



# Moderate to vigorous physical activity and sedentary behavior changes in self-isolating adults during the COVID-19 pandemic in Brazil: a cross-sectional survey exploring correlates

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## Abstract

**Background** The COVID-19 pandemic imposed major changes on daily-life routine worldwide. To the best of our knowledge, no study quantified the changes on moderate to vigorous physical activity (MVPA) and sedentary behaviors (SB) and its correlates in Brazilians. This study aimed to (i) evaluate the changes (pre versus during pandemic) in time spent in MVPA and SB in self-isolating Brazilians during the COVID-19 pandemic, and (ii) to explore correlates.

**Methods** A cross-sectional, retrospective, self-report online web survey, evaluating the time spent in MVPA and SB pre and during the COVID-19 pandemic in self-isolating people in Brazil. Sociodemographic, behavioral, and clinical measures, and time in self-isolation were also obtained. Changes in MVPA and SB and their correlates were explored using generalized estimating equations (GEE). Models were adjusted for covariates.

**Results** A total of 877 participants (72.7% women, 53.7% young adults [18–34 years]) were included. Overall, participants reported a 59.7% reduction (95% CI 35.6–82.2) in time spent on MVPA during the pandemic, equivalent to 64.28 (95% CI 36.06–83.33) minutes per day. Time spent in SB increased 42.0% (95% CI 31.7–52.5), corresponding to an increase of 152.3 (95% CI 111.9–192.7) minutes per day. Greater reductions in MVPA and increases in SB were seen in younger adults, those not married, those employed, and those with a self-reported previous diagnosis of a mental disorder.

**Conclusions** People in self-isolation significantly reduced MVPA levels and increased SB. Public health strategies are needed to mitigate the impact of self-isolation on MVPA and SB.

**Keywords** Physical activity · Sedentary behavior · COVID-19 · Pandemic

## Introduction

The coronavirus disease 2019 (COVID-19) pandemic, caused by the spread of the severe acute respiratory coronavirus 2 (SARS-CoV-2), has infected more than 13 million people in more than 200 countries around the world resulting in nearly 570 thousand deaths on the 14th of July 2020 according to the World Health Organization (WHO) [1]. As a response to reduce the virus spread, the WHO recommended national governments to adopt non-pharmacological

strategies based on social and physical distancing, such as lockdown, quarantine, and self-isolation.

In Brazil, the epidemiological report number 05 of the Ministry of Health has recommended the adoption of social distancing measures, including self-isolation in areas with community transmission [2]. When self-isolating, people were advised to stay at home, and only go out in public for essential activities, such as going to the supermarket, to the pharmacy, or to use essential services, such as medical assistance. All other non-essential services, including gyms, parks, stadiums, and other places where people exercised were closed.

Self-isolation measures impose a drastic and sudden disruption of daily-life routine, resulting in limited physical and social mobility, and fewer opportunities to be active [3]. Moreover, the emotional burden [4, 5] of the pandemic

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likely resulted in additional barriers to remain focused and motivated to be and/or stay physically active, potentially reducing the time spent in physical activity (PA), defined as any bodily movement produced by skeletal muscles that result in energy expenditure [6]. The negative impact of the pandemic and self-isolation measures on PA levels, both on light PA and moderate to vigorous PA (MVPA), defined as any activities that result in energy expenditure above 3 metabolic equivalents (METs) [7] noted in many countries including Australia [8, 9], Canada [10], Croatia [11], France [12], Italy [13], Spain [14], the UK [15, 16], and the USA [17–19]. However, some moderating factors on PA changes in this period were identified. For example, age [13, 15], sex [14], and the presence of chronic physical diseases or mental disorders moderated the pandemic impact on PA levels [15]. Further, increases in time spent in sedentary behavior (SB), defined as any waking behavior characterized by an energy expenditure  $\leq 1.5$  METs, while in a sitting, reclining or lying posture [20], were noted during the pandemic in the US [18, 19], France and Sweden [21], and Spain [14]. In Spain, sex moderated the increase in time spent in SB [14].

