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Changes in the clustering of unhealthy movement behaviors during the COVID-19 quarantine and the association with mental health indicators among Brazilian adults

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Abstract

Our aim was to analyze the prevalence of unhealthy movement behavior clusters before and during the COVID-19 pandemic, as well as to investigate whether changes in the number of unhealthy behaviors during the COVID-19 pandemic quarantine were associated with mental health indicators. Data of 38,353 Brazilian adults from a nationwide behavior research were used. For movement behaviors, participants reported the frequency and duration of physical activity and daily time on TV viewing and computer/tablet use before and during the pandemic period. Participants also reported the frequency of loneliness, sadness (feeling sad, crestfallen, or depressed), and anxiety feelings (feeling worried, anxious, or nervous) during the pandemic period. Sex, age group, highest academic achievement, working status during quarantine, country region, and time adhering to the quarantine were used as correlates. We used descriptive statistics and logistic regression models for the data analysis. The prevalence of all movement behavior clusters increased during the COVID-19 pandemic. The cluster of all three unhealthy movement behaviors increased from 4.6% (95% confidence interval [CI]: 3.9–5.4) to 26.2% (95% CI: 24.8–27.7). Younger adults, people with higher academic achievement, not working or working at home, and those with higher time in quarantine presented higher clustering. People that increased one and two or three unhealthy movement behaviors were, respectively, more likely to present loneliness (odds ratio [OR] = 1.41 [95% CI: 1.21–1.65] and OR = 1.71 [95% CI: 1.42–2.07]), sadness (OR = 1.25 [95% CI: 1.06–1.48] and OR = 1.73 [95% CI: 1.42–2.10]), and anxiety (OR = 1.34 [95% CI: 1.13–1.57] and OR = 1.78 [95% CI: 1.46–2.17]) during the COVID-19 quarantine. Clustering of unhealthy movement behaviors substantially increased and was associated with poorer mental health during the COVID-19 pandemic.

Keywords

Exercise, Sitting, Sedentary behavior, Sedentary lifestyle

Implications

Practice: Individuals should practice physical activity according to the recommendations during the quarantine, as well as decrease the time in sedentary behaviors with the objective of protecting mental health during the quarantine.

Policy: Policymakers should be aware of increases in the prevalence of clusters of unhealthy movement behaviors, which can be associated with increases in chronic diseases, and develop public policies to encourage the practice of physical activity according to the recommendations, especially considering the mostly affected subgroups of the population.

Research: Researchers should continue to monitor the prevalence of unhealthy movement behaviors clusters and determinants as well as to formulate as well as test possible interventions during the COVID-19 period and after.

INTRODUCTION

The practice of physical activity and low sedentary behavior are important behaviors for health promotion, reported as protective factors for several negative physical and mental health outcomes [1–3]. In addition to their isolated approach, the co-occurrence of physical inactivity and sedentary behavior is associated with a greater increase in the risk for mental and physical negative health outcomes [4–6]. However, the prevalence of physical inactivity and elevated sedentary behavior are high worldwide [7,8], especially considering Latin America countries, which present even higher prevalences of physical inactivity and elevated sedentary behavior [7–9].

Although these unhealthy behaviors have been public health concerns for several years, the current COVID-19 pandemic has made this situation even worse [10]. The measures of social distancing and "stay-at-home" messages, effective for controlling the pandemic, have directly affected these movement behaviors [11]. Quarantine measures reduce opportunities for physical activity, especially outdoor activities, and increase daily sedentary behaviors [12], which can affect cardiovascular [13], metabolic [14], and mental health [15]. However, although recent studies have shown the potentially harmful effects of physical inactivity and sedentary behaviors

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during the COVID-19 pandemic [16,17], less attention has been paid to the population groups that are clustering these unhealthy behaviors. In recent years, physical inactivity and sedentary behaviors have been pointed out as distinct behaviors; however, stronger evidence suggests that the coexistence of both increases the risk of many negative health outcomes and mortality [18,19]. In addition, it was shown that the different types of sedentary behaviors (e.g., TV viewing and computer use) are specifically associated with mortality risk in interactions with physical activity [4], and the effects of the different sedentary behaviors have been especially identified regarding mental health outcomes [20]. Given that previous findings showed that sedentary behavior and reductions in physical activity can be negatively associated with mental health even after periods as short as 2 weeks [21,22], the negative effect of clustering physical inactivity and different types of sedentary behaviors during the COVID-19 pandemic may not only be summed but also amplified. Thus, we identified unhealthy movement behavior clusters before and during the COVID-19 pandemic and investigated whether changes in the number of unhealthy behaviors due to the COVID-19 pandemic quarantine are associated with mental health issues.

