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Increased risk for signs and clinical symptoms associated with sedentary behaviour in people diagnosed with COVID-19: a retrospective observational study

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ABSTRACT

This study aimed to verify the association between sedentary behaviour (SB) and clinical signs and symptoms in individuals with COVID-19. Five hundred nine people diagnosed with COVID-19 were cross-sectionally assessed by telephone interviews. Sociodemographic characteristics, clinical signs and symptoms and SB (IPAQ-SV) were obtained. It was found an association between increased sedentary behaviour (ISB) and clinical signs/symptoms of COVID-19 ($p< 0.05$). Controlling for the variables age, body mass index and moderate/vigorous physical activity, men with ISB had a higher occurrence of headache (OR= 2.357; 95%CI 1.312–4.232) and cough (OR= 2.508; 95%CI 1.268–4.959), women with ISB had a reduction in fatigue or tiredness (OR= 0.574; 95%CI 0.353–0.932). Four or more hours of SB increased the risk of headache and cough in men. Women experienced reduced symptoms of fatigue/tiredness during COVID-19 diagnosis.

KEYWORDS: physical activity; SARS-CoV-2; sedentary lifestyle; clinical outcomes.

INTRODUCTION

COVID-19 is an infection caused by the severe acute respiratory syndrome virus (SARS-CoV-2) (Wu et al., 2020). The most common signs and clinical symptoms of COVID-19 are fever, headache, muscle pain, cough, dyspnea, nausea, generalised weakness or fatigue, vomiting, diarrhoea, stomach discomfort, sore throat, runny nose, loss of smell and taste (Zhou et al., 2020). The most serious ones are severe acute respiratory syndrome, hypoxia, delirium, encephalopathy, hypercoagulability, and pulmonary fibrosis (Filgueira et al.,

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2021; Marino et al., 2022). COVID-19 symptomatology may be related to the individual's existing health status. Emerging data suggests that those most severely affected are those with pre-existing comorbidities (Marino et al., 2022).

Physically active people become less susceptible to infections. Moderate-intensity physical activity has been shown to be effective against respiratory tract infections (Channappanavar & Perlman, 2017). Furthermore, regular physical activity exerts a protective effect against severe forms of COVID-19 (Gomide et al., 2022a; Gomide et al., 2022b) because it counteracts the chronic inflammatory condition of the body, increases antibody responses in vaccination, and reduces systemic inflammation, with a better recovery prognosis for certain diseases (Chen et al., 2022; Clemente-Suárez et al., 2022; Hamer & Chida, 2008), including COVID-19 itself (Gomide et al., 2022a). Conversely, data has shown amplification in sedentary activities and a nonnegligible association between sedentary behaviour (SB) and worse outcomes for health (Bohn et al., 2017; Martinez-Ferran et al., 2020; Rezende et al., 2014). Despite the above mentioned information, data regarding SB and subsequent negative health outcomes arising from low-to-middle income countries such as Brazil, still needs to be included, especially when considering COVID-19 related-outcomes. The obligation to stay home during initial COVID-19 waves directly influenced the SB (Bohn et al., 2021; Carvalho et al., 2021; Martinez-Ferran et al., 2020).

Many physiological pathways can explain the deleterious effect of SB on the prognosis of COVID-19 since the association of a sedentary lifestyle with chronic diseases, such as obesity, diabetes, metabolic disorders, cardiovascular diseases, among others, is already well established in the scientific literature (Channappanavar & Perlman, 2017; Gomide et al., 2022b). Time spent in SB can negatively impact immune system functionality, increasing the risk of COVID-19 infection and disease severity (Tavakol et al., 2023). In turn, physical activity reduces systemic inflammation in the body, stimulates anti-inflammatory cytokines, increases the activity of macrophages, neutrophils and natural killer cells and is positively associated with shorter recovery times. Compared to sedentary people, active people had a lower chance of hospitalization, fewer days of hospitalisation, less respiratory difficulty and less need for oxygen support (Gomide et al., 2022a; Gomide et al., 2022b). Therefore, the exacerbation of the cytokine "storm" triggered by SARS-CoV-2 infection, added to SB (Meneguci et al., 2015) could directly influence the occurrence of clinical signs and symptoms in people dealing with the infection. However, there is still a lack of knowledge in this regard. Despite the variability of sedentary behavior time, all point to deleterious effects with greater risks for different types of diseases depending on the time spent sitting (Charansonney, 2011; Mazo et al., 2018; Rutten et al., 2013). To the best of our knowledge, no studies in Brazil have investigated the effect of SB on the clinical signs and symptoms of COVID-19.

