Effects of physical activity and sociodemographic aspects on the mental health of the Brazilian population at different times of the COVID-19 pandemic

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Effects of physical activity and sociodemographic aspects on the mental health of the Brazilian population at different times of the COVID-19 pandemic

Short title

Brazilians' mental health during COVID-19

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Abstract

The objective of this study was to analyze the psychological responses of the Brazilian population and understand their level of anxiety, depression, and stress during different times of the COVID-19 pandemic, as well as how the PA level and sociodemographic aspects may have influenced them. This longitudinal study collected data in two periods: April/May 2020 (T1) at the beginning of the COVID-19 pandemic with restrictions and social distancing indication (during the lockdown), and October/November 2021 (T2) period with fewer restrictions and vaccines available in Brazil (after the lockdown). Data were collected online, including sociodemographic information (age, gender, education), mental health by the Depression, Anxiety, and Stress Scale (DASS-21), and estimated PA levels using the International Physical Activity Questionnaire (IPAQ) short version. Statistical analysis used generalized linear regression models to evaluate the impact of time, sociodemographic aspects, and PA on the risk of depression, anxiety, and stress between periods. Adjusted risk probabilities and Odds Ratio (OR) with 95% confidence intervals (95% CI) were calculated with a 5% significance level. Comparisons between T2 and T1 showed an increased risk for depression (OR = 1.48 [95%CI = 1.03; 2.12]), anxiety (2.66 [1.70; 4.17]), and stress (1.95 [1.36; 2.79]). Low PA levels were associated with a higher risk of depression (2.08 [1.14; 3.82]) and stress (2.03 [1.09; 3.80]) but not anxiety in the comparison between T2 and T1. The findings highlight the increased risk for depression, anxiety, and stress in T2 and suggest PA promotion as a possibility for mental health care.

Keywords: anxiety, depression, psychological stress, SARS-CoV-2, sedentary behavior.

Introduction

The COVID-19 pandemic began spreading globally at the end of 2019 and has led not only to a global public health crisis but also to significant psychological and social challenges. By January 2025, the world had already accumulated more than 777 million cases and 7 million deaths, with Brazil continuing to occupy a prominent position, being the sixth country of cases (more than 37 million) and the second in the number of reported deaths (more than 702 thousand).[1]

In the first months of the pandemic in 2020, when cases were increasing rapidly in all countries, health authorities, including the World Health Organization (WHO), issued safety recommendations with precautions to reduce exposure and transmission of the virus. In this context, social distancing was identified as an effective measure to control the spread of the SARS-CoV-2 virus, which causes COVID-19.[1,2] This measure led to several changes in people's lifestyles since staying at home came to be considered a fundamental safety step to help combat the widespread spread of the virus. As a result, the recommendations and guidelines imposed against travel, access to certain places, and participation in indoor and even outdoor activities have limited the activities of daily living for billions of people.[3]

With the social distancing measures, there was a reduction in the number of infected people and mortality at the end of 2020. However, at the beginning of 2021, after the end-of-the-year holidays, which are quite traditional in Brazil, there was a second wave, with an increasing number of cases and deaths. For this reason, restrictions continued, and the indication of social distancing was used more rigidly in some cities.[4] The impact of the COVID-19 pandemic during this period had important consequences on the economy of families and the population's mental health, mainly in Latin America. With a prolonged time at home during the crisis, it was expected that

the negative psychological effects would increase,[5] leading to increased fear,[6] and panic.[7] Some studies have shown an increase in symptoms of depression, anxiety, and post-traumatic stress.[8,9]

According to the WHO (2017), a survey carried out in 2015 showed that Brazil already led the world in the prevalence of anxiety disorders, with 9.3% of the population, and ranked third in depression rates, with 5.8% of the population. In the very first months of the pandemic, when the recommendations were for social isolation, there was a significant increase in the prevalence of anxiety and depression disorders.[10] Other studies have shown an increase of more than 25% in 2020,[5,11,12] and an indication that women are more prone to high levels of anxiety and depression than men.[13–15]