To the best of our knowledge, no study has evaluated how the COVID-19 pandemic changed PA and SB during self-isolating Brazilians. The present study aimed (i) to examine the changes (pre versus during COVID-19 pandemic) on PA and SB in self-isolating Brazilians, and (ii) to evaluate whether sociodemographic (sex, age, ethnicity, marital status, employment, monthly household income), behavioral (smoking, current alcohol consumption), clinical (presence of chronic physical diseases or mental disorders), and contextual factors (i.e., number of days of self-isolation) moderated these changes.

## Methods

This paper presents pre-planned interim analysis of data from a cross-sectional study. Data collection was performed through an online survey ([www.qualtrics.com](http://www.qualtrics.com)). The study was launched on 11 April 2020 and data collection continued until 05 May. The study was approved by the Federal University of Santa Maria Research Ethics Committee and by the National Commission of Ethics in Research [CONEP] (30244620.1.0000.5346).

## Participants and recruitment

Participants were recruited through social media (Facebook, Instagram, Twitter), and by distributing an invitation to participate through existing researcher networks. The inclusion criteria were: (1) Brazilians adults (18–65 years), (2) currently residing in Brazil, and (3) in self-isolation due to the COVID-19 pandemic. Self isolation was defined as

staying-at-home and only leaving for essential activities such as food shopping, visiting the pharmacist or other health professionals. Participants who self-reported the presence of COVID-19 symptoms, assessed through a list of symptoms (fever, cough, dry mouth, coriza, sore throat), were removed from this analysis.

## Moderate to vigorous physical activity (MVPA) and sedentary behavior (SB) assessment

Participants were asked to recall the amount of time in vigorous and moderate physical activity, and sedentary behavior they undertook on an average day, separately both pre- and during self-isolation [16]. Participants were asked: (1) “How much time on an average day have you spent in vigorous activity before/since social distancing?”; (2) “How much time on an average day have you spent in moderate activity since/before social distancing?” and (3) “How much time on an average day have you spent sitting since/before social distancing?” Responses were given in hours and minutes. MVPA and SB were analyzed as continuous variables (minutes per day). We also categorized PA levels ( $\geq 30$  min/day or  $< 30$  min/day of MVPA), which is in accordance with the WHO recommendations. Next, four categories were derived to identify patterns of change: (1) persistent inactive ( $< 30$  min/day of MVPA pre and during the pandemic), (2) decreased PA ( $\geq 30$  min/day of MVPA pre and  $< 30$  min/day of MVPA during the pandemic), (3) increased PA ( $< 30$  min/day of MVPA pre and  $\geq 30$  min/day of MVPA during the pandemic) and (4) persistent active ( $\geq 30$  min/day of MVPA pre and during the pandemic).

## Covariates

Demographic data were collected, including sex (men or women), age (in 10-year age bands), ethnicity (Caucasian, Black, Asian, mixed, others), marital status (single, divorced, widowed or married), employment (employed, student, military, unemployed), monthly household income  $\leq$  R\$1254, R\$1255–R\$2004, R\$2005–R\$8640, R\$8641–R\$11,261  $\geq$  R\$11,262). Health behaviors data included current smoking (y/n) or alcohol consumption (y/n). Clinical data included self-reported previous diagnosis of physical diseases or mental disorders, such as: obesity, hypertension, myocardial infarction, angina pectoris, and other coronary diseases, other cardiac diseases, varicose veins of lower extremities, osteoarthritis, chronic neck pain, chronic low back pain, chronic allergy (excluding allergic asthma), chronic bronchitis, emphysema or chronic obstructive pulmonary disease, type 1 diabetes, type 2 diabetes, diabetic retinopathy, cataract, peptic ulcer disease, urinary incontinence or urine control problems, hypercholesterolemia, chronic skin disease, chronic constipation,

liver cirrhosis and other hepatic disorders, stroke, chronic migraine/others, depression, anxiety disorders, bipolar disorder and schizophrenia/others. Number of days (extension) in self-isolation was registered with a single question.

