

## Time trends of physical activity for leisure and transportation in the Brazilian adult population: results from Vigitel, 2010-2019

Tendências temporais da atividade física para lazer e transporte na população adulta brasileira: resultados do Vigitel, 2010-2019

Tendencias temporales de la actividad física para el ocio y el transporte en la población adulta brasileña: resultados del Vigitel, 2010-2019

Alessandra de Carvalho Bastone <sup>1</sup>  
Bruno de Souza Moreira <sup>2,3</sup>  
Karina Simone de Souza Vasconcelos <sup>3</sup>  
Amanda Silva Magalhães <sup>3,4</sup>  
Débora Moraes Coelho <sup>3,4</sup>  
Juliana Ilídio da Silva <sup>5</sup>  
Vanessa Moraes Bezerra <sup>3,6</sup>  
Adalberto Aparecido dos Santos Lopes <sup>3,7</sup>  
Amélia Augusta de Lima Friche <sup>3,4</sup>  
Waleska Teixeira Caiaffa <sup>3,4</sup>  
Amanda Cristina de Souza Andrade <sup>3,5</sup>

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### Abstract

*This time-series study examined a 10-year historical series of the physical activity prevalence for leisure and transportation in the Brazilian adult population. Information from 512,969 adults interviewed from the Vigitel between 2010 and 2019 was analyzed. Individuals who reported practicing at least 150 minutes/week of moderate-intensity physical activity or at least 75 minutes/week of vigorous-intensity physical activity were considered active during leisure time. Individuals who reported walking or cycling to/from work, course, or school at least 30 minutes/day, equivalent to at least 150 minutes/week of moderate-intensity physical activity, were considered active during transportation. The prevalence of physical activity for leisure and transportation was calculated annually and stratified by sex, age group, schooling, and race/skin color. The segmented regression model was applied to analyze the time series. Annual percent change and average annual percent change were calculated. Over time, the prevalence of physical activity for leisure increased, and the prevalence of physical activity for transportation decreased. The highest prevalence of physical activity for leisure was observed among males, young individuals, and those with high education. Older adults, those with high education, and white people presented the lowest prevalence of active transport. Policymakers should propose strategies that encourage and facilitate physical activity for leisure in women, individuals aged  $\geq 35$  years, and those with less education ( $< 12$  years), and physical activity for transportation among older adults ( $\geq 60$  years), those with high education ( $\geq 12$  years), and white people.*

*Exercise; Transportation; Delivery of Health Care*

### Correspondence

A. C. Bastone  
Rua do Ouro 125A, Diamantina, MG 39100-000, Brasil.  
alessandra.bastone@ufvjm.edu.br

<sup>1</sup> Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, Brasil.

<sup>2</sup> Instituto René Rachou, Fundação Oswaldo Cruz, Belo Horizonte, Brasil.

<sup>3</sup> Observatório de Saúde Urbana de Belo Horizonte, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.

<sup>4</sup> Faculdade de Medicina, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.

<sup>5</sup> Instituto de Saúde Coletiva, Universidade Federal de Mato Grosso, Cuiabá, Brasil.

<sup>6</sup> Instituto Multidisciplinar em Saúde, Universidade Federal da Bahia, Vitória da Conquista, Brasil.

<sup>7</sup> Programa de Pós-graduação em Educação Física, Universidade Federal de Santa Catarina, Florianópolis, Brasil.



## Background

The benefits of physical activity are widely recognized for mental and physical health in all age groups <sup>1,2</sup>. The regular practice of physical activity improves physical fitness, bodyweight control, and sleep quality and reduces the risk of cardiovascular diseases, high blood pressure, and type II diabetes <sup>1</sup>. Although these messages are highlighted in every health and well-being guideline <sup>2</sup>, physical activity levels are still insufficient worldwide <sup>3,4</sup>. Besides this pandemic of physical inactivity, the prevalence of obesity is expected to continue rising in the following years <sup>5</sup>, with serious implications for the global burden of chronic diseases. Note that the prolonged quarantine imposed by the COVID-19 pandemic had a negative impact on the physical activity level around the world, contributing to a worse quality of life, and that physical activity has proven to be beneficial in clinical conditions frequently associated with severe COVID-19 <sup>6</sup>. Many countries are currently struggling to attenuate the negative impacts of these diseases, spending large amounts of public funds to keep complex health systems instead of investing in simple and inexpensive actions to promote physical activity <sup>7,8,9</sup>.

This scenario places physical activity at the center of the public health program <sup>10</sup>, with a growing need for evidence on the effectiveness of different strategies to increase its levels. Thus, the scientific literature has shifted from emphasizing indicators and outcomes of physical activity to a more recent focus on context determinants, public policies, and global monitoring <sup>11,12</sup>. However, comprehending all aspects that affect physical activity as a lifestyle behavior is a complex task. Many personal and environmental factors, including age, sex, urban characteristics, safety, income, and others, play a role in people's decision to engage in health practices as part of their daily lives <sup>13</sup>. Similarly, economic and cultural aspects of different communities and regions can impact the perception of barriers encountered by population groups to perform physical activity <sup>13,14</sup>. Nevertheless, most research is conducted in high-income countries <sup>15</sup>.