The restrictions imposed by the pandemic, especially between the start of the pandemic in 2020 and the end of the first half of 2021, meant that people started to use and access television, video games, cell phones, and the internet more,[16–18] increasing their time sitting or lying down. This had a strong influence on increasing sedentary behavior[6,19] and reducing physical activity (PA) levels.[18,20,21]

People who had the habit of practicing PA regularly and had to adapt or decrease these activities reported an increase in symptoms of anxiety and depression.[22,23] Importantly, regular PA habits can help control emotions[24,25] and individuals who managed to remain physically active or started doing PA showed reduced psychological symptoms that affected mental health when compared to inactive individuals.[13,23] The Physical Activity Guidelines for the Brazilian Population [26] recommends at least 150 minutes of moderate aerobic PA or 75 minutes of vigorous PA per week, as well as muscle-strengthening activities twice a week. However, the recommendation emphasizes that every movement counts and encourages people to

do as much as they can. In addition to the benefits for mental health, PA regularly acts primarily and secondarily to promote health and prevent and control chronic diseases, for example: diabetes, hypertension, obesity, and osteoporosis, among others.[27]

The prevalence of mental health disorders is high in Brazil,[15] and during the COVID-19 pandemic, these numbers have increased.[10,13] In this sense, some studies have reported that individuals who performed regular PA had fewer mental health problems.[28–31] Therefore, there seems to be a positive relationship between PA and mental health, also in the COVID-19 pandemic.[32,33]

However, it is worth noting that these cross-sectional studies were carried out at specific times during the pandemic, mainly at the beginning. The present study presents a proposal with a longitudinal characteristic, by comparing the results of the same participants in two different periods of the pandemic. The first time of data collection took place at the beginning of the pandemic between April and May 2020 (T1), with restrictions and social distancing, during the lockdown;[28] and, the second time took place between October and November 2021, period with fewer restrictions and vaccines available in Brazil (after the lockdown) (T2).[34]

Thus, the objective of this study was to analyze the psychological responses of the Brazilian population and understand their level of anxiety, depression, and stress during different times of the COVID-19 pandemic, as well as how the PA level and sociodemographic aspects may have influenced them.

Methodological procedures

This is an observational, longitudinal epidemiological study. This article followed the guidelines of The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)[35] (Supplementary Material -

https://doi.org/10.17605/OSF.IO/KXAFH) and the Checklist for Reporting Results of Internet, E-Surveys conference list (CHERRIES)[36] (Supplementary Material - https://doi.org/10.17605/OSF.IO/KXAFH).

This project was approved by the Research Ethics Committee of the Ribeirão Preto School of Physical Education and Sport (EEFERP) at USP (CAAE: 30477320.5.0000.5659).

The T1 collection data (April/May 2020) was performed with participants from three countries, Spain (n = 1030), Chile (n = 532), and Brazil (n = 3386), for a total of 4948 participants.[28] At this period, almost all the world was in a lockdown. The T2 (October/November 2021) was carried out using the email provided at T1, only with Brazilian participants. All 3386 participants from Brazil who had answered the form in T1 were invited to participate in T2. At T2, Brazil was in the vaccination phase, and restrictions eased. Therefore, this study was performed during two different periods of the COVID-19 pandemic with the same Brazilian participants.

Participants

Those participants who confirmed their participation by accepting the informed consent form were included in the new data collection. This data collection on T2 obtained 1,044 participants. When repeated answers from the same participant, only the last one was considered. So, after this stage, this study had 1006 participants, corresponding to (29.7%) of the total number of Brazilian participants who could participate in T1. All participants were between 18 and 75 years old, women and men. It is, therefore, a convenience sample, where sampling is non-probabilistic and participants are selected based on ease of access.

