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RESEARCH ARTICLE

Physical activity during the SARS-CoV-2 pandemic is linked to better mood and emotion

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Abstract

The SARS-CoV-2 pandemic may negatively impact mood and emotion. Physical activity may protect against mood disturbance and promote positive affect. This study asked if physical activity before, during, or the change in physical activity with the pandemic, impacted affect and mood during the pandemic. US adult residents (18–74 years; $N = 338$) were surveyed from 29 April to 3 June 2020. Physical activity before and during the pandemic was assessed with the Physical Activity Rating survey. The Positive and Negative Affect Schedule measured affect and the Profile of Moods Questionnaire assessed mood. Comparisons between physically inactive and active participants by Analysis of Covariance found greater vigour in participants classed as physically active before the pandemic. Positive affect, vigour and esteem-related affect were greater in participants physically active during the pandemic. Multiple linear regression revealed relationships between the change in physical activity and mood. Change in physical activity positively associated with positive affect ($b = 1.06$), esteem-related affect ($b = 0.33$) and vigour ($b = 0.53$), and negatively associated with negative affect ($b = -0.47$), total mood disturbance ($b = -2.60$), tension ($b = -0.31$), anger ($b = -0.24$), fatigue ($b = -0.54$), depression ($b = -0.50$) and confusion ($b = -0.23$). These data demonstrate that physical activity during the pandemic, and increased physical activity relative to before the pandemic, related to better mood.

KEYWORDS
COVID-19, exercise, PANAS, POMS, stress

1 | INTRODUCTION

The global pandemic caused by SARS-CoV-2 is a source of ongoing psychological stress. This stress may result from anxieties related to the virus itself, from social isolation, professional development uncertainty, or from employment and other financial concerns (Babore et al., 2020). Each of these stressors may interact and contribute towards depressed mood and emotions. Other public health emergencies have been documented to negatively affect mental health (Kamara et al., 2017; Neria & Shultz, 2012). The SARS-CoV-2 pandemic appears similar, as initial surveys indicate increased symptoms of anxiety, depression, fatigue, mood disturbance and stress among individuals worldwide due to the pandemic (Qiu et al., 2020; Salari et al., 2020). Critically, psychological stress is a risk factor for mental illnesses, including depressive, bipolar and psychotic disorders (Kessler et al., 2008). Long-lasting psychological stress is also thought to foment disease by inducing a state of chronic inflammation, a known risk factor for many health conditions, such as cardiovascular and metabolic diseases (Dantzer et al., 1999; Mooy et al., 2000; Rohleder, 2014). With these long-term risks in mind, there is a clear need to identify means to mitigate the negative effects of psychological stress associated with the SARS-CoV-2 pandemic, including those on mood and emotion.

Physical activity is movement of the body produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). Higher rates of physical activity are associated with reduced odds of developing depressive symptoms in epidemiologic surveys (Camacho et al., 1991; Farmer et al., 1988). Ecological momentary assessment studies have demonstrated that higher physical activity levels are associated with subsequent greater positive affect (Dunton et al., 2014; Schultchen et al., 2019; Wichers et al., 2012) as well as lower negative affect (Dunton et al., 2014; Schultchen et al., 2019). Cardiorespiratory fitness, the ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity, is negatively associated with psychological distress, depression and anxiety (Babyak et al., 2000; Grasdalsmoen et al., 2020; Kandola et al., 2018). Both greater levels of cardiorespiratory fitness and higher rates of physical activity are associated with lower physiological responses to acute psychological stress, including moderated blood pressure, cortisol, heart rate and heart rate variability.

As physical activity may attenuate the negative impacts of psychological stress, such as depressed mood, we sought to test the hypothesis that adults who reported greater levels of physical activity before and during the SARS-CoV-2 pandemic would have a greater positive affect and lower mood disturbance. We were also interested in whether a change in physical activity levels was related to mood and emotions, as the impact of change in exercise volume on psychological parameters has rarely been considered outside of the athlete-context (Kageta et al., 2016; Pierce, 2002). We hypothesized that participants who increased their physical activity during the pandemic relative to before the pandemic would have a greater positive affect and lower mood disturbance, compared to participants who maintained and decreased physical activity levels. We also hypothesized that those who maintained their physical activity level during the pandemic would have a greater positive affect and lower mood disturbance than those who decreased their physical activity levels.