Brazil has achieved some advances with surveillance programs and specific interventions targeting physical activity in different domains. In recent decades, behavior change programs have focused on physical activity for leisure, with educational and counseling actions associated with infrastructure investments and qualification of human resources <sup>16,17</sup>. Nonetheless, information about the process and impacts of these programs across regional areas and vulnerable groups is scarce <sup>18,19</sup>. These programs have given less attention to physical activity for transportation, with limited actions to promote active commuting for schools or local changes in urban structure and facilities to enable walking and bicycling <sup>17</sup>. The unequal distribution of these initiatives and the shortage of supportive urban environments in many countries of Latin America make sustaining these approaches in the long term more challenging <sup>15,20</sup>.

Among these countries, Brazil stands out for monitoring physical activity behavior since 2006, with the *Risk and Protective Factors Surveillance System for Chronic Noncommunicable Diseases Through Telephone Interview* (Vigitel, in the Portuguese-language acronym) <sup>21</sup>. The Vigitel survey holds people sociodemographic and health information from all capitals and the Federal District, enabling a longitudinal analysis of physical activity among the Brazilian population <sup>22</sup>. An annual scientific report gathering all these data provides a unique opportunity to guide public health decision-making and tailor physical activity promotion strategies according to regional contexts and population profiles.

Despite the successful implementation of physical activity promotion strategies in Brazil, the implementation of actions is still rising, and more research is necessary to identify the circumstances and the differences among groups for the effective and sustainable adoption of an active lifestyle. Therefore, to better understand the physical activity pattern at the national level in different groups and guide policymakers to develop strategies to promote public health, this study aimed to analyze a historical series of the physical activity prevalence for leisure and transportation in the Brazilian population according to sex, age group, schooling, and race/skin color, by a 10-year temporal trend from 2010 to 2019. We have also investigated the difference in the overall prevalence of physical activity in both domains in the Brazilian state capitals and Federal District comparing the rates of the initial and final years of the historical series.

## Methods

This time-series study analyzed data from the Brazilian adult population ( $\geq 18$  years) from the Vigitel between 2010 and 2019. The Vigitel is a population-based study, started in 2006, whose objective is to monitor, by a telephone survey, the frequency and distribution of the main determinants of chronic diseases. For that purpose, each year, the system obtains probabilistic samples of adult individuals residing in households with at least one landline phone registered in each of the Brazilian state capitals and Federal District <sup>23,24</sup>.

The Vigitel sample size calculation defined a minimum sample of approximately 2,000 adults per city/year to estimate the frequency of any risk factor in this population, using a 95% confidence interval (95%CI) and a maximum error of two percentage points. For specific estimates, according to sex, a maximum error of three percentage points was expected, assuming similar proportions of women and men in the sample.

Briefly, the Vigitel sampling procedure is conducted in two stages. In the first stage, 5,000 probabilistic samples of telephone lines in each city are drawn. The Vigitel obtains the lists of telephone lines from the landline phone companies operating in the cities. Commercial and non-operational lines are excluded. This draw takes place systematically and stratified by region of the city or according to the prefix of the phone lines (area code). Then, the phone line samples are drawn again and organized into replicas of 200 lines. Each replica reproduces the same distribution ratio as the original record. The second stage involves identifying active residential lines in parallel with randomly selecting a resident aged 18 or over living in the respective household to answer the questionnaire <sup>23</sup>. More details of the sampling procedure can be seen in a previous publication and the annual report of the Brazilian Ministry of Health <sup>23,24</sup>.

The outcomes considered in this time-series study were the practice of physical activity for leisure and transportation. The block of questions corresponding to the physical activity practice was validated by Monteiro et al. <sup>25</sup> and remained unchanged over the analyzed period.

Physical activity for leisure was assessed using the following questions: "In the last three months, have you practiced any type of physical exercise or sport? (yes/no)", "Do you exercise at least once a week? (yes/no)", "How many days a week do you usually practice physical exercise or sport? (1-2; 3-4; 5-6 days/week; every day including Saturday and Sunday)", "On the day you practice exercise or sport, how long does this activity last? (< 10; 10-19; 20-29; 30-39; 40-49; 50-59;  $\geq 60$  minutes)" <sup>24</sup>. Individuals who reported practicing at least 150 minutes/week of moderate-intensity physical activity or at least 75 minutes/week of vigorous-intensity physical activity were considered active during leisure time <sup>26</sup>.

Concerning physical activity for transportation, the following questions were asked: "Do you go to or return from work walking or cycling?" (yes, the entire journey; yes, part of the journey; no)", "How much time do you spend to go to and return from this journey (on foot or by bicycle)? (< 10; 10-19; 20-29; 30-39; 40-49; 50-59;  $\geq 60$  minutes)", "Currently, are you attending a course/school or taking someone to a course/school? (yes/no)", "Do you go to or return from school walking or cycling? (yes, the entire journey; yes, part of the journey; no)", "How much time do you spend to go to and return from this journey (on foot or by bicycle)? (< 10; 10-19; 20-29; 30-39; 40-49; 50-59;  $\geq 60$  minutes)" <sup>24</sup>. Individuals who reported walking or cycling to/from work, course, or school at least 30 minutes/day, equivalent to at least 150 minutes/week of moderate-intensity physical activity, were considered active during transportation <sup>26</sup>.

The prevalence of active individuals in leisure and transportation was calculated annually from 2010 to 2019 for the total level and stratified by sex (male/female), age group (18-34/35-59/ $\geq 60$  years), schooling in years (0-8/9-11/ $\geq 12$ ), and self-perceived race/skin color (white/non-white). The prevalence was also estimated for the state capitals and Federal District for the initial and final years of the time series and the prevalence difference between these years (change) was calculated.