The relationship between comorbidities and the evolution of patients with COVID-19 is a significant factor; however, in a complex scenario such as Brazil, where social, health and economic differences are accentuated by strong inequalities, these socioeconomic, geographic, structural, and personal characteristics, such as age and sex, state of residence and development index, level of education and hospital plan, can worsen the clinical signs and symptoms of COVID-19. (Baqui et al., 2021). Considering these factors, the signs and clinical symptoms are distinct, depending on modifiable and non-modifiable variables. In this regard, it is necessary to develop studies in various contexts investigating the association between SB and signs and clinical symptoms among people with COVID-19. Understanding this impact may indicate a direct relationship between SB and the worsening of clinical signs and symptoms of the disease. Thus, this study aimed to verify the association between SB and the occurrence of COVID-19 and clinical symptoms, as well as verify the odds ratio of SB influencing the higher occurrence of these clinical signs and symptoms. We hypothesise that SB may exert a more pronounced influence on the clinical signs and symptoms of individuals diagnosed with COVID-19 taking into account variables such as sex, moderate to vigorous physical activity, age grouping, and BMI. Additionally, we hypothesise that SB may have a differential impact on signs and symptoms across different sexes and clinical symptoms.

METHODS

Study design

This is a retrospective observational study derived from a larger study (Gomide et al., 2022b). Data was collected between June and December 2021 from individuals diagnosed with COVID-19 during March 2020 and February 2021. This manuscript followed the guidelines of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (Elm et al., 2007) and the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) (Eysenbach, 2004).

Ethical aspects

The study was approved by the Ethics and Research Committee of the Nursing School of Ribeirão Preto, Universidade de São Paulo (CAAE: 39645220.6.0000.5393). The study followed the guidelines of the Council Resolution National Health System (CNS) 466/12, which regulates research involving human beings (Novoa, 2014). The study was then forwarded to the Municipal Health Department of Ribeirão Preto and was approved (official letter 462/2020). All participants were informed of the study's purposes and methods, emphasising their right to withdraw from the research at any time.

Sample and location for data collection

We included people who resided in the city of Ribeirão Preto, São Paulo - Brazil , aged≥ 18 years old, positive polymerase chain reaction (PCR) test for COVID-19, no presence of any immunologically compromised conditions, prolonged use and administration of corticosteroids and/or chemotherapy, transplant recipients, and neurodegenerative diseases. We excluded people who did not answer all the questions or withdrew from participating in the study. Recruitment, participant selection, and data collection were conducted via telephone interviews by Resolution 510/2016 on the norms applicable to research in Human and Social Sciences (Lordello & Silva, 2017). The researchers identified themselves and presented the study goals, risks, procedures, and benefits to the participants. The research was initiated only after the participant accepted and sent their free informed consent, which was sent via WhatsApp® or email and explained via phone calls. After obtaining informed consent, data collection began following validated questionnaires (Matsudo et al., 2001; Ramos et al., 2022). The interviewer entered the responses into a Google Forms® database while the phone call was ongoing, ensuring that all mandatory questions were answered.

Sample size

The sample size was calculated a priori using The Power and Sample Size Program®, version 3.043. The selected parameters were a prevalence of hospitalisation due to COVID-19 of 10.0% with a precision of 3.5%, a confidence interval of 95%, and a finite population of 33,643 infected individuals in the city where the study was conducted during the data collection period, resulting in a minimum sample size of 500 to 650 participants.

Data collection

The Ribeirão Preto Municipal Health Secretariat provided telephone numbers, and emails of 33.643 individuals diagnosed with COVID-19. Using Microsoft Excel®, seven evaluators trained and supervised by the main researcher made 3.814 random phone calls. Out of this total, 647 participants answered the calls after a maximum of three attempts. Data from 14 individuals was excluded due to not meeting the eligibility criteria, and 124 people declined to participate in the study. Thus, a total of 509 individuals diagnosed with COVID-19 were deemed eligible, interviewed, and had their data included in the study. The data collection flowchart has been previously published (Gomide et al., 2022b).