METHODS

Sample

The "Brazilian behavioral research during the COVID-19 pandemic" is a nationwide health survey that used a virtual questionnaire to assess the changes that occurred in the lives of Brazilians after the arrival of the coronavirus pandemic in the country, related to social restriction initiatives to protect people, including quarantine. Data collection was conducted between April 24 and May 24, 2020.

Participants were invited through a chain sampling procedure. In the first stage, the 15 researchers involved in the study chose a total of 200 other researchers from different states in Brazil, as well as 20 people each from their social networks, making a total of 400 people chosen. The people chosen in the first stage were denominated influencers. These 400 sent the survey link to at least 12 people from their social networks, obeying a stratification by sex, age range (18–39; 40–59; and 60+), and education level (incomplete high school or less; education complete medium or more). In addition, information about the study was disseminated through press releases, social communications from participating research institutions, state health departments, and social media. The survey link was also available at the influencers' research institutions. All procedures were approved by the National Research Ethics Commission (process: 30598320.1.0000.5241). Initially, 45,161 participants completed the questionnaire. The sample was weighted according to characteristics from the 2019 National Household Sample Survey (conducted annually), considering the population in each state, education, age, sex, and prevalence of chronic diseases, aiming to include a nationally representative sample.

Movement behaviors

The questionnaires of physical activity and TV viewing were based on the questionnaire of the "Brazilian Telephone-based Risk Factor Surveillance System for Chronic Diseases," which is an annual Brazilian survey begun in 2006. A previous study found good reproducibility for physical activity during leisure time (K = 0.70) and moderate reproducibility for TV viewing (K = 0.56) and also good values in comparison with the global physical activity questionnaire [23]. For physical activity before the COVID-19 pandemic, participants were asked "Before the COVID-19 pandemic, how many days a week did you practice any type of physical exercise or sport? (do not consider physical therapy)." Possible answers were: (a) less than 1 day/week; (b) 1–2 days/week; (c) 3–4 days/week; or (d) 5 or more days/week. For those reporting physical activity practice, we also asked: "How long did this activity last?" Possible answers were: (a) less than 30 min; (b) 30–45 min; (c) 46–60 min; or (d) more than 1 hr. For physical activity during the COVID–19 pandemic, participants were asked: "During the COVID-19 pandemic how many days a week did you practice any type of physical exercise or sport? (do not consider physical therapy)." Possible answers were: (a) less than 1 day/week; (b) 1–2 days/week; (c) 3–4 days/week; or (d) 5 or more days/week. For those reporting physical activity practice, we also asked: "How long did this activity last?" Possible answers were: (a) less than 30 min; (b) 30–45 min; (c) 46–60 min; or (d) more than 1 hr. We classified activities using the recommendation of 150 min/week [24], which was calculated using the median point of frequency and duration in each category.

For TV viewing, participants were asked: "Usually, before the pandemic, how many hours a day did you spend watching television?" and "During the pandemic, how many hours a day did you watch television?" Possible answers for both were (a) none; (b) less than 1 hr/day; (c) between 1 and less than 2 hr/day; (d) between 2 and less than 3 hr/day; (e) between 3 and less than 4 hr/day; (f) between 4 and less than 5 hr/day; (g) between 5 and less than 6 hr/day; and (h) 6 hr/day or more. For the assessment of computer/tablet use, we also used two questions "Usually, before the pandemic, how many hours a day did you spend using a computer or tablet?" and "During the pandemic, how many hours a day did you spend using a computer or tablet?" with an open answer. TV viewing and computer/tablet use were classified using the cutoff point of 4 hr/day at both moments (before and during the quarantine),

especially considering the substantial increase in cardiovascular risk and depressive symptoms of 4 hr/day of TV viewing, which we standardized to computer use [25,26]. We created four mutually exclusive clusters of unhealthy movement behaviors: (a) inactive + high TV viewing; (b) inactive + high computer/tablet use; (c) high TV viewing + high computer/tablet use; and (d) inactive + high TV viewing + high computer/tablet use.