## Data analysis

The annual prevalence of physical activity for leisure and transportation was calculated for the total sample and according to sex, age group, schooling, and self-perceived race/skin color. The complex sample design and the sample-weighting factor were considered in all these analyses. The differences between groups were evaluated using a 95%CI.

A segmental regression model was used to analyze the physical activity prevalence time series<sup>27</sup>. This statistical modeling technique, also called joinpoint regression or regression with inflection points, explains the relationship between two variables by using regression lines. It also assumes a linear trend between these points and has the same assumptions of the linear regression, except for homoscedasticity and no autocorrelation. This analysis allows incorporating such conditions when they are violated in an adjustment using a weighted regression model.

In this study, the annual prevalence rates of physical activity were considered as dependent variables (Y) and years of the study period as independent variables (X). The segmented regression model allowed to categorize the prevalence trends as stationary, increasing, or decreasing and to detect points of change in the trends. This statistical approach assumes that the change in rates is constant over each time partition defined by the transition points but varies among different time partitions. This model also provides annual percent change (APC), average annual percent change (AAPC), and their respective 95%CI. Significant changes (increase or decrease) in variables were indicated when regression coefficients were significantly different from zero ( $p < 0.05$ ).

Lastly, the chi-square test ( $\chi^2$ ) was used to verify differences in the prevalence of physical activity for leisure and transportation between 2010 and 2019 for all state capitals and the Federal District. We used Stata, version 16.0 (<https://www.stata.com>); Python, version 3.7.10 (<http://www.python.org>); and R (<http://www.r-project.org>). The significance level adopted was 5%.

## Results

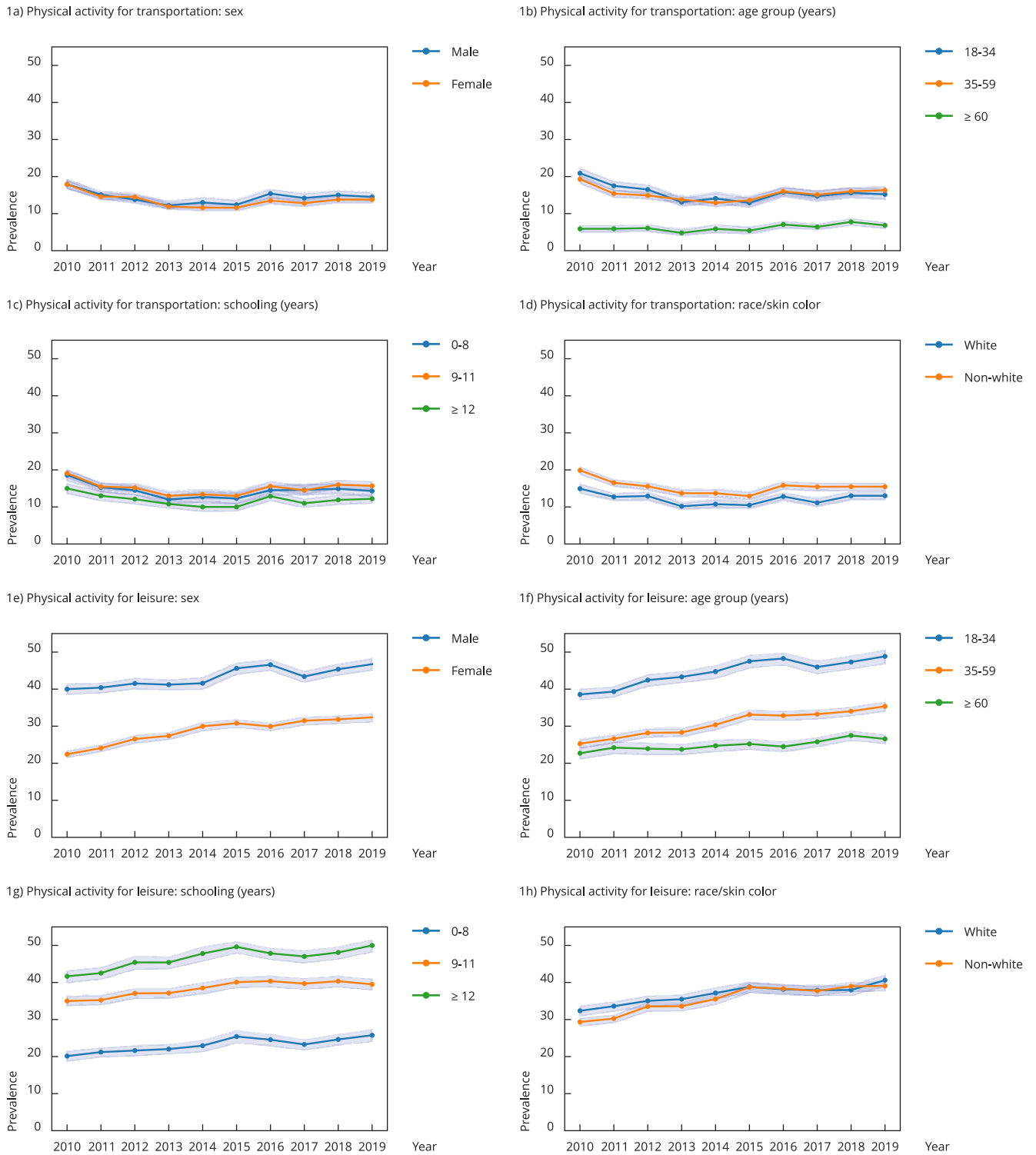
From 2010 to 2019, the Vigitel interviewed 512,969 individuals. Participants were mostly women (53.9%); aged 35-59 years (42.7%); reported 9-11 years of schooling (37.5%), and declared having non-white skin color (55.6%). The annual prevalence rates of physical activity for leisure and transportation between 2010 and 2019 to total sample and by sex, age group, schooling, and race/skin color were calculated.