2 | METHODS

2.1 | Research design and participants

This was an observational, survey-based study that sought to understand if physical activity levels relate to mood and affect in a pandemic. Adults between the ages of 18 and 75 years were recruited for this study (N = 354). Additional inclusion criteria included access to an electronic device to complete the questionnaires, currently living in the United States, and able to read and respond in English. Responses from participants that did not consent (n = 1), were not in the targeted age range (n = 4), were a duplicate response (n = 1), were out of the recruitment period (n = 3), incorrectly responded to or skipped validity questions (n = 6), or did not respond to either physical activity questionnaire (n = 2) were not included in the dataset (included n = 338). All included participants consented to the study by submitting a 'yes' response to the consent page of the electronic survey. The survey was expected to take 5–10 min to complete. The study was approved by the institutional review board at the University of Houston.

2.2 | Recruitment and screening

Participants were recruited using social media posts, email distribution lists, previous research participants databases and word of mouth. Participants were invited to take part in a research study about physical activity and psychological stress; specific hypotheses were not mentioned. Interested participants were directed to an anonymized online electronic survey form (Microsoft Forms). After providing consent and confirming eligibility, the participant was directed to the survey questions. Responses to the survey were anonymous, and participants accessed the survey via an anonymized link. Responses to the survey were collected over a 6-week period from 29 April 2020 to 3 June 2020.

2.3 | Surveys and questionnaires

The survey included two validation questions, where the participants were asked to select a specific number from the list. Participants who did not select the correct number (n = 6) were not included in the dataset and analyses to exclude responses from participants not carefully reading the survey. Responses included general demographic information, SARS-CoV-2 pandemic-specific impacts (i.e., change in income, change in employment, close family or friend with known or suspected infection), physical activity and exercise practised before and during the SARS-CoV-2 pandemic, and feelings and emotions felt both in the moment (Profile of Moods Questionnaire short form) and the 7 days immediately prior (Positive and Negative Affect Schedule) to taking the survey.

Physical activity was measured using the Physical Activity Rating survey (PA-R), which asks participants to identify their overall level of physical activity on a scale from 0 ('avoid walking and exertion; e.g., always use elevator, drive when possible instead of walking') to 10 ('run over 25 miles per week or spend over 8 h per week in comparable physical activity such as running or jogging, lap swimming, cycling, rowing, aerobics, skipping rope, running in place or engaging in vigorous aerobic-type activity such as soccer, tennis, basketball, racquetball or handball'). The scale includes several examples of activities corresponding to light, moderate and vigorous activities. For example, moderate physical activity examples included 'golf, horseback riding, calisthenics, table tennis, bowling, weight-lifting, yard work, cleaning house, walking for exercise'. The self-report physical activity questions in the PA-R were developed by Jackson et al. (1990) with extensions into a higher range of physical activity

(Kolkhorst & Dolgener, 1994). Regression models built from responses to this questionnaire have been shown to be a valid means of estimating cardiorespiratory fitness (George et al., 1997). Participants were first asked to select the sentence that best described their overall level of physical activity in the three months prior to the SARS-CoV-2 pandemic ('before'; December 2019 to early March 2020). Participants then selected the physical activity description they felt best described their overall level of physical activity during the pandemic ('during'; mid-March 2020 to date survey was completed). Responses to the PA-R were used to categorize participants as physically inactive (selected 0–5, corresponding to less than 60 min per week of vigorous activity) or physically active (selected 6–10, corresponding to at least 1 h per week of vigorous activity). The cut-off for physically active was based on the American College of Sports Medicine and American Heart Association guidelines for physical activity (American College of Sports Medicine et al., 2018; Nelson et al., 2007), which recommends 60 min per week of vigorous activity to meet physical activity guidelines. Change in physical activity level was calculated by subtracting the PA-R response pertaining to during the pandemic from the PA-R response pertaining to before the pandemic.

The Profile of Moods Questionnaire short form (POMS) was used to measure mood in the moment of taking the survey (Grove & Prapavessis, 1992). Reliability coefficients (Cronbach's alpha) for the present study's survey subscales were calculated for fatigue (0.913), anger (0.883), vigour (0.860), tension (0.893), esteem (0.582), confusion (0.787) and depression (0.909). Participants were asked to rate how strongly they identified with each of 40 moods or feelings on a five-point scale (0, 'Not at all' to 4, 'Extremely'). Responses were scored according to the survey to identify seven dimensions of mood. Two items (ashamed, embarrassed) for esteem-related affect were reverse scored. Total mood disturbance (TMD) was calculated by subtracting totals for positive subscales (esteem-related affect, vigour) from the totals for negative subscales (tension, anger, fatigue, depression and confusion). Some participants did not answer all survey questions; these participants were included in the reporting of completed POMS subscales but not in total mood disturbance ($n = 20$).