Questionnaires

The instrument used in this study was the "Profile of the Person Diagnosed by COVID-19" questionnaire, which referred to the week prior to the diagnosis (Ramos et al., 2022). We collected information about age (years), self-reported skin colour, sex, height (m), and weight (kg) to calculate the Body Mass Index (BMI) and the signs and clinical symptoms due to COVID-19. The International Physical Activity Questionnaire — Short Version (IPAQ-SV) (Matsudo et al., 2001), validated for Brazilian (Garcia et al., 2013), was adopted to obtain sitting time (SB) on one normal weekday and one normal weekend day to the week prior to the diagnosis (including during work and leisure). SB was collected as minutes and then transformed into hours per day. The number of hours per day of SB on weekdays was multiplied by five, and the number of hours per day of SB on weekend days was multiplied by two. These values were summed and divided by seven to obtain the SB number of hours per day (Di Fusco et al., 2021). Finally, SB was categorised as reduced sedentary behaviour (*RSB*< 4 h/day) and increased sedentary behaviour (*ISB*≥ 4 h/day) (Hamer & Stamatakis, 2014).

Statistical analysis

After completing the inclusion of the interview results in Google Forms®, the information was downloaded in a Microsoft Excel® spreadsheet format. Two researchers independently coded the data, and the validation was performed by double checking in Microsoft Excel® to minimise the risk of bias in data tabulation. The variables, including sex, age group (18 to 59 years; 60≥ years), self-reported skin colour (White, Black, Yellow, and Brown), BMI (kg/m^2), and clinical signs and symptoms of COVID-19 were presented as absolute (n) and relative (%) frequency. Signs and clinical symptoms of COVID-19 were dichotomised into yes (1) or no (0). Fisher's exact test was used to verify the association between SB and clinical signs and symptoms for the total sample, which was grouped by sex. Only those signs and clinical symptoms statistically significantly associated (p< 0.050) were included in the binary logistic regression analysis. Binary logistic regression was conducted to indicate the odds ratio (OR) of people with ISB (independent variable) manifesting a certain sign and/or symptom (dependent variable). Thus, for logistic regression, the following dichotomised confounding variables which were associated with clinical outcomes due to COVID-19 (Baqui et al., 2021) were controlled: age grouping (0= 18≥ 59 years; 1= 60≥ years), BMI (0= Normal weight≤ 24.9kg/m^2; 1= Overweight or obesity≥ 25kg/m^2), and moderate/vigorous physical activity (0= inactive↓ 150 minutes of physical activity per week; 1= active≥ 150 minutes of physical activity per week). Criteria for these variables, age and BMI are presented with a worse prognosis for covid-19 (Wu et al., 2020), as well as the difference between the sexes, with greater involvement for males (Lustosa et al., 2022) and physical activity level as a modifiable factor (Gomide et al., 2022b) or not of the influence of sedentary behaviour. Additionally, we assessed the effect size (d) of sedentary behaviour on the manifestation of signs and symptoms, exclusively focusing on those that demonstrated a statistically significant association through the exact Fisher's test. We adopted Cohen's d (1988) reference values (d< 0.1= negligible; 0.1≤ d< 0.3= small; 0.3≤ d< 0.5= medium; d≥ 0.5= large). The statistical analysis was performed using the SPSS® version 20.0 program with a significance level of α= 5%.

RESULTS

The sample characteristics are presented in Table 1. The age of the participants varied between 18 and 89 years old, with the majority (78%) in the group from 18 to 59 years old, while the remaining 22% were 60 years old or older. Of the participants, 61% were female. Among the total sample, 44.8% were classified as having ISB, with 38.6% of females and 54.5% of males exhibiting this behaviour. Most participants (71.7%) were classified as overweight or obese according to their BMI.

ISB is associated with the symptoms of headache (*OR*= 1.483; *p*= 0.037) and cough (*OR*= 1.448; *p*= 0.038) for the total sample; headache (*OR*= 2.306; *p*= 0.004), muscle pain (*OR*= 1.831; *p*= 0.045) and cough (*OR*= 2.511; *p*= 0.007) for males; and fatigue/tiredness (*OR*= 0.610; *p*= 0.042) for females (Table 2).