Figure 1 shows a 10-year temporal trend (2010-2019) of physical activity for leisure and transportation according to sex, age group, schooling, and race/skin color. During the entire study period, prevalence of physical activity for leisure was significantly higher among men compared with women, individuals aged 18-34 years compared with the other age groups, and those with  $\geq 12$  years of schooling compared with other groups. The prevalence between white and non-white individuals showed no significant difference, except for the years 2010 and 2011, when the prevalence was significantly higher among white individuals. Concerning physical activity for transportation, we observed a significantly lower prevalence among those aged  $\geq 60$  years compared with younger groups and a significantly higher prevalence among non-white individuals compared with white individuals in all analyzed years. No significant difference was found between the sexes, age groups 18-34 and 35-59 years, and individuals with 0-8 and 9-11 years of schooling over the entire study period. Prevalence rates were significantly lower among those with  $\geq 12$  years of schooling compared with the other groups in the years 2010, 2014, 2017, and 2018.

Table 1 shows the time trend analysis of physical activity for leisure. All variables showed a trend with only one inflection point over the study period. The total sample showed a significant increasing trend from 2010-2015 (APC = 1.31%). The same trend occurred among men in 2010-2016 (APC = 0.94%) and among women in 2010-2014 (APC = 1.85%) and 2015-2019 (APC = 0.50%). Increasing trends were also observed for individuals aged 18-34 years (APC = 1.75%) and 35-59 years (APC = 1.41%) in 2010-2015; for those with 0-8 years of schooling (APC = 0.83%) and 9-11 years (APC = 1.00%) in 2010-2015 and for those with  $\geq 12$  years in 2010-2014 (APC = 1.51%); for white individuals in 2010-2014 (APC = 1.15%) and non-white individuals in 2010-2015 (APC = 1.77%). All variables

**Figure 1**

Time trend in physical activity for leisure and transportation. *Risk and Protective Factors Surveillance System for Chronic Noncommunicable Diseases Through Telephone Interview (Vigitel)*, Brazil, 2010-2019.



Note: values refer to prevalence (blue, orange, and green lines) and 95% confidence interval (gray lines).

**Table 1**

Segmented temporal analysis of physical activity for leisure. *Risk and Protective Factors Surveillance System for Chronic Noncommunicable Diseases Through Telephone Interview (Vigitel)*, Brazil, 2010-2019.

Characteristics	Period	APC (95%CI)	AAPC (95%CI)
Total	2010-2015	<b>1.31 (0.87; 1.74) *</b>	<b>0.91 (0.78; 1.04) *</b>
	2016-2019	0.41 (-0.02; 0.85)	
Sex	Male	2010-2016	<b>0.94 (0.26; 1.62) *</b>
		2017-2019	0.29 (-2.25; 2.84)
Female	2010-2014	<b>1.85 (1.44; 2.25) *</b>	<b>1.10 (0.98; 1.23) *</b>
	2015-2019	<b>0.50 (0.10; 0.91) *</b>	
Age group (years)	18-34	2010-2015	<b>1.75 (1.17; 2.33) *</b>
		2016-2019	0.25 (-0.83; 1.33)
35-59	2010-2015	<b>1.41 (1.03; 1.79) *</b>	<b>1.10 (0.94; 1.26) *</b>
	2016-2019	0.72 (-0.002; 1.44)	
≥ 60	2010-2016	0.32 (-0.07; 0.72)	<b>0.45 (0.28; 0.61) *</b>
	2017-2019	0.69 (-0.05; 1.43)	
Schooling (years)	0-8	2010-2015	<b>0.83 (0.17; 1.50) *</b>
		2016-2019	0.21 (-0.46; 0.88)
9-11	2010-2015	<b>1.00 (0.72; 1.29) *</b>	<b>0.56 (0.44; 0.68) *</b>
	2016-2019	-0.20 (-0.73; 0.33)	
≥ 12	2010-2014	<b>1.51 (0.64; 2.38) *</b>	<b>0.80 (0.53; 1.07) *</b>
	2015-2019	0.10 (-0.77; 0.97)	
Race/Skin color	White	2010-2014	<b>1.15 (0.51; 1.79) *</b>
		2015-2019	0.34 (-0.30; 0.98)
Non-white	2010-2015	<b>1.77 (1.33; 2.22) *</b>	<b>1.11 (0.92; 1.29) *</b>
	2016-2019	0.28 (-0.56; 1.11)	

95%CI: 95% confidence interval; AAPC: average annual percent change; APC: annual percent change.

\* p < 0.05.

had a significant increasing trend during the whole period, with AAPC ranging from 0.45% for the age group ≥ 60 years to 1.11% for non-white individuals.