## Statistical analyses

Data were analyzed using mean and standard deviation (SD) or 95% confidence interval (95%CI) for continuous data and the raw numbers and % for categorical variables. Normality was checked with the Kolmogorov–Smirnov test. Due to the non-normal distribution, the mean changes (pre versus during the pandemic) of MVPA levels and SB were evaluated using two generalized estimating equations models (GEE), one with changes in MVPA and one with change in SB as the dependent variable. The models were run testing the time effects (pre/during) and the interactions between time and the factors included in the model. The factors included in the models were (sex [male versus female], age [young adults {18–34 years} versus middle-age adults {35–54 years} versus older adults {55–65 years}], ethnicity [Caucasian versus Asian/Black/mixed/others], marital status [married versus single/divorced/widowed], employment [employed/students/military versus unemployed/retired], monthly household income [< R\$2005 versus R\$2005–R\$8640 versus R\$8641–R\$11,261 versus > R\$11,261], current smoking [yes versus no], alcohol consumption [yes versus no], self-reported previous diagnosis of any chronic diseases [yes versus no] or any mental disorders [yes versus no]). When the interaction between time and any factor was significant, the Bonferroni test was applied. The results of the models are presented using estimated marginal means and 95% CI. We also calculated the delta% change (pre to during), together with 95% CI as the effect size measure. The associations between the time (in days) in self-isolation and the change in MVPA and SB were tested using linear regression models. Days in self-isolation were collected as a continuous variable, and linear regression models were used to test the association of time in self-isolation with changes in MVPA and SB. The level of statistical significance was set at  $p$  value < 0.05. All analyses were performed using SPSS (v. 21).

## Results

A total of 1354 participants responded to the survey. Of these, 877 participants reported being in self-isolation and provided complete data for the present analysis. The sample was predominantly comprised of women ( $n=635$ , 72.7%), young adults ranging from 18 to 34 years ( $n=471$ , 53.7%), Caucasians ( $n=669$ , 76.3%), singles ( $n=442$ , 50.9%), currently employed/students/military ( $n=723$ , 92.6%), with a

monthly income ranging from R\$2005 to R\$8640 ( $n=364$ , 41.5%), non-smokers ( $n=836$ , 95.3%), currently consuming alcohol ( $n=605$ , 69.1%), with a self-reported previous diagnosis of a physical chronic disease ( $n=824$ , 94%) and without a self-reported previous diagnosis of a mental disorder ( $n=523$ , 59.6%). More than half of the participants were from the Rio Grande do Sul state (80%), 11% from the Rio de Janeiro, and about 6% from Ceará. Participants were on average 27.13 (6.57) days in self-isolation. The full details of the sample can be seen at Table 1.

## Mean changes in MVPA and SB (pre versus during pandemic)

A total of 432 (49.3%) of participants persisted to be active during the pandemic, 32 (3.6%) increased MVPA levels during the pandemic, 306 (34.9%) reduced MVPA levels during the pandemic, and 107 (12.2%) persisted to be inactive. We found an overall reduction of 64.28 (95% CI 36.06–83.33) minutes per day on time spent in MVPA, corresponding to a reduction of 59.7% (95% CI 35.64–82.21,  $p < 0.001$ ). The average time spent in SB increased 42.0% (95% CI 31.74–52.50,  $p < 0.001$ ) during the pandemic, corresponding to additional 152.3 (95% CI 111.9–192.7) minutes per day in SB. The mean time spent in MVPA and SB at baseline and during the pandemic can be found at Fig. 1.