Procedures

Participants for T1 were recruited through an online questionnaire, and the method used was snowball sampling. The dissemination strategy was defined by sending emails and posting infographics and videos on social media (*Facebook* and *Instagram*). Contacts were made with various universities, communities, and associations with activities related to culture, and sports, among others, asking their members to answer and spread the form. Each person who responded was encouraged to pass on the questionnaire to people in their contacts and social media. The data received was stored in a secure database, to which only the authors of the survey had access.

To recruit participants in T2, we used the database with the emails of the participants who had answered the form in T1. An e-mail was sent with an invitation and the form website to be answered. The deadline for replying was set at three weeks, and after this period, a new email was sent to those who had not yet replied, waiting another two weeks for the replies to be received.

Measures

The form was sent by e-mail and prepared using the *Google Forms* tool, with automatic saving in a spreadsheet when the participants sent their answers. Firstly, the participant received information about the research data storage (data stored for up to five years on the study group's computer, protected by password), and then informed their consent to the research. The participant had to complete the form to be included in the study. All the answers were compulsory, and participants were told they could stop filling in the form anytime. Incomplete forms were not analyzed.

The form in T2, published previously,[34] was made up of questions that covered the following aspects: (a) sociodemographic data; (b) psychological responses in the last 7 days - Depression, Anxiety, and Stress Scale (DASS - 21); (c) PA level - International Physical Activity Questionnaire (IPAQ) (last 7 days).

Concerning sociodemographic data, questions were asked about the following aspects: gender (women, men or others that the person identifies), group age in years (18-29; 30-39; 40-49; 50-59; and 60 or more), and current education level (elementary school, high school, undergraduate, and graduate studies – specialization, master, and doctorate).

Psychological responses during the COVID-19 pandemic were assessed using the Depression, Anxiety, and Stress Scale (DASS-21),[37,38] which uses a Likert scale and is self-administered and validated for the Brazilian population, based on the seven days before the application. The participant answered how much they applied each of the 21 statements (0 - Not applied at all; 1 - Applied to some degree or for a short time; 2 - Applied to a considerable degree or for a good part of the time; 3 - Applied a lot or most of the time). The score calculation was based on a previous study.[39] For the analytical part of the study results, we used a combination of risk classifications, from mild to extreme, keeping the nomenclature "risk". The "no risk" classification was maintained in the same way. More detailed information was published previously.[40]

The International Physical Activity Questionnaire (IPAQ - short version), validated for the Brazilian population, was used to assess PA levels.[41] The participant was instructed to think of the last 7 days and, if the last week had not been usual, to think of a usual week. Participants were classified according to their PA level, obtained by adding up the frequency and duration of all activities in a typical week, categorizing

them as having a "low", "moderate" or "high" PA level, according to the classification proposed previously. [42]

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Statistical analysis

Continuous quantitative variables were expressed as mean (standard deviation), and categorical variables as absolute (n) and relative (%) frequency. The effect of the interaction between time and the variable was analyzed using a generalized linear regression model with mixed effects, binomial distribution, random effect on individuals, and logit link function. Three models were developed, one for each DASS-21 (depression, anxiety, and stress), with the variables gender, group age, education level, and PA level as factors. From the models, we report and interpret the descriptive measure of the risk probability for depression, anxiety, and stress; and the Odds Ratio (OR), as well as its 95% confidence interval (95% CI), calculated by Wald method. The OR reported is the exponential of the slope coefficients of the regression model, representing the effect of the difference between the categories of the same independent variable over time, i.e. the comparison of the change between the categories of each independent variable between time 1 (T1 - collection from April to May 2020) and time 2 (T2 - collection from October to November 2021). All analyses were performed using R (version 4.4.2) in the RStudio Integrated Development Environment (version 2024.12.0.467), using the lme4 (version 1.1.36) and emmeans

(version 1.10.7) packages, and the significance level was 5% (Available on the Open Science Framework https://doi.org/10.17605/OSF.IO/KXAFH).