In the time trend analysis of physical activity for transportation, we found only one inflection point over the study period in all investigated variables (Table 2). Significant decreasing trends occurred for the total sample in 2010-2013 (APC = -1.80%); for males in 2010-2012 (APC = -2.05%) and for females in 2010-2013 (APC = -1.81%). The same occurred with individuals aged 18-34 years in 2010-2013 (APC = -2.42%) and aged 35-59 years in 2010-2012 (APC = -2.20%); those with 0-8 years of schooling in 2010-2012 (APC = -2.05%), 9-11 years in 2010-2013 (APC = -1.86%), and ≥ 12 years in 2010-2013 (APC = -1.35%); white (APC = -1.39%) and non-white individuals (APC = -1.95%) in 2010-2013. Conversely, significant increasing trends occurred for the total sample in 2014-2019 (APC = 0.46%); for males in 2013-2019 (APC = 0.45%); for females in 2014-2019 (APC = 0.48%); for individuals aged 35-59 years in 2013-2019 (APC = 0.54%); for those with 0-8 years of schooling in 2013-2019 (APC = 0.49%) and 9-11 years in 2014-2019 (APC = 0.55%). A significant decreasing trend in the period occurred for most variables, except the age group ≥ 60 years and white race/skin color, which exhibited a stationary trend. Significant AAPC values ranged between -0.25% for the 35-59 years age group and -0.56% for the 18-34 years age group (Table 2).

**Table 2**

Segmented temporal analysis of physical activity for transportation. *Risk and Protective Factors Surveillance System for Chronic Noncommunicable Diseases Through Telephone Interview (Vigitel)*, Brazil, 2010-2019.

Characteristics	Period	APC (95%CI)	AAPC (95%CI)	
Total	2010-2015	<b>-1.80 (-2.63; -0.97) *</b>	<b>-0.32 (-0.50; -0.13) *</b>	
	2016-2019	<b>0.46 (0.02; 0.90) *</b>		
Sex				
Male	2010-2016	<b>-2.05 (-3.54; -0.56) *</b>	<b>-0.28 (-0.49; -0.06) *</b>	
	2017-2019	0.45 (0.06; 0.85) *		
Female	2010-2014	<b>-1.81 (-2.59; -1.03) *</b>	<b>-0.38 (-0.55; -0.20) *</b>	
	2015-2019	<b>0.48 (0.07; 0.90) *</b>		
Age group (years)				
	18-34	2010-2015	<b>-2.42 (-3.39; -1.44) *</b>	
		2016-2019	0.37 (-0.15; 0.90)	
	35-59	2010-2015	<b>-2.20 (-3.77; -0.63) *</b>	<b>-0.25 (-0.48; -0.03) *</b>
		2016-2019	<b>0.54 (0.12; 0.96) *</b>	
	≥ 60	2010-2016	-0.26 (-0.98; 0.46)	0.14 (-0.01; 0.30)
2017-2019		0.35 (-0.04; 0.73)		
Schooling (years)				
	0-8	2010-2015	<b>-2.05 (-3.37; -0.73) *</b>	
		2016-2019	<b>0.49 (0.13; 0.84) *</b>	
	9-11	2010-2015	<b>-1.86 (-2.82; -0.90) *</b>	<b>-0.27 (-0.48; -0.06) *</b>
		2016-2019	<b>0.55 (0.04; 1.07) *</b>	
	≥ 12	2010-2014	<b>-1.35 (-2.28; -0.42) *</b>	<b>-0.26 (-0.47; -0.06) *</b>
2015-2019		0.42 (-0.07; 0.92)		
Race/Skin color				
	White	2010-2014	<b>-1.39 (-2.33; -0.45) *</b>	-0.19 (-0.40; 0.02)
		2015-2019	0.48 (-0.02; 0.98)	
	Non-white	2010-2015	<b>-1.95 (-2.90; -1.00) *</b>	<b>-0.38 (-0.58; -0.17) *</b>
2016-2019		0.47 (-0.04; 0.97)		

95%CI: 95% confidence interval; AAPC: average annual percent change; APC: annual percent change.

\*  $p < 0.05$ .

Considering the Brazilian state capitals and Federal District, all cities, except for the Federal District and Porto Alegre, showed a statistically significant increase in the prevalence of physical activity for leisure between 2010 and 2019. The significant increase ranged from 5.5% in Recife to 18.7% in Rio Branco. Regarding physical activity for transportation, 17 out of 27 cities showed a significant reduction in prevalence between 2010 and 2019. The significant reduction ranged from 3% in Natal to 8.6% in Rio Branco (Table 3).

## Discussion

This nationally representative study conducted with the Brazilian adult population showed opposite trends when analyzing the prevalence of physical activity for leisure and transportation over a 10-year period. We found that the prevalence of physical activity for leisure increased and the prevalence of physical activity for transportation decreased. The highest prevalence of physical activity for leisure occurred among males, young individuals (18-34 years), and those with high education ( $\geq 12$  years), whereas older adults ( $\geq 60$  years), those with high education ( $\geq 12$  years), and white people presented the lowest prevalence of physical activity for transportation over the last decade. Consid-

**Table 3**

Annual prevalence of physical activity for leisure and transportation. *Risk and Protective Factors Surveillance System for Chronic Noncommunicable Diseases Through Telephone Interview (Vigitel)*, Brazil, 2010-2019.