In Table 3, the logistic binary regression shows the OR of people with ISB presenting a higher occurrence for determining signs and symptoms, controlling for confounding variables (age grouping, sex, BMI, and moderate/vigorous physical activity) that were statistically significant. Signs/symptoms that had no significant association with ISB were not presented. For the total sample, people with ISB have a higher occurrence of headache (*OR*= 1.582; 95%CI 1.085–2.305; *p*= 0.017) and cough (*OR*= 1.519; 95%CI 1.019–2.265; *p*= 0.040). For males, ISB was associated with the occurrence of headache (*OR*= 2.357; 95%CI 1.312–4.232; *p*= 0.004) and cough (*OR*= 2.508; 95%CI 1.268–4.959; *p*= 0.008). For females, ISB reduced the chance of experiencing symptoms of fatigue/tiredness (*OR*= 0.574; 95%CI 0.353–0.932; *p*= 0.025), given as a protective factor.

For the total sample, the effect size for ISB on the occurrence of headache was (d= 0.3), and for cough (d= 0.2). For males, the effect size for both headache and cough was (d= 0.5). For females, the effect size for fatigue or tiredness was (d= -0.4). Therefore, the effect size classification for these conditions was deemed "medium," except for cough in the total sample, which was classified as "small."

DISCUSSION

This retrospective observational study identified an association between SB and clinical signs and symptoms of COVID-19. Specifically, the most frequent symptoms observed among those with ISB were headache, fatigue/tiredness, and muscle pain. Among the participants, 44.8% were classified as having ISB, with 38.6% of the total females and 54.5% of the total males. Furthermore, ISB increased the odds for the occurrence of clinical signs and symptoms such as headache (1.5 times) and cough (1.5 times) for the total sample, headache (2.3 times), and cough (2.5 times) for males. Additionally, there was an association with a lower occurrence of the fatigue or tiredness symptom (0.5 times) for females, which was given as a protective factor; more time sitting, there is less effort, resulting in a reduction in the fatigue or tiredness symptom.

Thus, the study highlights a worrying aspect of SB and its adverse health outcomes. An observational analysis evaluated 38 young adults, grouped by sex, to verify whether BMI and physical activity level modulate autonomic function after SARS-CoV-2 infection. The study found that even after mild to moderate COVID-19 infection, young adults had higher sympathetic activity, lower parasympathetic activity, and global variability compared to uninfected individuals. In addition, overweight and physically inactive participants had worse cardiac autonomic modulation (Freire et al., 2022). Such comorbidities, along with COVID-19, present autonomic dysregulation, corroborating the hypothesis that an organism with a systemic inflammatory profile decreased physical activity and increased SB aggravates COVID-19 disease (Chen et al., 2022; Freire et al., 2022; Gomide et al., 2022b). In addition, our findings show that the symptoms differ in

Table 1. Absolute (n) and relative (%) frequency of sociodemographic characteristics and clinical signs and symptoms of COVID-19 in the total sample and grouped by sex.

Variables	Categories	Total Sample (n= 509)		Female (n= 311)		Male (n= 198)	
		(n)	(%)	(n)	(%)	(n)	(%)
Sociodemographic							
Age groups	60≥ years	112	22.0	73	23.5	39	19.7
	18 a 59 years	397	78.0	238	76.5	159	80.3
Sedentary Behavior	< 4 hours	281	55.2	191	61.4	90	45.5
	≥ 4 hours	228	44.8	120	38.6	108	54.5
Skin color	White	301	59.1	187	60.1	114	57.6
	Black	48	9.4	33	10.6	15	7.6
	Yellow	3	0.6	2	0.6	1	0.5
	Brown	156	30.6	88	28.3	68	34.3
	Prefer not to declare	1	0.2	1	0.3	0	0.0
BMI (kg.m²)	24.9 ≤	144	28.3	86	27.7	58	29.3
	25 or more	365	71.7	225	72.3	140	70.7
Signs and symptoms							
Fever	Yes	259	50.9	146	46.9	113	57.1
	No	250	49.1	165	53.1	85	42.9
Headache	Yes	297	58.3	200	64.3	97	49
	No	212	41.1	111	35.7	101	51
Muscle pain	Yes	280	55.0	178	57.2	102	51.5
	No	229	45.0	133	42.8	96	48.5
Difficulty Breathing	Yes	147	28.9	97	31.2	50	25.3
	No	362	72.1	214	68.8	148	74.7
Cough	Yes	144	28.3	90	28.9	54	27.3
	No	365	71.7	221	71.1	144	72.7
Loss of taste	Yes	245	48.1	160	51.4	85	42.9
	No	264	51.9	151	48.6	113	57.1
Loss of smell	Yes	248	48.7	162	52.1	86	43.4
	No	261	51.3	149	47.9	112	56.6
Stomach discomfort	Yes	27	5.3	19	6.1	8	4.0
	No	482	94.7	292	93.9	190	96.0
Diarrhea	Yes	72	14.1	48	15.4	24	12.1
	No	437	85.9	263	84.6	174	87.9
Nausea	Yes	35	6.9	29	9.3	6	3.0
	No	474	93.1	282	90.7	192	97.0
Vomit	Yes	30	5.9	26	8.4	4	2.0
	No	479	94.1	285	91.6	194	98.0
Chest pain/pressure	Yes	24	4.7	14	4.5	10	5.1
	No	485	95.3	297	95.5	188	94.9
Runny nose	Yes	64	12.6	48	15.4	16	8.1
	No	445	87.4	263	84.6	182	91.9