Results

The sample consisted of 1006 participants, 66.8% women, 33.2 men, and no responses for other genders. About the age group, more frequency in the young categories: 44.0% with 18–29 years old, 24.7% with 30–39, 14.1% with 40–49; 11.3% with 50–59, and 5.9% with 60 years or more. The majority presented a higher level of education, being high school, undergraduate or graduate students (13.8%, 46.0%, and 40.2%, respectively).

Regarding physical activity levels, at time point T1, 399 participants (39.7%) were classified as having low physical activity, 305 (30.3%) as moderate, and 302 (30.0%) as high. In comparison, at time point T2, 368 participants (36.6%) reported low activity levels, 355 (35.3%) moderate, and 283 (28.1%) high.

The data showed that over time, the probability of participants presenting an indication of risk for the three mental health problems (depression, anxiety, and stress) increased (table 1). From the time effect, there was an increase in the chance of risk indication at T2 compared to T1 for depression (OR = 1.48 [95%CI = 1.03; 2.12]), anxiety (2.66 [1.70; 4.17]), and stress (1.95 [1.36; 2.79]) (table 1). In the comparison between T2 and T1 (Table 2-4), there was an increase in risk probability for all three mental health problems, depression (Table 2), anxiety (Table 3), and stress (Table 4), in all categories, based on the analysis of gender, group age, and education level. However, there were no significant changes in the OR risk indication for depression (Table 2), anxiety (Table 3), and stress (Table 4) at T2 compared to T1, among categories, based on the analysis of gender, group age, and education level.

The data related to PA level showed an increase in T2 compared to T1 in the participants with a low PA level having a risk indication for depression (2.08 [1.14; 3.82]) (Table 2) and stress (2.03 [1.09; 3.80]) compared to the high level (Table 4). Although the risk probability for anxiety indication more than doubled at all levels of PA, there was no change in the OR risk indication risk for anxiety in participants with low PA levels compared to the high PA level when comparing T2 with T1 (Table 3).

Table 1. Effect of time on the risk indication for depression, anxiety, and stress

	T1			T2			
	Risk n (%)	No risk n (%)	Risk probability %	Risk n (%)	No risk n (%)	Risk probability %	OR [95%CI] T2-T1
Depression	432 (42.9)	574 (57.1)	26.9	481 (47.8)	525 (52.2)	34.4	**1.48 [1.03; 2.12]**
Anxiety	286 (28.4)	720 (71.6)	0.8	361 (35.9)	645 (64.1)	20.2	**2.66 [1.70; 4.17]**
Stress	493 (49.0)	513 (51.0)	34.9	611 (60.7)	395 (39.3)	51.1	**1.95 [1.36; 2.79]**

Notes: Generalized linear regression with mixed effects and binomial distribution. OR = Odds Ratio. T1 and "No risk" as reference. T1 (data collection from April to May 2020). T2 (data collection from October to November 2021). Bold = statistically significant values.

Table 2. Effect of the difference between the categories of gender, group age, education level, and physical activity level over time on the risk indication for depression