The Positive and Negative Affect Schedule (PANAS) was used to measure positive and negative affect over the week immediately prior to taking the survey (Watson et al., 1988). The Cronbach's alpha for the present study was calculated for positive (0.732) and negative (0.646) subscales. Participants were asked to rate on a five-point scale (1, 'Very Slightly or Not at all' to 5, 'Extremely') the extent to which they experienced each of 10 positive feelings and emotions and 10 negative feelings and emotions over the prior week. Items were scored as indicated by the survey to calculate a positive affect score (possible range 10–50, higher scores represent higher levels of positive affect) and a negative affect score (possible range 10–50, lower scores represent lower levels of negative affect). Some participants did not answer all survey questions; these participants were included where possible (only positive ($n = 5$) or negative affect score ($n = 4$)).

2.4 | Statistical analyses

Data were screened by visual inspection of histograms and Q-Q plots for outliers and normality. Primary dependent variables included scores on the seven dimensions of mood, TMD, positive affect, and negative affect. To identify potential covariates for inclusion in the models, the relationships between the dependent variables with categorical demographic variables and SARS-CoV-2 pandemic specific impacts (gender, age, race, ethnicity, income, children at home, infection, change in income) were assessed by Analysis of Variance (ANOVA). To assess reliability, Cronbach's alpha was calculated for all subscales of POMS and PANAS.

Independent variables included participant physical activity categorization before (Aim 1), during (Aim 2) and the change in physical activity level from before to during the pandemic (Aim 3). Differences between physically inactive and physically active participants on the dependent variables were assessed by Analysis of Covariance, which included the covariates gender and age. Tukey *post hoc* adjustments were used to control overall Type I error. Linear models were used to determine the effect of change in physical activity on dependent variables for Aim 3 and included gender and age as covariates. Statistical significance was determined a priori at $p < 0.05$. All statistical analyses were conducted with R (version 4.0.2).

3 | RESULTS

3.1 | Participant characteristics

Data from 338 participants were included in these analyses. Table 1 summarizes participant characteristics. At the time of completing the survey, 117 (34.6%) had experienced a decline in income since the beginning of the pandemic, and 184 (54.4%) reported a change from working outside of the home to working from home since the beginning of the pandemic. At the time of completing the survey, 99 (29.3%) reported a confirmed or suspected case of SARS-CoV-2 infection in a close friend or a family member. Only age and gender were found to be significantly related to moods and affect (all $p < 0.05$); outcome variables were adjusted for age and gender.

Similar numbers of participants were categorized as physically inactive ($N = 165$, 48.8%) or physically active ($N = 173$, 51.2%) before the pandemic. Similar results were found during the pandemic (physical inactive: $N = 165$, 49%; physically active: $N = 172$, 51%).

When examining any change in physical activity level (difference between During PA-R response and Before PA-R response) a plurality of participants (31.8%) did not report a change in physical activity level during the pandemic relative to before; equal numbers ($n = 80$, 23.7%) reported small increases in physical activity level as reported small decreases in physical activity (±2 levels). Overall, similar numbers of participants reported maintaining their physical activity level ($n = 107$) as reported an increase ($n = 111$) or a decrease ($n = 119$).

TABLE 1 Participant characteristics

Characteristic		N (%)
Gender	Woman/Trans-woman	261 (77.2)
	Male/Trans-male	75 (22.2)
	Prefer not to say	2 (0.6)
Age (years)	18–24	49 (14.5)
	25–34	77 (22.8)
	35–44	84 (24.9)
	45–54	47 (13.9)
	55–64	47 (13.9)
	65–75	34 (10.1)
Race	American Indian or Alaska Native	2 (0.6)
	Asian	32 (9.5)
	Black or African American	7 (2.1)
	Native Hawaiian and other Pacific Islander	4 (1.2)
	White	259 (76.6)
	Preferred not to say	3 (0.9)
	Other and/or multiple races selected	31 (9.2)
Ethnicity	Hispanic or Latino	29 (8.6)
	Not Hispanic or Latino	304 (89.9)
	Preferred not to say	5 (1.5)
Household annual income (USD)	Under $15,000	7 (2.1)
	$15,000–$24,999	9 (2.7)
	$25,000–$34,999	21 (6.2)
	$35,000–$49,999	30 (8.9)
	$50,000–$74,999	58 (17.2)
	$75,000–$99,999	33 (9.8)
	$100,000–$149,999	78 (23.1)
	$150,000–$199,999	45 (13.3)
	$200,000 and over	52 (15.4)
Living with children	No	208 (61.5)
	Under the age of 10 years	103 (30.5)
	Aged 10–18 years	53 (15.7)