## Correlates of MVPA change

Significant interactions in MVPA change were found for age ( $p=0.013$ ), marital status ( $p=0.006$ ) and employment ( $p=0.008$ ). Bonferroni post-hoc test found that young adults (mean change =  $-71.37$ , 95% CI  $-99.76$  to  $-42.98$ ) and middle-age adults (mean change =  $-66.76$ , 95% CI  $-94.50$  to  $-39.01$ ) had greater decreases in time spent in MVPA when compared to older adults (mean change =  $-54.70$ , 95% CI  $-86.25$  to  $-23.16$ ). Also, those not married (single/divorced/widowed) had greater reductions (mean change =  $-75.50$ , 95% CI  $-102.00$  to  $-49.00$ ) when compared to those married (mean change =  $-53.05$ , 95% CI  $-79.36$  to  $-26.75$ ), and those with an occupation (employed/student/military) had greater reductions (mean change =  $-78.69$ , 95% CI  $-105.21$  to  $-52.16$ ) when compared to those without occupation (unemployed/retired). Mean change =  $-49.87$ , 95% CI  $-78.83$  to  $-20.90$ ). The detailed results of the MVPA model with mean changes can be seen in Table 2. Those not married (mean difference = 22.08, 95% CI 6.79–37.36,  $p=0.005$ ), and with no occupation (mean difference = 38.55, 95% CI 14.08–63.03,  $p=0.002$ ) had greater MVPA levels at baseline (pre and during pandemic means are shown in Supplementary Material 1). The number of days in self-isolation was not associated with changes in MVPA (unstandardized beta

**Table 1** Sample characteristics

	Category/mean (standard deviation)	Overall N=877 <sup>a</sup> (%)
Sex	Male	238 (27.3)
	Female	635 (72.7)
Age	18–24 years	131 (14.9)
	25–34 years	340 (38.8)
	35–44 years	220 (25.1)
	45–54 years	108 (12.3)
	55–64 years	78 (8.9)
Ethnicity	Asian	3 (0.3)
	Black	24 (2.7)
	Mixed	163 (18.6)
	Caucasian	669 (76.3)
	Others	16 (1.8)
Marital Status	Married	363 (41.4)
	Widowed	4 (0.5)
	Divorced	60 (6.9)
	Single	442 (50.9)
Employment	Employed	558 (63.6)
	Unemployed	43 (1.6)
	Student	235 (26.8)
	Military	19 (2.2)
	Retired	22 (2.5)
Monthly household income	< R\$1254 (\$232)	30 (3.4)
	R\$1255 (\$232)–R\$2004 (\$371)	94 (10.7)
	R\$2005 (\$371)–R\$8640 (\$1600)	364 (41.5)
	R\$8641 (\$1600)–R\$11,261 (\$2085)	139 (15.8)
	> R\$11,262 (\$2085)	250 (28.5)
Current smoking	No	836 (95.3)
	Yes	41 (4.7)
Current alcohol consumption	No	271 (30.9)
	Yes	605 (69.1)
Self-reported previous diagnoses of physical disease	No	53 (6)
	Yes	824 (94)
Self-reported previous diagnoses of mental disorder	No	523 (59.60)
	Yes	354 (40.4)
Days in self isolation	Mean (standard deviation)	27.07 (6.71)

<sup>a</sup>Total sample with available data. Number of cases can be different for each variable due to missing cases (minimum=869)