Mental health

As mental health indicators, we adopted three questions regarding feelings of loneliness, sadness, and anxiety. For loneliness, participants were asked: "During the pandemic period, how often did you feel isolated or alone?," for sadness: "During the pandemic period, how often did you feel sad, crestfallen, or depressed?," and for anxiety: "During the pandemic period, how often did you feel worried, anxious, or nervous?" Possible answers for each question were: (a) "Never," (b) "A few times," (c) "Often," or (d) "Always." We classified participants as positive for loneliness, sadness, and anxiety if they answered "often" or "always."

Correlates

We used sex, age group (18–39, 40–59, and ≥ 60 years), country region (North, Northeast, Southeast, South, and Midwest), highest academic achievement, working status during the pandemic, change in income, and time adhering to quarantine as correlates. Academic achievement was classified as no academic achievement or elementary school, high school, and higher education or more. Working status during quarantine was classified as currently not working, working in a normal routine, and home office. Change in income was assessed by asking the participants about how their income had changed since the beginning of the COVID–19 pandemic, classified as (a) maintained or increased, (b) slightly reduced, or (c) substantially reduced or lost their income. The time adhering to quarantine was assessed through a question asking about adherence to quarantine. Those that answered adherence through staying at home and just going shopping at the supermarket and pharmacy or staying strictly at home, leaving only for health care needs also reported the duration of these measures. We classified adherence into no adherence to quarantine, less than 1 month, 1–2 months, and 2 or more months in quarantine.

Statistical procedures

Weighted frequencies, 95% confidence intervals, and difference in percentage points (p.p.) were used to describe the clustering of unhealthy movement behaviors in the general sample, as well as according to correlates. Crude and adjusted (adjusting for sex, age group, academic achievement, working status during the quarantine, change in income, and quarantine adherence) logistic regression models were created to analyze the association of changes in the number of unhealthy movement behaviors with mental health indicators. All analyzes were conducted using the software Stata 15.1.

RESULTS

Due to missing data, our final sample was composed of 38,353 adults. The prevalences of each cluster of unhealthy movement behaviors are presented in Fig. 1. All clusters presented increased prevalence, including inactive + high TV viewing (3.3 p.p.), inactive + high computer/tablet use (7.7 p.p.), high TV viewing + high computer/tablet use (1.3 p.p.), and inactive + high TV viewing + high computer/tablet use (21.6 p.p.).

The increase in the number of unhealthy movement behaviors was substantial (Fig. 2) considering that 20.5% of those reporting no unhealthy behaviors before the pandemic changed to reporting three during the pandemic and 38.6% changed to reporting two. Similarly, those reporting only one unhealthy behavior before the pandemic were more likely to increase to two (44.0%) or three (22.2%) during the pandemic, while those reporting two or three unhealthy behaviors before the pandemic presented a stability pattern. The prevalence of people that presented two or three unhealthy behaviors before the pandemic and reduced to zero during the pandemic was lower than 1% each.

Table 1 shows the changes in the prevalence of clustering of physical inactivity and sedentary behaviors according to correlates. In general, the clustering of the three unhealthy movement behaviors was high, with a crude difference ranging between 13.5% and 26.0% depending on the subgroup. Considering the correlates, a greater increase in the prevalence of clustering unhealthy movement behaviors occurred among younger adults, people with higher academic achievement, those with a different routine of working during the pandemic (not working or home office), and those with a longer time adhering to quarantine.