Continue...

Table 1. Continued.

Variables	Categories	Total Sample (n= 509)		Female (n= 311)		Male (n= 198)	
		(n)	(%)	(n)	(%)	(n)	(%)
Sore throat	Yes	86	16.9	61	19.6	25	12.6
	No	423	83.1	250	80.4	173	87.4
Fatigue/ Tiredness	Yes	288	56.6	191	61.4	97	49
	No	221	43.4	120	38.6	101	51
Other Symptoms	Yes	73	14.3	59	19.0	14	7.1
	No	436	85.7	252	81.0	184	92.9

n: absolute value; %: relative value; BMI: body mass index.

Table 2. Association between sedentary behavior and signs and symptoms of COVID-19 for the total sample and grouped by sex.

Clinical signs and symptoms	Total Sample (n= 509)			Male (n= 198)			Female (n= 311)		
	RSB	ISB	OR	RSB	ISB	OR	RSB	ISB	OR
	n (%)	n (%)		n (%)	n (%)		n (%)	n (%)	
Fever	143 (55.2)	116 (44.8)	1.000	53 (46.9)	60 (53.1)	0.873	90 (61.6)	56 (38.4)	0.982
Headache	152 (51.2)	145 (48.8)	1.483*	34 (35.1)	63 (64.0)	2.306*	118 (59.0)	82 (41.0)	1.335
Muscle pain	151 (53.9)	129 (46.1)	1.122	39 (38.2)	63 (61.8)	1.831*	112 (62.9)	66 (37.1)	0.862
Difficulty Breathing	73 (49.7)	74 (50.3)	1.369	20 (40.0)	30 (60.0)	1.346	53 (54.6)	44 (45.4)	1.507
Cough	70 (48.6)	74 (51.4)	1.448*	16 (29.6)	38 (70.4)	2.511*	54 (60.0)	36 (40.0)	1.087
Loss of taste	138 (56.3)	107 (43.7)	0.916	42 (49.4)	43 (50.6)	0.756	96 (60.0)	64 (40.0)	1.131
Loss of smell	138 (55.6)	110 (44.4)	0.966	40 (46.5)	46 (53.5)	0.927	98 (60.5)	64 (39.5)	1.085
Stomach discomfort	17 (63.0)	10 (37.0)	0.712	5 (62.5)	3 (37.5)	0.486	12 (63.2)	7 (36.8)	0.924
Diarrhea	39 (54.2)	33 (45.8)	1.050	8 (33.3)	16 (66.7)	1.783	31 (64.6)	17 (35.4)	0.852
Nausea	23 (65.7)	12 (34.3)	0.623	3 (50.0)	3 (50.0)	0.829	20 (69.0)	9 (31.0)	0.693
Vomit	19 (63.3)	11 (36.7)	0.699	1 (25.0)	3 (75.0)	2.543	18 (69.2)	8 (30.8)	0.687
Chest pain/ pressure	11 (45.8)	13 (54.2)	1.484	2 (20.0)	8 (80.0)	3.520	9 (64.4)	5 (35.7)	0.879
Runny nose	40 (62.5)	24 (37.5)	0.709	5 (31.2)	11 (68.8)	1.928	35 (72.9)	13 (27.1)	0.542
Sore throat	49 (57.0)	37 (43.0)	0.917	10 (40.0)	15 (60.0)	1.290	39 (63.9)	22 (36.1)	0.875
Fatigue/ Tiredness	165 (57.3)	123 (42.7)	0.824	39 (40.2)	58 (59.8)	1.517	126 (66.0)	65 (34.0)	0.610*

RSB: Reduced Sedentary Behavior; ISB: Increased Sedentary Behavior; n: Absolute Value; %: Relative Value; OR: Odds Ratio; *p< 0.05 in Fisher's Exact Test.

their occurrence between sexes, affecting more males, which is consistent with literature that shows that the mortality and hospitalisation rate between sexes is higher in males (Lustosa et al., 2022; Rodrigues et al., 2023).