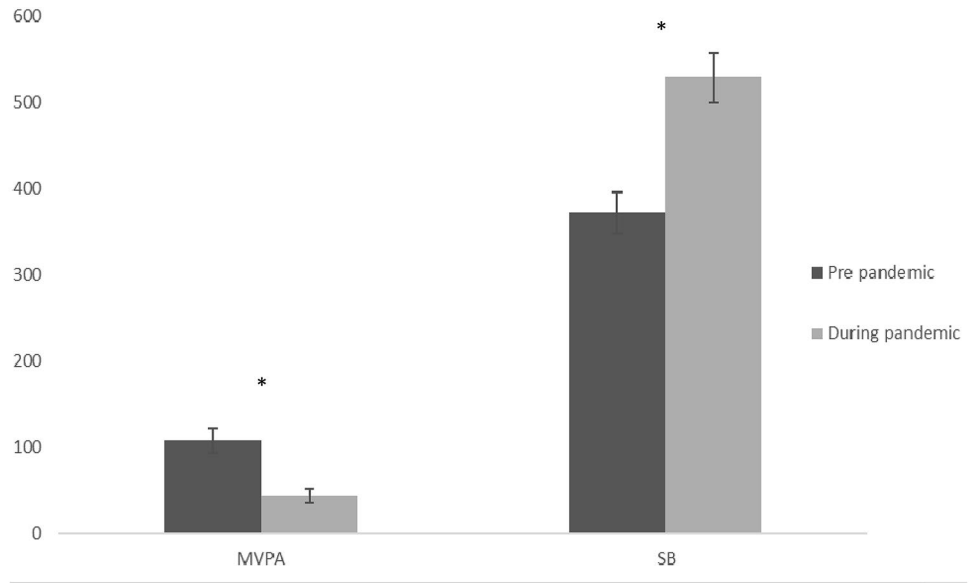
coefficient = 0.234, 95% CI – 0.816 to 1.284,  $p = 0.662$ ,  $R^2 = 0.00$ ).

### Correlates of SB changes

The interactions found for the SB model were age ( $p < 0.001$ ), marital status ( $p = 0.024$ ), employment ( $p = 0.03$ ), and self-reported previous diagnosis of mental disorders ( $p = 0.003$ ). Young adults had greater increases (mean change = 190.48, 95% CI 149.65–231.30) in time spent in SB when compared to middle age (mean change = 143.35 95% CI 99.48–187.21) or older adults

(mean change = 136.71, 95% CI 77.88–195.54). Also, greater increases in time spent in SB were found in those not married (mean change = 176.15, 95% CI 133.74–218.56) compared to those married (mean change = 137.96, 95% CI 96.85–178.24), in those with an occupation (mean change = 179.85, 95% CI 142.15–217.55) compared to those with no occupation (mean change = 133.84, 95% CI 79.26 to 188.42), and in those with a self-reported previous diagnosis of mental disorders (mean change = 173.16, 95% CI 129.97–216.34) compared to those with no history of mental disorders (mean change = 140.53, 95% CI 101.07–180.00). The detailed results of the SB model with interactions can

**Fig. 1** Moderate to vigorous physical activity and sedentary behavior, pre and during COVID-19 pandemic in 2020 in Brazil. Values are shown as the estimated marginal means, in minutes per day, of moderate to vigorous physical activity (MVPA) and sedentary behavior (SB) together with their standard error. Significant changes across time were found for MVPA ( $p < 0.001$ ) and SB ( $p < 0.001$ )



**Table 2** Moderate to vigorous physical activity change (pre-post pandemic) in self-isolated adults during the SARS-CoV-2 pandemic in 2020 in Brazil