	T1			T2			
	Risk n (%)	No risk n (%)	Risk probability %	Risk n (%)	No risk n (%)	Risk probability %	OR [95%CI] T2-T1
Gender							
Men	116 (26.9)	218 (38.0)	19.5	141 (29.3)	192 (36.6)	29.5	1.36 [0.84; 2.21]
Women	316 (73.1)	356 (62.0)	34.1	340 (70.7)	333 (63.4)	39.6	1
Group age in years							
18–29	260 (60.2)	183 (31.9)	60.5	247 (51.4)	171 (32.6)	61.6	0.74 [0.24; 2.27]
30–39	91 (21.1)	157 (27.4)	33.5	115 (23.9)	138 (26.3)	61.6	1.03 [0.34; 3.18]
40–49	49 (11.3)	93 (16.2)	28.0	72 (15.0)	84 (16.0)	42.3	1.32 [0.40; 4.32]
50–59	21 (4.9)	93 (16.2)	12.4	32 (6.7)	83 (15.8)	41.9	1.28 [0.36; 4.53]
≥ 60	11 (2.5)	48 (8.3)	11.6	15 (3.0)	49 (9.3)	15.6	1
Education Level							
High school	86 (19.9)	53 (9.2)	36.2	78 (16.2)	57 (10.9)	38.6	1
Undergraduate	207 (47.9)	256 (44.6)	22.8	204 (42.4)	209 (39.8)	30.8	1.36 [0.64; 2.88]
Graduate	139 (32.2)	265 (46.2)	20.9	199 (41.4)	259 (49.3)	34.0	1.75 [0.79; 3.90]
PA level							
Low	167 (38.6)	232 (40.4)	23.9	207 (43.0)	161 (30.7)	44.9	**2.08 [1.14; 3.82]**
Moderate	142 (32.9)	163 (28.4)	29.9	155 (32.3)	200 (38.1)	30.1	0.81 [0.43; 1.54]
High	123 (28.5)	179 (31.2)	24.9	119 (24.7)	164 (31.2)	29.1	1

Notes: Generalized linear regression with mixed effects and binomial distribution. T1 and "No risk" as reference. OR = Odds Ratio. PA = physical activity. T1 (data collection from April to May 2020). T2 (data collection from October to November 2021). Bold = statistically significant values.

Table 3. Effect of the difference between the categories of gender, group age, education level, and physical activity level over time on the risk indication for anxiety

	T1			T2			
	Risk n (%)	No risk n (%)	Risk probability %	Risk n (%)	No risk n (%)	Risk probability %	OR [95%CI] T2-T1
Gender							
Men	53 (18.5)	281 (39.0)	4.4	86 (23.8)	247 (38.3)	13.0	1.50 [0.87; 2.58]
Women	233 (81.5)	439 (61.0)	16.5	275 (76.2)	398 (61.7)	30.1	1
Group age in years							
18–29	165 (57.7)	278 (38.6)	23.7	194 (53.7)	224 (34.7)	40.5	0.30 [0.06; 1.43]
30 39	65 (22.7)	183 (25.4)	15.1	84 (23.3)	169 (26.2)	40.5	0.26 [0.05; 1.27]
40–49	37 (13.0)	105 (14.6)	13.2	43 (11.9)	113 (17.5)	25.5	0.19 [0.04; 0.97]
50–59	16 (5.6)	98 (13.6)	5.6	28 (7.8)	87 (13.5)	17.5	0.42 [0.08; 2.32]
≥ 60	3 (1.0)	56 (7.8)	1.6	12 (3.3)	52 (8.1)	10.4	1
Education level							
High school	49 (17.1)	90 (12.5)	10.4	71 (19.7)	64 (9.9)	30.0	1.26 [0.54; 2.94]
Undergraduate	149 (52.1)	314 (43.6)	9.5	147(40.7)	266 (41.3)	15.4	0.59 [0.33; 1.05]
Graduate	88 (30.8)	316 (43.9)	6.6	143(39.6)	315 (48.8)	17.2	1
PA level							
Low	113 (39.5)	286 (39.7)	8.8	145(40.2)	223 (34.6)	23.3	1.46 [0.77; 2.80]
Moderate	89 (31.1)	216 (30.0)	8.6	126(34.9)	229 (35.5)	20.7	1.28 [0.64; 2.56]
High	84 (29.4)	218 (30.3)	8.7	90 (24.9)	193 (29.9)	17.0	1

Notes: Generalized linear regression with mixed effects and binomial distribution. T1 and "No risk" as reference. OR = Odds Ratio. PA = physical activity. T1 (data collection from April to May 2020). T2 (data collection from October to November 2021). Bold = statistically significant values.

