (231 homens; 18-65 anos). Cada período de epoch de um minuto foi classificado como sedentário, atividade física leve (AFL), moderada (AFM) ou vigorosa (AFV). As variáveis de composição corporal medidas foram: perímetro abdominal (PA) e circunferência do pescoço (CP).

**RESULTADOS:** Os homens acumularam significativamente ( $p < 0,001$ ) mais min/dia em AFM (37,82 versus 27,28), AFV (1,10 versus 0,31), AVMV (39,02 versus 27,61), e passos/dia (14.978 versus 13.443) do que as mulheres. Nos homens, AFM, AFV, AVMV e passos/dia associaram-se ( $p < 0,05$ ) negativamente com PA, independentemente do CS. Somente AFV associou-se significativamente ( $\beta = -0,113$ ;  $p = 0,002$ ) com CP. Já nas mulheres, apenas CS associou-se significativamente com o PA ( $\beta = 0,003$ ;  $p = 0,031$ ). Não houve associações significativas entre as intensidades de atividade física com a composição corporal nas mulheres.

**CONCLUSÕES:** Nossos achados sobre a associação desigual da atividade física com composição corporal entre os sexos aumentam a base de evidências e podem ajudar a informar futuras estratégias de intervenção no Brasil.

**PALAVRAS-CHAVE:** Acelerometria. Obesidade. Antropometria.

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