Capitals/Federal District	Physical activity for leisure			Physical activity for transportation		
	2010	2019	Change	2010	2019	Change
North						
Belém	33.1	43.2	<b>+10.1 *</b>	21.5	15.1	<b>-6.4 *</b>
Boa Vista	28.7	39.7	<b>+11.0 *</b>	14.6	8.1	<b>-6.5 *</b>
Macapá	34.0	44.4	<b>+10.4 *</b>	21.2	16.3	<b>-4.9 *</b>
Manaus	28.8	37.1	<b>+8.2 *</b>	17.6	12.4	<b>-5.2 *</b>
Rio Branco	25.8	44.6	<b>+18.7 *</b>	18.7	10.1	<b>-8.6 *</b>
Palmas	34.2	49.9	<b>+15.7 *</b>	13.5	7.2	<b>-6.4 *</b>
Porto Velho	27.9	37.1	<b>+9.2 *</b>	18.6	13.0	<b>-5.6 *</b>
Northeast						
Aracaju	31.3	41.9	<b>+10.5 *</b>	16.0	13.2	-2.8
Fortaleza	31.0	40.3	<b>+9.3 *</b>	14.7	10.3	<b>-4.4 *</b>
Maceió	27.6	39.9	<b>+12.3 *</b>	18.0	12.7	<b>-5.3 *</b>
Natal	31.0	45.4	<b>+14.4 *</b>	12.8	9.8	<b>-3.0 *</b>
João Pessoa	30.4	40.2	<b>+9.8 *</b>	13.7	10.9	-2.8
Salvador	28.0	41.3	<b>+13.4 *</b>	18.9	13.8	<b>-5.1 *</b>
São Luís	27.9	37.9	<b>+9.9 *</b>	17.8	11.1	<b>-6.6 *</b>
Recife	30.2	35.6	<b>+5.5 *</b>	16.8	15.3	-1.5
Teresina	26.5	44.3	<b>+17.8 *</b>	15.3	13.5	-1.8
Central-West						
Federal District	42.9	47.1	+4.2	12.7	10.6	-2.1
Cuiabá	30.1	38.3	<b>+8.3 *</b>	16.5	12.2	<b>-4.4 *</b>
Campo Grande	30.7	39.5	<b>+8.8 *</b>	13.7	11.1	-2.6
Goiânia	35.4	41.0	<b>+5.6 *</b>	14.0	8.7	<b>-5.3 *</b>
Southeast						
Belo Horizonte	32.3	39.7	<b>+7.4 *</b>	17.8	14.5	<b>-3.3 *</b>
Rio de Janeiro	31.3	37.8	<b>+6.5 *</b>	20.6	15.4	<b>-5.3 *</b>
São Paulo	26.4	34.6	<b>+8.2 *</b>	20.3	17.5	-2.8
Vitória	36.9	44.2	<b>+7.4 *</b>	14.5	13.7	-0.8
South						
Curitiba	33.4	41.1	<b>+7.7 *</b>	14.9	14.8	-0.1
Florianópolis	37.2	45.2	<b>+8.0 *</b>	17.6	13.1	<b>-4.5 *</b>
Porto Alegre	34.0	37.7	+3.7	15.6	14.0	-1.6

\* p < 0.05.

ering the World Health Organization (WHO) action plan on physical activity that aims to support all people being more physically active and improving health <sup>26</sup>, our findings are quite relevant due to revealing inequalities in the physical activity levels in Brazil and identifying subgroups on which the public policies should be focused.

The lower prevalence of physical activity for leisure observed in women, older individuals, and among those with lower schooling has been well documented in the literature <sup>28,29,30,31,32,33,34</sup>. Regarding race/skin color, some studies have described an association between white race/skin color and higher physical activity levels for leisure <sup>29,35</sup>, but little is known about the nature of this disparity. Most evidence attributes it to social class issues, such as unaffordable facilities, unavailable childcare, high crime rates, and fear for personal safety <sup>28,34,35</sup>. A prior study designed to examine the differences in physical activity for leisure by race/ethnicity and education in a nationally representative cohort of 9,261 community-dwelling adults in the United States showed that education was far more impor-



tant than race/ethnicity as a determinant of physical activity for leisure <sup>29</sup>. A more recent study, also conducted in the United States, demonstrated that white adults had a higher prevalence of physical activity than black adults, considering achieving 10 minutes of moderate activity and 10 minutes of vigorous activity in the past month. Nevertheless, individual poverty and neighborhood poverty were associated with decreased physical activity rates among both white and black participants <sup>36</sup>. Findings from the *National Health and Nutrition Examination Survey* (NHANES 2007-2016), also demonstrated that among adolescents and young adults (12-29 years), younger age, white race, and higher income were associated with a higher level of physical activity for leisure <sup>37</sup>.

As far as we know, in Brazil, only two studies investigated the relationship between physical activity for leisure and race/skin color and they found a higher prevalence of physical activity for leisure among white adults <sup>30,38</sup>. In this study, the prevalence of physical activity for leisure was higher in white adults solely in the years 2010-2011, showing no difference in the years from 2012 to 2019. A possible explanation for the lack of difference observed since 2012 is the implementation of the Health Academy Program in Brazil, by the Ministry of Health, in 2011 <sup>39</sup>. Preliminary results from one center of the Health Academy Program in Belo Horizonte showed that most participants of this program were non-white individuals (56.4%) <sup>40</sup>.