Table 4. Effect of the difference between the categories of gender, group age, education level, and physical activity level over time on the risk indication for stress

	T1			T2			
	Risk n (%)	No risk n (%)	Risk probability %	Risk n (%)	No risk n (%)	Risk probability %	OR [95%CI] T2-T1
Gender							
Men	119 (24.1)	215 (41.9)	21.9	154 (25.2)	179 (45.3)	34.7	0.95 [0.58; 1.54]
Women	374 (75.9)	298 (58.1)	50.6	457 (74.8)	216 (54.7)	67.2	1
Group age in years							
18–29	261 (52.9)	182 (35.5)	60.2	301 (49.3)	117 (29.6)	77.4	1.54 [0.53; 4.48]
30–39	123 (25.0)	125 (24.4)	50.2	147 (24.1)	106 (26.8)	77.4	1.00 [0.34; 2.93]
40–49	62 (12.6)	80 (15.5)	36.7	93 (15.2)	63 (15.9)	59.7	1.74 [0.55; 5.49]
50–59	31 (6.3)	83 (16.2)	19.1	49 (8.0)	66 (16.8)	59.8	1.52 [0.46; 5.06]
≥ 60	16 (3.2)	43 (8.4)	17.5	21 (3.4)	43 (10.9)	23.8	1
Education level							
High school	86 (17.4)	53 (10.3)	45.5	95 (15.6)	40 (10.1)	56.2	0.70 [0.30; 1.63]
Undergraduate	228 (46.3)	235 (45.8)	29.1	258 (42.2)	155 (39.3)	47.4	1.01 [0.58; 1.73]
Graduate	179 (36.3)	225 (43.9)	31.0	258 (42.2)	200 (50.6)	49.6	1
PA level							
Low	188 (38.1)	211 (41.1)	31.5	240 (39.3)	128 (32.4)	56.9	**2.03 [1.09; 3.80]**
Moderate	159 (32.3)	146 (28.5)	38.3	217 (35.5)	138 (34.9)	53.1	1.30 [0.67; 2.51]
High	146 (29.6)	156 (30.4)	35.1	154 (25.2)	129 (32.7)	43.2	1

Notes: Generalized linear regression with mixed effects and binomial distribution. T1 and "No risk" as reference. OR = Odds Ratio. PA = physical activity. T1 (data collection from April to May 2020). T2 (data collection from October to November 2021). Bold = statistically significant values.

Discussion

This study aimed to analyze the psychological responses of the Brazilian population and understand their level of anxiety, depression, and stress during different times of the COVID-19 pandemic, as well as how the PA level and sociodemographic aspects may have influenced them. An increased risk of depression, anxiety, and stress was observed in the T2 (October to November 2021) compared to the T1 (April to May 2020). The PA level was an important independent variable for the outcomes of depression and stress, with participants with a low PA level showing a greater increase in the risk of these mental health problems at T2 compared to T1, compared to participants with a high level of PA. On the other hand, there was no effect between PA levels and the outcome anxiety.

The risk probability was higher in T2 than in T1 in all categories of gender, group age, and education level. However, besides the risk probability for depression, anxiety, and stress being higher in T2 than in T1 in all categories, there were no significant changes among those in the same variable in the OR risk indication for depression, anxiety, and stress. These results are important to society because, besides no increase in OR, we can observe a higher risk probability in women, young people, and those with low education levels.