The association between changes in the number of unhealthy movement behaviors and mental health is presented in Table 2. In the adjusted analyses, people that reported increases of one and two or three unhealthy movement behaviors were more likely to present loneliness, sadness, and anxiety in comparison to those who maintained their number of unhealthy behaviors. In addition, reductions in the number of unhealthy behavior clusters were associated with lower odds for anxiety during the COVID-19 quarantine.

DISCUSSION

The current study investigated the prevalence of unhealthy movement behavior clustering before and

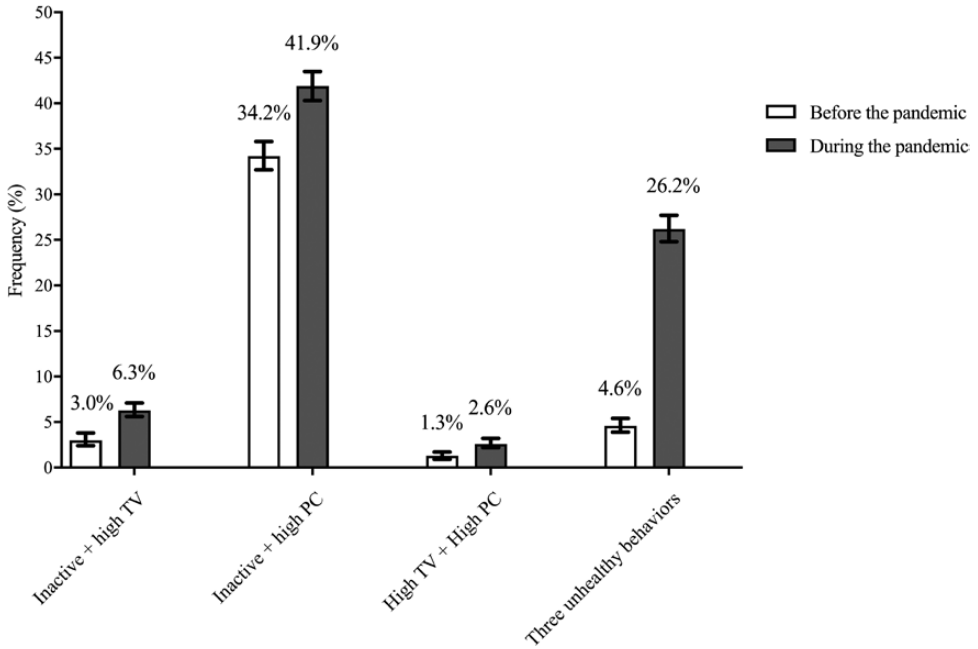

Fig 1 | Changes in the prevalence of clustering movement behaviors during the COVID-19 pandemic in Brazil (*N* = 38,353). *PC* computer/tablet use. Inactive refers to not attending the current physical activity recommendations (<150 min/week). High TV or computer/tablet use refers to the cutoff point of 4 hr/day.

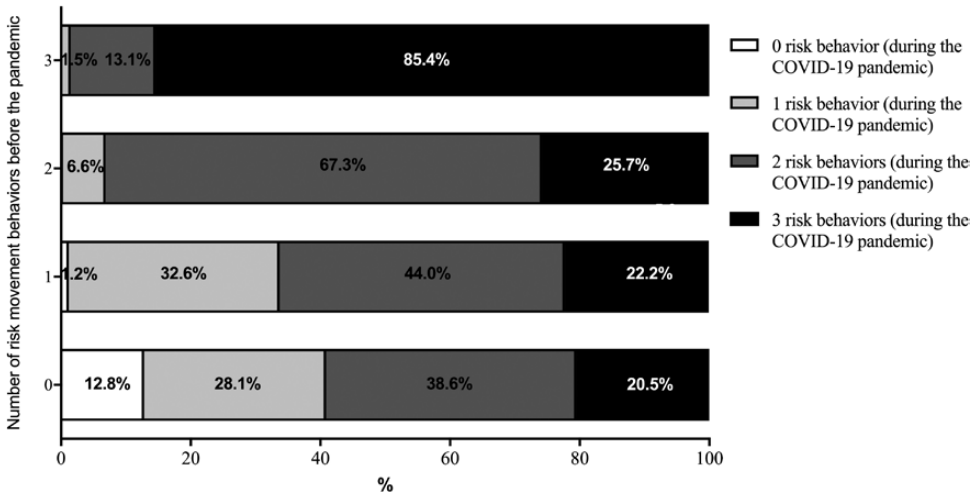

Fig 2 | Prevalence of the number of unhealthy movement behaviors during the COVID-19 pandemic according to the number of unhealthy behaviors before the pandemic in Brazil (*N* = 38,353)