The main objective of the Health Academy Program is to promote health for all the population by implementing gym centers throughout Brazil, with infrastructure, equipment, and professional staff <sup>41</sup>. This program includes physical activity classes in rehabilitated public open spaces in low-income neighborhoods, health screening and counseling, and many other community-building activities in place-based settings (parks and plazas) <sup>39</sup>. A prior study investigated the impact of the Health Academy Program in 80 cities in the Pernambuco state, assessing 2,370 individuals in 2011, 3,824 individuals in 2012, and 3,835 individuals in 2013. The authors reported that the odds of reaching 150 minutes/week of physical activity for leisure was 5.06 (95%CI: 3.34; 7.67) for current participants ( $\leq 6$  months) and 10.35 (95%CI: 6.93; 15.47) for current participants ( $> 6$  months) compared with individuals that never participated <sup>42</sup>. A recent scoping review, including 24 studies published between 2008 and 2020, concluded that the Health Academy Program increases the amount of physical activity for leisure <sup>39</sup>. These findings are in line with our results, which showed an increase in the prevalence of physical activity for leisure from 2010 to 2015 in the Brazilian adult population, irrespective of sex, schooling, and race/skin color. The national coverage of this program can also justify the increase in the prevalence of physical activity for leisure in most Brazilian state capitals.

Regarding the physical activity for transportation, shifts from sedentary transport to active transport (walking and cycling) are a potential source of physical activity and enable its accumulation in daily life, rather than requiring intentional exercise <sup>43</sup>. In this study, the prevalence of adults that reached the recommended level of 150 minutes of moderate activity during the week accrued from active transport was low compared with studies from other countries <sup>43,44</sup>, varying from 11.9% to 17.9%, and it decreased over the 10-year period (AAPC = -0.32). In fact, the prevalence of physical activity for transportation decreased from 2010 to 2013 (APC = -1.80) and increased slightly from 2014 to 2019 (APC = 0.46). However, the increase was insufficient to offset the decrease at the beginning of the decade.

The use of public transportation in Brazil is associated with lower income <sup>45,46</sup>, which hinders access to individual means of transportation more efficient than collective modes <sup>47</sup>. From 2001 to 2012, the increase in the average income of the Brazilian population was accompanied by a rise of 138.6% in the fleet of motor vehicles, with a remarkable increase of 14.6% in the year 2012 <sup>48</sup>, which may have contributed substantially to reducing physical activity for transportation as observed in this study. A study conducted on a large sample of Swedish adults reported that vehicle ownership mediated a significant proportion of the association between walkability parameters (e.g., residential density and land use mix) and walking for transportation <sup>49</sup>. Note that the inflection point observed between 2013 and 2014 happened at the same time as the deep economic Brazilian recession that started in the second trimester of 2014 and severely compromised the workers' income <sup>50</sup>, which may have contributed to an increase in active transport in this period. Regarding the increase in the prevalence of physical activity for transportation in the period from 2014 to 2019, note that the bike lanes in Brazilian capitals increased by 133% from 2014 to 2018, which is as an effective government strategy to improve cycling for transport and leisure <sup>51</sup>.

The higher prevalence of physical activity for transportation in adults with lower education (< 12 years of schooling) and non-white race/skin color observed in all years studied reinforces the association between active transport and lower socioeconomic status. In Brazil, these individual characteristics are associated with informal work, unemployment, and lower average earnings per hour<sup>52</sup>. When considering solely the race/skin color, 70% of the people who live below the poverty line and 69% of the people who live in houses with some sort of inadequacy are black or mixed race<sup>53</sup>. A prior study developed in Curitiba (Brazil) has shown that adults living in areas with higher income showed a 44% lower likelihood of walking for transportation when compared with residents of lower-income areas<sup>54</sup>.

The inverse relationship between socioeconomic status and physical activity for transportation has been described elsewhere, mainly in low- and middle-income countries<sup>45,46,54</sup>, where occupational, household, and transport domains are the most common types of physical activity. A prior study designed to provide data about the frequency and distribution of active transportation to work in Brazil showed that around one-third of the adult population travels on foot or by bike to work and the frequency of active transportation decreased with increased income and schooling in both sexes and was higher among younger adults<sup>45</sup>. According to Rydin et al.<sup>55</sup>, the higher prevalence of physical activity for transportation in low- and middle-income countries might be due to the budgetary constraint of the poorest families, the spatial segregation existing in the metropolises, and the precariousness of public transport, rather than a practice guided by the health benefits. By contrast, in high-income countries, physical activity for leisure is the main contributor to the total physical activity level<sup>13</sup>.

This study has some limitations. The Vigitel sample included only the households with landlines, which could potentially introduce some selection bias. However, post-stratification weights were used to minimize possible sociodemographic differences and the absence of universal coverage of the telephone landline network<sup>56</sup>. Also, physical activity measures were obtained by self-report, which could lead to an under or overestimation of the prevalence. To minimize this bias, the Vigitel planning included information quality control with the management of each survey measure. Studies evaluating the physical activity indicators' validity and reliability have shown that they seem reproducible and sufficiently accurate<sup>25,57</sup>.

As for strengths, we highlight the use of data from a population-based survey including all Brazilian capitals and the Federal District, with a large sample in a 10-year historical series. Also, we analyzed the trends of physical activity for leisure and transportation according to important sociodemographic characteristics of the sample, such as sex, age group, schooling, and race/skin color. The study results may contribute to monitoring risk factors for chronic diseases and subside the policymakers to implementing public policies to promote physical activity and improve active mobility in cities.

To comprehend other aspects associated with the variation in the prevalence of physical activity for leisure and transportation in the Brazilian adult population, future studies should address environmental factors, such as climate and urban characteristics, including safety, structure, and facilities that enable walking and cycling.