Characteristics	Category	MVPA change (pre versus during)					Interaction $p$ value
		Mean change in minutes	95% CI	Delta%	95% CI (%)		
Sex	Male	-65.86	-92.26 -39.52	-61.24	-85.79	-36.75	0.778
	Female	-62.71	-89.37 -36.05	-58.18	-82.91	-33.44	
Age	Young adults (18–35 years)	<b>-71.37a</b>	<b>-99.76 -42.98</b>	<b>-72.68</b>	<b>-101.51</b>	<b>-43.77</b>	<b>0.013</b>
	Middle age adults (36–55 years)	<b>-66.76a</b>	<b>-94.50 -39.01</b>	<b>-64.53</b>	<b>-91.34</b>	<b>-37.07</b>	
	Older adults (55–64 years)	<b>-54.70b</b>	<b>-86.25 -23.16</b>	<b>-45.08</b>	<b>-71.08</b>	<b>-19.08</b>	
Ethnicity	Black/Asian/Mixed/Others	-66.00	-95.52 -36.48	-62.67	-90.70	-34.64	0.216
	White	-62.55	-86.72 -38.38	-56.59	-78.87	-34.98	
Marital status	Single/divorced/widowed	<b>-75.50a</b>	<b>-102.00 -49.00</b>	<b>-63.60</b>	<b>-85.93</b>	<b>-41.28</b>	<b>0.006</b>
	Married	<b>-53.05b</b>	<b>-79.36 -26.75</b>	<b>-54.91</b>	<b>-82.14</b>	<b>-27.68</b>	
Employment	Employed/students/military	<b>-78.69a</b>	<b>-105.21 -52.16</b>	<b>-61.99</b>	<b>-82.88</b>	<b>-41.09</b>	<b>0.008</b>
	Unemployed/retired	<b>-49.87b</b>	<b>-78.83 -20.90</b>	<b>-56.42</b>	<b>-89.19</b>	<b>-23.64</b>	
Monthly household income	< R\$2005(\$371)	-82.58	-114.49 -50.66	-63.52	-88.15	-39.00	0.647
	R\$2005(\$371)–R\$8640(\$1600)	-57.53	-82.31 -32.75	-56.57	-80.94	-32.20	
	R\$8641(\$1600)–R\$11,261(\$2085)	-56.72	-89.26 -24.19	-58.06	-91.38	-24.76	
	> R\$11,261	-60.28	-88.92 -31.63	-59.44	-87.69	-31.19	
Current smoking	Yes	-70.76	-112.95 -28.57	-67.02	-106.9	-27.06	0.090
	No	-57.80	-77.29 -38.30	-52.77	-70.43	-34.90	
Current alcohol consumption	Yes	-58.39	-84.85 -31.93	-57.09	-82.97	-31.22	0.378
	No	-70.16	-97.22 -43.10	-62.06	-85.29	-38.12	
Self-reported previous diagnosis of mental disorders	Yes	-67.46	-95.88 -39.05	-63.37	-90.07	-36.68	0.112
	No	-61.09	-85.60 -36.58	-56.11	-78.63	-33.60	
Self-reported previous diagnosis of physical diseases	Yes	-67.42	-89.62 -45.23	-59.64	-79.28	-40.01	0.803
	No	-61.13	-96.90 -25.63	-59.77	-94.74	-25.63	

Different letters mean significant differences according the Bonferroni post-hoc test ( $p < 0.05$ )

Bold values indicate that the significance of  $p < 0.05$

be seen in Table 3. Younger adults spent more time in SB than middle-age adults (mean difference = 39.99, 95% CI 5.27–74.71,  $p=0.017$ ), but not more than older adults (mean difference = 43.28, 95% CI – 13.15 to 99.75,  $p=0.20$ ). Those with a self-reported previous diagnosis of a mental disorder spent more time in SB at baseline (mean difference = 24.09, 95% CI 0.41–48.66,  $p=0.046$ ) than those without (pre and during pandemic means are shown in Supplementary Material 2). The number of days in self-isolation was not associated with changes in SB (unstandardized beta coefficient = 0.306, 95% CI – 1.732 to 2.345,  $p=0.77$ ,  $R^2=0.00$ ). The sample size ( $n=1000$ ) was calculated for evaluating the association of MVPA with mental health outcomes, published elsewhere [22].

## Discussion

The present study is, to the best of our knowledge, the first study demonstrating the impact of the self-isolation during the COVID-19 pandemic on Brazilians for self-reported MVPA and SB. Approximately 35.0% of the sample became insufficiently active during the self-isolation period. Only 3.6% became active with self-isolation. On average, there was a reduction of about 1 h/day of time spent in MVPA, which corresponds to a reduction of 60.0% of their MVPA pre-pandemic levels. Participants reported spending 2.5 h/day more in SB during the pandemic than before the pandemic, corresponding to an increase of 40.0%.