during the COVID-19 pandemic, as well as the association between changes in the clustering of unhealthy movement behaviors and mental health indicators during the COVID-19 pandemic among Brazilian adults. Our main findings were that the clustering of physical inactivity and sedentary behaviors substantially increased during the COVID-19 pandemic, especially considering the clustering of all three unhealthy behaviors. A quarter of Brazilian adults are inactive and spend more than 8 hr in sedentary behaviors during the day (TV viewing + computer/tablet use), which significantly increases the risk for mortality [18]. Furthermore, the increase in the number of unhealthy movement behaviors was associated with loneliness, sadness, and anxiety feelings during the COVID-19 pandemic.

Both physical inactivity and sedentary behavior were highly prevalent before the COVID-19 pandemic. It is estimated that the prevalence of physical inactivity was approximately 40% in Latin America [7] and the prevalence of high sedentary behavior was between 14% and 58%, depending on the indicator [9]. However, the co-occurrence of physical inactivity and sedentary behavior was not evaluated using nationally representative cohorts. In our study, we found that the co-occurrence of

Table 1 | Changes in the prevalence of unhealthy movement behaviors clusters according correlates before and during the COVID-19 pandemic, Brazil 2020

	Inactive + high TV			Inactive + high PC			High TV + high PC			Inactive + high TV + high PC		
	Before (*n* = 808)	During (*n* = 2,359)	Δ	Before (*n* = 13,383)	During (*n* = 16,405)	Δ	Before (*n* = 420)	During (*n* = 1,116)	Δ	Before (*n* = 1,188)	During (*n* = 9,068)	Δ
Gender												
Female	2.8 (2.4–3.4)	7.0 (6.2–7.9)	4.2	33.9 (32.2–35.5)	40.5 (38.8–42.2)	6.6	0.8 (0.6–1.2)	2.6 (2.0–3.3)	1.8	4.9 (4.0–6.1)	27.8 (26.1–29.5)	22.9