## Conclusions

During the 10-year study period, the prevalence of physical activity for leisure increased and the prevalence of physical activity for transportation decreased. Regarding the different sociodemographic groups, women, individuals aged  $\geq 35$  years, and those with lower education (< 12 years) showed a lower prevalence of physical activity for leisure, whereas older adults ( $\geq 60$  years), those with high education ( $\geq 12$  years), and white people demonstrated a lower prevalence of physical activity for transportation. Considering the Brazilian state capitals and Federal District, the prevalence of physical activity for leisure increased in most cities, whereas the prevalence of physical activity for transportation decreased in 17 out of 27 cities. To increase the overall physical activity level of the population, policymakers should propose synergic strategies that encourage and facilitate physical activity for leisure and transportation, also considering the differences among sex, age group, schooling, and race/skin color.

## Contributors

A. C. Bastone contributed to the study design, data collection, writing, and review. B. S. Moreira, A. S. Magalhães, and A. C. S. Andrade contributed to the statistical analysis and review. K. S. S. Vasconcelos, D. M. Coelho, J. I. Silva, V. M. Bezerra, A. A. S. Lopes, A. A. L. Friche, and W. T. Caiaffa contributed to the study design and review. All authors approved the final version of the manuscript.

## Additional informations

ORCID: Alessandra de Carvalho Bastone (0000-0002-2414-3730); Bruno de Souza Moreira (0000-0001-8840-4496); Karina Simone de Souza Vasconcelos (0000-0001-7733-6571); Amanda Silva Magalhães (0000-0001-5112-2866); Débora Moraes Coelho (0000-0003-0948-0971); Juliana Ilídio da Silva (0000-0002-0604-6662); Vanessa Moraes Bezerra (0000-0001-5333-2875); Adalberto Aparecido dos Santos Lopes (0000-0002-3001-6412); Amélia Augusta de Lima Friche (0000-0002-2463-0539); Waleska Teixeira Caiaffa (0000-0001-5043-4980); Amanda Cristina de Souza Andrade (0000-0002-3366-4423).

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## Resumo

*Este estudo de série temporal analisou a prevalência de atividade física para lazer e transporte na população adulta brasileira em uma série histórica de uma década. Foram analisadas informações de 512.969 adultos entrevistados pelo Vigitel entre 2010 e 2019. Os indivíduos que relataram praticar pelo menos 150 minutos/semana de atividade física moderada ou pelo menos 75 minutos/semana de atividade física vigorosa foram considerados ativos durante seu lazer. Os indivíduos que relataram caminhar ou andar de bicicleta para/do trabalho, curso ou escola por pelo menos 30 minutos/dia (equivalente a pelo menos 150 minutos/semana de atividade física moderada) foram considerados ativos durante seu transporte. A prevalência de atividade física para lazer e transporte foi calculada anualmente e estratificada por sexo, faixa etária, escolaridade e cor da pele/raça. Modelo de regressão segmentada foi aplicado para analisar a série temporal. Foram calculadas as mudanças percentuais anuais e as mudanças médias anuais. Com o tempo, a prevalência de atividade física para o lazer aumentou e a prevalência de atividade física para o transporte diminuiu. A maior prevalência de atividade física para lazer foi observada entre homens, jovens e pessoas com Ensino Médio completo. Idosos, pessoas com Ensino Médio e brancos apresentaram a menor prevalência de transporte ativo. Formuladores de políticas devem propor estratégias que incentivem e facilitem a atividade física para o lazer em mulheres, indivíduos com idade  $\geq 35$  anos e pessoas com baixa escolaridade ( $< 12$  anos), e atividade física para transporte entre idosos ( $\geq 60$  anos), aqueles com Ensino Médio completo ( $\geq 12$  anos) e pessoas brancas.*

*Exercício Físico; Transportes; Atenção à Saúde*

## Resumen

*Este estudio de serie temporal analizó la prevalencia de la actividad física para el ocio y el transporte en la población adulta brasileña en una serie histórica de una década. Se analizaron las informaciones de 512.969 adultos, entrevistados por Vigitel entre 2010 y 2019. Las personas que informaron practicar al menos 150 minutos/semana de actividad física moderada o al menos 75 minutos/semana de actividad física vigorosa se consideraron activas durante su tiempo libre. Las personas que informaron caminar o andar en bicicleta al/desde el trabajo, curso o escuela por al menos 30 minutos/día (equivalente al menos a 150 minutos/semana de actividad física moderada) se consideraron activas durante su transporte. La prevalencia de la actividad física para el ocio y el transporte se calculó anualmente y se estratificó por sexo, grupo de edad, escolaridad y color de piel/raza. Se aplicó un modelo de regresión segmentada para analizar la serie temporal. Se calcularon las variaciones porcentuales anuales y las variaciones porcentuales medias anuales. Con el paso del tiempo, la prevalencia de la actividad física para el ocio tuvo un aumento y una reducción para el transporte. La mayor prevalencia de actividad física para el ocio se observó entre hombres, jóvenes y personas con educación secundaria. Los ancianos, las personas con educación secundaria y los blancos tuvieron una prevalencia más baja en el transporte activo. Los formuladores de políticas deben proponer estrategias de fomento a la actividad física para el ocio en mujeres, personas  $\geq 35$  años y personas con baja escolaridad ( $< 12$  años), y la actividad física para el transporte entre los ancianos ( $\geq 60$  años), aquellos con educación secundaria ( $\geq 12$  años) y personas blancas.*

*Ejercicio Físico; Transportes; Atención a la Salud*

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