In Brazil, the proportion of deaths from COVID-19 was higher for males (2020), data similar to deaths in the Italian population for the same year (Souza et al., 2020). In another prospective cohort study in Sweden, it was shown

Table 3. Association of increased sedentary behavior with signs and clinical symptoms of people diagnosed with COVID-19.

Sample	Signs and symptoms	Variables	OR	Confidence Interval (95%)		p-value
Total (*n*= 509)	**Headache**	Sedentary Behavior	1.582	1.085	2.305	0.017
		MVPA	0.678	0.413	1.112	0.123
		Age grouping	0.665	0.428	1.034	0.070
		Sex	0.476	0.327	0.694	0.001
		BMI (kg.m²)	1.061	0.706	1.593	0.776
	Cough	Sedentary Behavior	1.519	1.019	2.265	0.040
		MVPA	1.223	0.735	2.101	0.417
		Age grouping	1.054	0.651	1.706	0.831
		Sex	0.864	0.576	1.295	0.478
		BMI (kg.m²)	0.906	0.586	1.400	0.657
Male (*n*= 198)	**Headache**	Sedentary Behavior	2.357	1.312	4.232	0.004
		MVPA	1.048	0.456	2.406	0.912
		Age grouping	0.806	0.383	1.696	0.569
		BMI (kg.m²)	0.737	0.385	1.411	0.358
	Cough	Sedentary Behavior	2.508	1.268	4.959	0.008
		MVPA	0.696	0.255	1.901	0.480
		Age grouping	0.903	0.383	2.130	0.816
		BMI (kg.m²)	0.678	0.331	1.387	0.287
Female (*n*= 311)	**Fatigue/tiredness**	Sedentary Behavior	0.574	0.353	0.932	0.025
		MVPA	0.713	0.378	1.343	0.295
		Age grouping	1.184	0.663	2.115	0.567
		BMI (kg.m²)	2.040	1.215	3.426	0.007

n: absolute value; OR: odds ratio; BMI (kg.m²): body mass index; MVPA: Moderate to vigorous physical activity. Confounding variables: age grouping, sex, BMI, and moderate/vigorous physical activity.

that for males, there was a four times greater risk of death from COVID-19 and an increased risk for viral pneumonia, acute discomfort syndrome, acute episode and sepsis (effect combined sex and age) (Sieurin et al., 2022). What can explain this male vulnerability are the associated comorbidity factors, lifestyle and biological differences that directly impact the immune system, where for females, there are stronger innate and adaptive responses in relation to antigens and with a greater burden of comorbidities non-fatal; males are more vulnerable to infectious diseases, higher levels of pro-inflammatory cytokines, and more fatal health conditions (Sieurin et al., 2022). Thus, it can explain the difference in the occurrence of clinical signs and symptoms of COVID-19 among sexes.

A study by Jimeno-Almazán et al. (2022) recruited individuals diagnosed with COVID-19 who had a chronic symptomatic phase (greater than twelve weeks from the onset of symptoms) and only received outpatient follow-up. The study presented the relationship between physical fitness and the severity of symptoms reported by the patient in the post-COVID-19 period. Greater physical fitness was associated with lower symptom severity in post-COVID-19 individuals. Physical fitness, lower limb muscle strength, maximal voluntary ventilation, and left ventricular ejection fraction were responsible for reducing fatigue and dyspnea (Jimeno-Almazán et al., 2022). Therefore, maintaining physical fitness during the disease, even in mild cases, was associated with milder symptoms in non-hospitalized individuals during the post-COVID-19 period. Individuals with an SB tend to have lower levels of physical fitness and lung function due to the inhibition of exertion due to this adopted behaviour (Souza et al., 2020). Low hours of SB are valuable pre- and post-COVID-19 measures that can reduce the severity, not only in the acute phase of the infection but also of persistent post-COVID-19 symptoms and prognosis (Souza et al., 2020).