Male	3.2 (2.2–4.7)	5.7 (4.6–7.1)	2.5	34.6 (32.1–37.2)	43.3 (40.6–46.0)	8.7	1.7 (1.1–2.6)	2.7 (1.9–3.6)	1.0	4.2 (3.3–5.4)	24.7 (22.4–27.2)	20.5
Age group												
18–39	1.3 (0.7–2.4)	3.8 (3.2–4.6)	2.5	39.4 (37.1–41.7)	50.4 (48.0–52.8)	11.0	1.0 (0.6–1.6)	2.3 (1.8–2.9)	1.3	2.7 (2.1–3.5)	25.4 (23.3–27.6)	22.7
40–59	3.4 (2.3–5.0)	7.9 (6.5–9.6)	4.5	33.2 (30.8–35.7)	36.2 (33.6–38.9)	3.0	1.1 (0.7–1.6)	3.0 (2.0–4.4)	1.9	5.4 (4.3–6.9)	28.0 (25.8–30.0)	22.6
≥60	7.2 (5.4–9.4)	10.5 (8.5–12.9)	3.3	21.4 (18.3–24.9)	28.4 (24.9–32.2)	7.0	2.3 (1.1–4.7)	2.9 (2.0–4.4)	0.6	8.3 (5.9–11.5)	25.0 (21.3–29.1)	16.7
Academic achievement												
Less than high school	4.0 (2.5–6.4)	6.3 (4.1–9.6)	2.3	22.6 (17.6–28.4)	27.7 (22.2–33.9)	5.1	3.7 (1.4–9.8)	4.2 (2.0–8.6)	0.5	7.1 (4.2–11.9)	29.5 (23.5–36.2)	22.4
High school	3.3 (2.5–4.4)	6.6 (5.7–7.7)	3.3	34.8 (32.8–36.8)	42.2 (40.1–44.3)	7.4	1.0 (0.7–1.5)	2.4 (1.9–3.2)	1.4	4.8 (4.0–5.9)	26.9 (25.0–28.8)	22.1
More than high school	1.5 (1.3–1.6)	5.3 (5.0–5.7)	3.8	36.9 (36.2–37.6)	46.4 (45.6–47.1)	9.5	1.1 (1.0–1.3)	2.7 (2.5–3.0)	1.6	2.6 (2.4–2.9)	22.6 (22.0–23.2)	20.0
Country region												
North	5.6 (1.7–17.0)	6.6 (3.0–13.8)	1.0	31.8 (25.4–38.9)	38.9 (31.9–46.4)	7.1	1.2 (0.4–3.0)	1.9 (1.1–3.3)	0.7	7.6 (3.6–15.5)	31.1 (23.6–39.7)	23.5
Northeast	1.9 (1.3–2.9)	5.3 (4.0–6.9)	3.4	35.6 (31.7–39.6)	41.9 (37.8–46.1)	6.4	1.3 (0.5–3.4)	3.7 (2.3–5.9)	2.4	3.4 (2.3–5.0)	28.1 (24.3–32.2)	24.7
Southeast	3.3 (2.7–4.1)	7.2 (6.3–8.2)	3.9	33.9 (32.3–35.5)	40.5 (38.9–42.2)	6.6	1.3 (1.0–1.8)	3.0 (2.4–3.7)	1.7	4.2 (3.6–5.0)	25.6 (24.1–27.2)	21.4
South	3.2 (2.0–5.0)	5.9 (4.3–8.0)	2.7	34.1 (30.4–38.0)	43.5 (39.7–47.5)	9.4	1.2 (0.6–2.6)	1.0 (0.6–1.5)	0.2	5.7 (3.9–8.2)	26.2 (23.0–29.7)	20.5
Midwest	1.6 (0.8–3.3)	5.0 (3.1–8.0)	3.4	35.0 (27.6–43.2)	50.4 (41.7–59.2)	15.4	0.7 (0.3–1.7)	1.5 (0.7–2.9)	0.8	5.3 (2.7–9.9)	18.8 (14.3–24.3)	13.5