The reduction in MVPA levels in Brazilians is consistent with the findings of previous studies in other countries. For example, we found that roughly 35.0% of respondents became inactive during the self-isolation period as did about 50.0% in similar studies collected in France [12], the USA

**Table 3** Sedentary behavior change (pre-post pandemic) in self-isolated adults during the SARS-CoV-2 pandemic in 2020 in Brazil

Characteristics	Category	SB change (pre versus during)					Interaction $p$ value	
		Mean change in minutes	95% CI	Delta%	95% CI (%)			
Sex	Male	161.41	119.48	203.35	42.51	31.47	53.56	0.380
	Female	152.28	111.87	192.69	41.72	30.61	52.78	
Age	Young adults (18–35 years)	<b>190.48a</b>	<b>149.65</b>	<b>231.30</b>	<b>47.62</b>	<b>37.42</b>	<b>57.81</b>	< 0.001
	Middle age adults (36–55 years)	<b>143.35b</b>	<b>99.48</b>	<b>187.21</b>	<b>39.87</b>	<b>27.62</b>	<b>51.99</b>	
	Older adults (55–64 years)	<b>136.71b</b>	<b>77.88</b>	<b>195.54</b>	<b>38.34</b>	<b>21.82</b>	<b>54.80</b>	
Ethnicity	Black/Asian/Mixed/Others	155.43	109.04	201.81	41.42	29.07	53.81	0.940
	White	158.26	121.24	195.29	42.81	32.80	52.83	
Marital status	Single/divorced/widowed	<b>176.15a</b>	<b>133.74</b>	<b>218.56</b>	<b>46.87</b>	<b>35.58</b>	<b>58.15</b>	<b>0.024</b>
	Married	<b>137.54b</b>	<b>96.85</b>	<b>178.24</b>	<b>37.29</b>	<b>26.18</b>	<b>48.32</b>	
Employment	Employed/students/military	<b>179.85a</b>	<b>142.15</b>	<b>217.55</b>	<b>45.58</b>	<b>36.02</b>	<b>55.14</b>	<b>0.030</b>
	Unemployed/retired	<b>133.84b</b>	<b>79.26</b>	<b>188.42</b>	<b>38.22</b>	<b>22.63</b>	<b>53.81</b>	
Monthly household income	<R\$2005(\$371)	171.17	118.64	223.70	47.39	32.85	61.94	0.632
	R\$2005(\$371)–R\$8640(\$1600)	166.74	125.52	207.95	45.81	34.49	57.14	
	R\$8641(\$1600)—R\$11,261 (\$2085)	150.63	102.05	199.21	40.36	27.34	53.38	
Current smoking	<R\$2005(\$371)	138.85	92.10	185.59	35.50	23.54	47.45	0.984
	Yes	158.87	108.25	209.49	42.72	29.10	56.33	
Current alcohol consumption	No	154.82	116.98	192.66	41.53	31.38	51.68	0.091
	Yes	173.39	134.25	212.53	46.86	36.28	57.44	
Self-reported previous diagnosis of mental disorders	Yes	<b>173.16a</b>	<b>129.97</b>	<b>216.34</b>	<b>45.02</b>	<b>33.79</b>	<b>56.25</b>	<b>0.003</b>
	No	<b>140.53b</b>	<b>101.07</b>	<b>180.00</b>	<b>39.03</b>	<b>28.07</b>	<b>49.99</b>	
Self-reported previous diagnosis of physical diseases	Yes	139.60	107.20	172.00	37.85	29.07	46.64	0.358
	No	174.09	117.49	230.69	46.31	31.25	61.37	

Different letters mean significant differences according the Bonferroni post-hoc test ( $p < 0.05$ )

Bold values indicate that the significance of  $p < 0.05$



[17], and Australia [9]. Our results included reductions of 60.0% of the time spent in MVPA in Brazil, which is comparable to the reductions found in the USA, where there was a decrease of 47.0% on time spent in moderate PA [17]. Additionally, we observed an increase of about 2.5 h/day on time spent in SB, which is consistent with other studies that have found an increase of about 2–3 h/day of SB in multiple countries [14, 23]. These findings highlight the urgent need for public health strategies to mitigate the impact of self-isolation on MVPA and SB.