The study of Zhang et al. (2022) carried out a bibliometric analysis of the 50 most cited articles on COVID-19 and physical activity. They concluded that physical activity is a crucial lifestyle change in this field, offering a research landscape on physical activity in global outbreaks of new coronaviruses linked to progress in coping with similar diseases based on physical activity. In addition, Gomide et al. (2022a) demonstrated that physically active individuals had a lower risk of hospitalisation, shorter hospital stays, fewer breathing difficulties, and lower oxygen support needs compared to sedentary individuals (Gomide et al., 2022b). These results, combined with those of Zhang et al. (2022), support our findings that reducing the ISB as a first step towards changing lifestyle habits and adopting physical activity at appropriate levels can reduce the occurrence of signs and symptoms and worsening of COVID-19.

The implications of SB, a term referring to activities with low energy expenditure (≤ 1.5 METs), such as sitting, reclining, or lying down, are associated with reduced or interrupted muscle contractility, resulting in decreased glucose utilisation by muscles and increased insulin levels, favouring the production of lipids. These lipids are mainly stored in the adipose tissue in the central region of the abdomen, leading to the production of inflammatory molecules and increased abdominal circumference, body weight, and chronic non-communicable diseases (Meneguci et al., 2015). In this sense, it is imperative to develop strategies with society to interrupt SB, as its association with several chronic non-communicable diseases persists, irrespective of the level of physical activity. Being physically active does not necessarily cancel out health problems related to SB (Meneguci et al., 2015). The exposure time to SB ranges from four to eleven hours per day, significantly damaging the individual's health (Hamer & Stamatakis, 2014; Jimeno-Almazán et al., 2022). Thus, interrupting SB through physical activity or even interrupting prolonged sitting with short, frequent periods of activity could mitigate the harmful health effects of SB (Dunstan et al., 2010). SB is associated with several diseases, such as cardiovascular diseases and diabetes, and maintaining adequate levels of physical activity according to recommendations reduces the risk of chronic non-communicable diseases (Gomide et al., 2022a; Meneguci et al., 2015). Therefore, public health campaigns need to promote physical activity as an essential lifestyle change to reduce SB and mitigate the negative effects of a sedentary lifestyle. The choice of the cut-off point for classifying RSB and ISB was arbitrary, ranging from zero to four hours and four hours or more (Mazo et al., 2018). Furthermore, individuals sitting down for eight hours a day typically work four hours, take a break (i.e., interruption of SB), and then work another four hours. Studies cited in this paper and others have demonstrated that exposure to SB for more than three hours increases the risk of certain diseases (Charansonney, 2011; Mazo et al., 2018).

Our study had several strengths, such as the information provided by the Municipal Health Secretariat of the study population (Ribeirão Preto/SP), the sufficient sample size to test the study hypothesis, and the absence of the "snowball" effect. This resulted in better control over instrument application. We confirmed the association between SB and clinical signs and symptoms of COVID-19, underscoring the importance of adopting an active lifestyle, avoiding ISB, and likely minimizing the occurrence of certain signs and symptoms of COVID-19. A potential limitation of our study was the possible memory deficit of the participants, which may have influenced their responses to the questionnaire. Prior training and standardization meetings were performed to minimize this factor and to ensure proper questioning and confirmation with the participants. Future studies are needed with different instruments to measure SB and confirm this relationship between ISB and clinical signs and symptoms of COVID-19 and even other similar viral diseases. Furthermore, our study was carried out with participants from a single municipality (Southeast region of Brazil), so the results cannot be immediately generalized to other locations with different socioeconomic, demographic and structural factors, stimulating future research in different contexts. Our investigation enabled the identification of the influence of ISB on the increased occurrence of certain clinical signs and symptoms of COVID-19, contributing to the worsening of the acute phase of the disease. The results show the importance of reducing ISB to minimise the occurrence of clinical signs and symptoms. Additionally, adopting physical activity at adequate levels can help minimise the effects of COVID-19 (Zhang et al., 2022). Therefore, reducing ISB and engaging in physical activity are essential modifiable factors to mitigate the effects of COVID-19.

CONCLUSIONS

ISB is significantly associated with clinical signs and symptoms in people diagnosed with COVID-19. The most common symptoms reported were headache, fatigue/tiredness, and muscle pain. When looking at the sex differences, males had greater involvement in associated signs and symptoms. In light of these findings, reducing SB for more than four hours can minimize the expression of certain signs and symptoms of COVID-19. Therefore, it is important to emphasize the significance of lifestyle modifications for promoting better health and reducing SB could be the first step towards such changes.

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