Table 1 | Continued

	Inactive + high TV			Inactive + high PC			High TV + high PC			Inactive + high TV + high PC		
	Before (*n* = 808)	During (*n* = 2,359)	Δ	Before (*n* = 13,383)	During (*n* = 16,405)	Δ	Before (*n* = 420)	During (*n* = 1,116)	Δ	Before (*n* = 1,188)	During (*n* = 9,068)	Δ
Working during the pandemic												
No	3.7 (3.0–4.6)	8.1 (7.1–9.3)	4.4	28.6 (26.6–30.7)	36.2 (34.0–38.5)	7.6	1.6 (1.0–2.4)	2.9 (2.2–3.8)	1.3	4.6 (3.6–5.8)	29.1 (27.0–31.3)	24.5
Normal routine	3.7 (1.9–7.1)	5.6 (3.9–8.1)	1.9	32.5 (29.0–36.2)	42.0 (38.3–45.9)	9.5	0.6 (2.5-1.4)	1.5 (0.9–2.5)	0.9	5.1 (3.6–7.1)	22.6 (18.9–26.6)	17.5
Home office	1.3 (0.9–2.0)	3.7 (2.9–4.6)	2.4	45.4 (42.6–48.2)	51.7 (48.9–54.5)	6.3	1.2 (0.8–1.8)	3.0 (2.1–4.3)	1.8	4.2 (3.1–5.5)	23.8 (21.7–26.1)	19.6
Change in the income during the pandemic												
Maintained or increased	3.6 (2.8–4.6)	7.4 (6.3–8.8)	3.8	35.5 (33.2–37.8)	42.5 (40.3–44.9)	7.0	1.5 (1.0–2.2)	2.6 (2.0–3.3)	1.1	5.6 (4.4–7.2)	22.9 (20.9–25.0)	17.3
Slightly reduced	1.7 (1.2–2.3)	4.8 (4.0–5.8)	3.1	34.9 (32.4–37.6)	45.1 (42.3–47.9)	10.2	1.4 (0.7–2.9)	3.1 (2.1–4.7)	1.7	3.1 (2.4–4.0)	26.0 (23.5–28.8)	22.9
Substantially reduced or lost	3.5 (2.1–5.8)	6.3 (4.9–8.1)	2.8	32.0 (29.0–35.1)	38.0 (34.6–41.5)	6.0	0.8 (0.5–1.3)	2.2 (1.5–3.3)	1.4	4.7 (3.5–6.3)	30.7 (27.7–33.8)	26.0
Time under quarantine adherence												
No	3.2 (1.9–5.3)	5.9 (4.3–8.0)	2.7	34.4 (31.3–37.8)	43.5 (40.1–46.9)	9.1	1.0 (0.5–1.9)	2.3 (1.4–3.8)	1.3	4.7 (3.4–6.4)	20.8 (18.1–23.8)	16.0
<1 month	2.7 (1.9–3.9)	5.5 (4.3–7.0)	2.8	32.4 (28.7–36.3)	42.0 (37.8–46.4)	9.6	1.2 (0.6–2.4)	2.9 (1.8–4.7)	1.7	4.9 (3.1–7.7)	27.9 (24.1–32.0)	23.0
1–2 months	2.8 (2.0–3.9)	6.6 (5.7–7.7)	3.8	35.2 (33.2–37.2)	42.4 (40.3–44.6)	7.2	1.4 (0.9–2.2)	2.8 (2.2–3.6)	1.4	4.5 (3.6–5.5)	27.7 (25.8–29.7)	23.2
>2 months	5.1 (3.2–8.1)	8.2 (5.6–12.0)	3.1	31.8 (26.5–37.7)	32.1 (27.1–37.4)	0.3	1.1 (0.6–2.3)	2.0 (1.2–3.3)	0.9	4.1 (2.7–6.2)	31.2 (25.7–37.4)	27.1

Data are described using values of percentage (95% confidence interval). 22,554 (56.9%) participants did not present any cluster of unhealthy movement behaviors before the pandemic and 9,405 (22.9%) participants did not present any cluster of unhealthy movement behaviors during the pandemic.

Table 2 | Associations between change in the number of movement behaviors and mental health and sleep outcomes during the COVID-19 pandemic, Brazil 2020 (*N* = 38,353)

Change in risk movement behaviors	Loneliness OR (95% CI)	Sadness OR (95% CI)	Anxiety OR (95% CI)
Crude models			
Reduced	1.08 (0.79–1.49)	0.83 (0.62–1.13)	0.68 (0.51–0.92)
Maintained	REF	REF	REF
Increased one	1.48 (1.27–1.73)	1.34 (1.14–1.56)	1.43 (1.23–1.67)
Increased 2 or 3	1.82 (1.50–2.19)	1.86 (1.54–2.24)	1.88 (1.56–2.27)
Adjusted models			
Reduced	1.07 (0.75–1.52)	0.86 (0.65–1.14)	0.74 (0.56–0.96)
Maintained	REF	REF	REF
Increased one	1.40 (1.20–1.64)	1.24 (1.05–1.46)	1.32 (1.12–1.55)
Increased 2 or 3	1.65 (1.36–1.99)	1.66 (1.36–2.02)	1.69 (1.39–2.06)

CI confidence interval; *OR* odds ratio.
Adjusted for age group, sex, highest academic achievement, working status during the COVID-19 quarantine, change in the income, and time under quarantine adherence.

physical inactivity, high TV viewing, and high computer/tablet use substantially increased, more than doubling in all the population subgroups. However, some subgroups were more affected by the elevation in the clustering rates. Young adults, those with higher academic achievement, without a normal work routine, and with a longer time adhering to quarantine presented higher rates of clustering.