Greater reductions in MVPA and increases in SB were found among younger adults, which is line with the findings from Italy and the UK [13, 15]. It is possible that this age group had fewer resources and greater difficulty coping with emotional responses to this situation [24]. In addition, those not married and currently working had higher MVPA levels at baseline, but decreased their MVPA to similar levels to those not married and with no work during the pandemic. Of note, those currently employed might have reduced their commuting-related PA and have likely increased their SB time due to online meetings and activities. Lastly, those with a self-reported previous pandemic diagnosis of a mental disorder spent more time in SB and reported the greatest increases in time spent in SB during the pandemic. This finding is in accordance with a study in the UK [15] that found a greater reduction in MVPA in people with depression. This finding is also consistent with previous studies showing that people with mental disorders have higher SB levels than people without mental disorders [25–27] and suggests that self-isolation during the pandemic might be specifically detrimental to people with a previous diagnosis of a mental disorder.

There is ample evidence to justify making PA promotion a global public health priority during the coronavirus pandemic [3]. The COVID-19 pandemic appears to have impacted mental health globally, increasing rates of depression and anxiety symptoms and disorders [5]. On the other hand, physical activity is a protective factor for mental disorders [28–30]. During the pandemic, cross-sectional and longitudinal evidence suggests that those with higher PA or lower SB levels are less likely to present depressive symptoms [22, 31]. Promoting MVPA and reducing SB during the pandemic is also essential for physical health. Higher mortality due to COVID-19 is seen in those with clinical comorbidities such as hypertension, diabetes, and coronary heart disease [32]. Increasing time spent in MVPA and reducing time spent in SB seems to reduce the risk of developing multiple chronic diseases, including those associated with a higher risk of COVID-19 mortality [33]. For example, people with higher PA levels have 35% and 23% less risk of developing diabetes [34] and heart failure [35], respectively. In addition, achieving the public health recommendations of 150 min of MVPA per week reduces the risk of all-cause

and cardiovascular mortality [36]. Lastly, initial evidence has suggested that physical inactivity may be a risk factor for hospitalization due to COVID-19 [37], further underlining the potential importance of promoting PA during the pandemic.

The present study has some limitations. First, MVPA and SB were assessed using self-reported questionnaires. Self-reported questionnaires are commonly associated with overestimations of MVPA [38] and underestimation of SB [39]. Second, pre-pandemic MVPA and SB were assessed retrospectively, and both can be susceptible to memory bias. Third, the representativeness of the sample is limited. However, participants were drawn from 24 of the 27 federative units of Brazil, with most participants being from the Rio Grande do Sul state, Rio de Janeiro, and Ceará. Also, some groups such as adults aging 55–64, Asian and Black people, and those with a household income lower than < R\$1254 are poorly represented. Fourth, we could not explore changes in light PA, such as walking. Also, we could not explore the changes in time spent on MVPA across the different PA domains (work/occupational, leisure, transportation, household). It is possible, for example, that some participants reduced the time spent in leisure, transportation, or work/occupational activities, but increased the time spent in household activities. This is important since we know that some mental health benefits are more likely to be associated with time spent in leisure activities [40]. The strengths of the manuscript are the large sample size of self-isolating Brazilians and the possibility to explore a variety of moderators. Although the sample size was calculated for estimating the association of MVPA and mental health outcomes, the large sample size is sufficiently powered for the present analyses.

## Conclusion

Self isolation during the pandemic significantly reduced time spent in MVPA and increased time spent in SB in Brazilian adults, particularly in younger adults, those who were single, and those who were employed. These findings highlight the urgent need of the adoption of public health strategies to address the impact of self-isolation during the COVID-19 pandemic on MVPA and SB.

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## Declarations

**Conflict of interest** The authors have no conflict of interest to declare.

**Ethical approval** The study was approved by the Federal University of Santa Maria Research Ethics Committee and by the National Commission of Ethics in Research [CONEP] (30244620.1.0000.5346).

**Informed consent** All participants read and signed the informed consent.

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