The increase in symptoms of mental health problems during the pandemic is consistent with existing literature, which documents a higher prevalence of symptoms during this period.[13,43] However, the results are intriguing because we hypothesize that in the second period of analysis (T2), with the availability and gradual increase of vaccinations and reduced restrictions on social distancing, indicators related to mental health might improve. However, we observed an increase in the risk for depression, anxiety, and stress in T2. The increase in this risk may be related to the various

stressors of the COVID-19 pandemic, such as grief, fear, economic uncertainty, and the public health crisis, among other factors that may have accumulated over this period and be reflected in the data collected in T2; and, in the specific case of Brazil, many people have no formal economic income, so the restrictions affected their economy, as we can observe in our results, where people with the lowest level of education are the ones with the highest increased risk probability for mental health problems. Besides that, it is important to highlight the inadequate management of the government that promoted a public health crisis, with the vaccination starting late and the health services full.[44,45]

A systematic review[5] evaluated symptoms of depression, anxiety, and stress at different times of the pandemic and observed an increase in the prevalence of these symptoms compared with the beginning of the pandemic. Before February 2020, symptoms of depression, anxiety, and stress accounted for 25.3%, 31.1%, and 16.3%, respectively. Between March and April 2020, there was an increase in depression to 30.5% and in stress to 29.4%, while anxiety decreased slightly to 30.5%. Other studies [45,46] have reported that even after the onset or peak of COVID-19, the negative effects on mental health remained high or even increased, corroborating our findings.

In our study, adults with a low PA level showed a greater increase in risk at T2 compared to T1 in comparison to those with a high PA level. This is noteworthy because despite the reduction in restrictions on movement, the reduction in people with low PA levels was not significant (there were 39.7% people at T1 and 36.6% at T2). Even with reduced restrictions on social isolation, the number of people with low levels of PA remained high. In this way, the indication of risk for depression and stress among people with low PA levels increased, highlighting the importance of promoting and maintaining the practice active lifestyle. Even with the improvement in the number

of cases and deaths, fear and uncertainty, as well as new possibilities, such as working from home, have influenced lifestyle patterns, resulting in an increase in physical inactivity[47,48] and an increase in sedentary behavior.[19] A systematic review[49] highlights these findings, reporting that during the COVID-19 pandemic in the world, there was a 16% increase in sedentary behavior and a 17% decrease in overall physical activity, with specific declines of 26% and 20% in light and moderate to vigorous physical activity, respectively.

The association between PA and mental health has been observed in several studies, suggesting that PA can mitigate symptoms of mental health problems.[22,23,28,31] Another study conducted online between October and November 2020 with 568 students from a university in northern Germany investigated whether a sense of control was related to PA practice and mental health. The study reported that PA was associated with positive mental health and the importance of remaining physically active, not only in extraordinary situations such as that caused by the COVID-19 pandemic but also in ordinary circumstances, given that PA can be seen as an extremely important possibility for promoting mental health benefits.[31]

The results of the present study highlighted that there was an increase in the probability of risk at T2 compared to T1 for depression, anxiety, and stress, similar to the findings of Feter *et al.*,[13] who compared the responses of depression and anxiety symptoms before and during (June and July 2020) the pandemic, in South Brazilian population, and the result for depression was 3.9% before the pandemic to 29.1% during; and anxiety before 4.5% to 37.8% during.

In the analysis by gender, group age, and education level, there was no difference in the magnitude of the increase (T2 compared to T1) between the categories of variables. The greater risk probability in women, younger people, and

those with less education can be found in other cross-sectional studies presented in systematic literature reviews.[11,23,46]

Concerning gender, an analysis centered on vulnerability indicates that single-parent families are predominantly headed by women, who often receive lower salaries than men, increasing their chances of facing conditions of poverty. In addition, women have a significant presence in occupations in the health sector and are the main providers of care for family members and the elderly.[50] Regarding age, a systematic review study,[51] which included 8,866 health professionals working on the front line, showed an increase in anxiety symptoms of 40.3% and depression of 39.9% in younger adults. Another systematic review with meta-analysis,[46] carried out during the COVID-19 pandemic, including medical students, showed that younger students had a higher prevalence of symptoms of depression and anxiety. Hypotheses suggest that better results in the older population compared to young people may be due to economic, cultural, and social aspects, such as greater financial and personal stability. Young people in their formative years seek this stability. Importantly, in reducing urban mobility due to social isolation can affect younger people differently (more strongly).[52]

Regarding education level, some studies[10,13,28] have identified that the length of the educational period can significantly affect the results related to anxiety and depression during phases of social isolation in the COVID-19 pandemic. In one of these studies,[10] conducted with 1,460 Brazilians at the beginning of the pandemic (March 2020), an inverse correlation was observed between education levels and the risk of depression.