Some aspects could underlie these associations. Younger adults present lower rates of physical inactivity, as well as TV viewing, which could contribute to a higher increase in the clustering of both behaviors [8,9]. Similarly, participants with higher educational status present lower physical inactivity, especially during leisure time, as well as TV viewing, which could be associated with a higher increase in these behaviors [9,27]. The exception is considering the higher prevalence of clustering of high computer/tablet use and physical inactivity, which is consistently high among younger adults and people with higher academic achievement. These findings highlight that, with the increases in the clustering rates during the COVID-19 quarantine, the subgroups with lower rates before the pandemic became similar (younger adults, higher academic achievement, and working in home office) or higher (longer time adhering to quarantine and not working during the pandemic). Thus, to tackle physical inactivity and elevated sedentary behaviors during the pandemic, it is necessary to change the target subgroups and strategies used before the pandemic [28].

Our study also found that the increase in the number of unhealthy behaviors during the COVID-19 pandemic increased the odds for poorer mental health indicators. These findings agree with a potential joint association between physical activity and sedentary behavior in the association with mental health, with an additive association [5,6]. In this sense, both sedentary behavior and physical activity are risk factors for mental health and their co-occurrence can increase the risk [5,6], especially considering the substantial increase in the odds given an increase of two or three unhealthy movement behaviors.

Several mechanisms can explain part of the association of changes in physical activity and sedentary behavior during the COVID-19 quarantine with poorer mental health. Biologically, sedentary behavior can be associated with inflammatory markers even after short periods of time, which can be associated with poorer mood indicators [22]. As a social aspect, lower physical activity may be associated with lower social interactions, which can be detrimental for mental health, especially for loneliness feelings [29,30]. In addition, the COVID-19 pandemic brought a massive amount of negative news both on the television and internet (especially social media), which is associated with worse mental health indicators, and could also partly explain the association of TV viewing and computer use with mental health [31–33].

Our study analyzed more than 35,000 Brazilian adults from a nationwide sample, weighted for national representativity to investigate the pattern of clustering unhealthy movement behaviors during the COVID-19 quarantine, as well as its association with mental health indicators in one of the countries most affected by the COVID-19 pandemic [34]. Given the urge for representative studies to identify the impacts of the COVID-19 pandemic quarantine on movement behaviors and their consequences, we consider that these findings advance the knowledge and reinforce the need to promote active lifestyles that can mitigate the harmful effects of the quarantine period on people's health. Despite this, our findings should be considered in the light of potential limitations. First, the self-reported data and retrospective design are prone to recall bias. Second, considering the web-based assessment, participants with extremely low socioeconomic conditions,

who were more affected by the pandemic, were underrepresented, potentially affecting the results. Third, physical activity and sedentary behavior questionnaires have some bias as participants frequently overestimate time in leisure-time physical activity and underestimate sedentary behavior [35,36]. Fourth, we adopted a specific indicator of physical activity (exercise/sport), which did not consider other domains of the day (e.g., domestic, transport, and occupational activities), as well as the pattern of the movement behaviors in terms of breaks and bouts.

In conclusion, the clustering of unhealthy movement behaviors substantially increased during the COVID-19 pandemic quarantine, especially considering some subgroups of the population (e.g., younger adults, higher academic achievement, working in home office, not working during the pandemic, and longer time adhering to quarantine). These increases are associated with poorer mental health outcomes.

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Compliance with Ethical Standards

Conflicts of Interest: The authors declare no conflict of interest.

Authors' Contributions: A.O.W. conceptualization, formal analysis, writing - original draft, writing - review & editing, visualization. D.R.S.: conceptualization, writing - original draft, writing - review & editing, visualization. D.C.M. methodology, project administration, writing - review & editing, validation. P.R.B.S.: project administration, investigation writing - review & editing, validation. L.O.A.: project administration, investigation writing - review & editing, validation. M.B.A.B.: methodology, project administration, writing - review & editing, validation. C.L.S.: supervision, methodology, project administration, writing - review & editing, validation.

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the National Research Ethics Commission (process: 30598320.1.0000.5241). This article does not contain any studies with animals performed by any of the authors.

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