Although our study has revealed important insights, it is essential to consider certain limitations. Initially, a convenience sampling strategy was used due to the limitations imposed by the pandemic context, which may affect the ability to extrapolate

our findings to the general population. Only people who responded to the invitation in T2 took part in this study. Furthermore, data collection through self-administered questionnaires is more subject to response bias. However, at the same time, it is important to note that these self-report instruments are advantageous in the current context,[53] as they are short and simple to apply and compatible with the social distancing measures imposed during the research. Finally, despite the longitudinal design (repeated measures), the outcomes were collected concurrently with the exposures, allowing no causal inference. These limitations present important possibilities for future research. Subsequent studies may benefit from including more representative and diverse samples, using new longitudinal methodological procedures to elucidate causal relations, and applying objective instruments to measure physical activity.

Regarding the strengths of this study, we found some cross-sectional studies related to mental health and PA, developed during specific periods of the COVID-19 pandemic. Otherwise, the present study developed data collection in two different periods of the COVID-19 pandemic (during and after the lockdown), with more than a thousand same Brazilian participants.

Final considerations

We verified an increased risk for depression, anxiety, and stress in T2, which was verified with low PA for depression and stress, suggesting an increased risk for those mental health issues and the association with PA in Brazilian adults during the COVID-19 pandemic. While the world continues to navigate the challenges posed by COVID-19, the findings of this study reinforce the importance of PA as a crucial and low-cost element in mental health care as a prevention tool during future crises.

Conflict of interest

The authors declare no conflict of interest.

Author's contributions

MJA: Conceptualization – Lead; Data Curation – Lead; Formal analysis – Equal; Funding acquisition – Supporting; Investigation – Lead; Methodology – Lead; Project Administration – Lead; Resources – Lead; Software – Equal; Supervision – Supporting; Validation – Lead; Visualization – Lead; Writing – original draft – Lead; Writing – review & editing – Lead.

GPC: Conceptualization – Equal; Data Curation – Lead; Formal analysis – Lead; Funding acquisition – Equal; Investigation – Lead; Methodology – Lead; Project Administration – Equal; Resources – Supporting; Software – Lead; Supervision – Lead; Validation – Lead; Visualization – Lead; Writing – original draft – Equal; Writing – review & editing – Lead.

APS: Conceptualization – Supporting; Data Curation – Equal; Formal analysis – Equal; Funding acquisition – Supporting; Investigation – Equal; Methodology – Equal; Project Administration – Equal; Resources – Supporting; Software – Equal; Supervision – Equal; Validation – Lead; Visualization – Lead; Writing – original draft – Supporting; Writing – review & editing – Lead.

MCC, EMN, JBS and ACC: Conceptualization – Equal; Data Curation – Equal; Formal analysis – Equal; Funding acquisition – Supporting; Investigation – Equal; Methodology – Equal; Project Administration – Equal; Resources – Supporting; Software – Equal; Supervision – Equal; Validation – Lead; Visualization – Lead; Writing – original draft – Supporting; Writing – review & editing – Equal.

ÁAT: Conceptualization – Lead; Data Curation – Lead; Formal analysis – Lead; Funding acquisition – Lead; Investigation – Lead; Methodology – Lead; Project Administration – Lead; Resources – Lead; Software – Lead; Supervision – Lead; Validation – Lead; Visualization – Lead; Writing – original draft – Lead; Writing – review & editing – Lead.

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