3.2 | Impact of physical activity before the pandemic

We investigated whether mood and emotions reported during the SARS-CoV-2 pandemic differed between individuals categorized as physically inactive or physically active in the three months before the pandemic. Vigour was greater in physically active participants relative to physically inactive participants (7.05 ± 0.32 vs. 5.65 ± 0.30; $p = 0.001$) (Table 2). No other measured mood or emotion differed between participants categorized as physically active or physically inactive before the pandemic (all $p > 0.05$; Table 2).

3.3 | Impact of physical activity during the pandemic

We next investigated if being physically active during the pandemic impacted mood and emotions during the pandemic. Positive affect, esteem-related affect and vigour were greater in physically active participants relative to physically inactive participants (positive affect: 27.60 ± 0.62 vs. 24.37 ± 0.64, $p < 0.001$; esteem-related affect: 14.47 ± 0.28 vs. 13.38 ± 0.30, $p = 0.005$; vigour: 7.78 ± 0.31 vs. 4.89 ± 0.29, $p < 0.001$) (Table 2). Physically inactive participants scored higher in total mood disturbance than physically

TABLE 2 Mood and emotions of participants categorized as physically inactive and physically active before and during the SARS-CoV-2 pandemic

Variable	Category	Physical activity before			Physical activity during		
		Mean ± SE	$F_{(df)}$; p	95% CI (lower, upper)	Mean ± SE	$F_{(df)}$; p	95% CI (lower, upper)
Positive affect	Active	26.20 ± 0.63	0.08 (7,323); 0.78	−2.21, 1.34	27.60 ± 0.62	**13.61 (7, 322); <0.001**	−5.07, −1.58
	Inactive	25.93 ± 0.66			24.37 ± 0.64		
Negative affect	Active	19.31 ± 0.56	0.04 (7,322); 0.85	−1.24, 1.86	18.58 ± 0.55	3.09 (7, 321); 0.08	0.01, 3.10
	Inactive	19.07 ± 0.60			19.85 ± 0.62		
TMD	Active	10.28 ± 2.00	0.02 (7,306); 0.90	−4.63, 6.53	6.93 ± 1.97	**5.73 (7, 305); 0.02**	1.74, 12.82
	Inactive	9.64 ± 2.13			13.25 ± 2.14		
TEN	Active	7.99 ± 0.40	0.29 (7,324); 0.59	−1.17, 1.08	7.6 ± 0.40	0.78 (7, 323); 0.38	−0.47, 1.78
	Inactive	7.62 ± 0.42			8.04 ± 0.43		
ANG	Active	4.27 ± 0.30	0.27 (7,325); 0.60	−0.54, 1.37	4.01 ± 0.31	2.87 (7, 324); 0.09	−0.06, 1.85
	Inactive	4.47 ± 0.39			4.77 ± 0.38		
FAT	Active	6.58 ± 0.40	<0.001 (7,317); 0.997	−0.91, 1.30	6.01 ± 0.38	4.45 (7, 316); **0.04**	0.04, 2.25
	Inactive	6.52 ± 0.42			7.11 ± 0.44		
DEP	Active	6.12 ± 0.42	0.33 (7, 323); 0.56	−1.34, 1.05	5.42 ± 0.40	3.39 (7, 322); 0.07	0.04, 2.42
	Inactive	5.72 ± 0.45			6.46 ± 0.46		
ERA	Active	14.05 ± 0.28	0.33 (7, 323); 0.57	−1.06, 0.56	14.47 ± 0.28	**8.03 (7, 322); 0.005**	−1.91, −0.32
	Inactive	13.86 ± 0.31			13.38 ± 0.30		
VIG	Active	7.05 ± 0.32	**10.41 (7, 323); 0.001**	−2.36, −0.64	7.78 ± 0.31	**49.06 (7, 322); <0.001**	−3.70, −2.06
	Inactive	5.65 ± 0.30			4.89 ± 0.29		
CON	Active	6.39 ± 0.30	1.04 (7, 325); 0.31	−1.10, 0.59	6.05 ± 0.31	0.44 (7, 324); 0.51	−0.49, 1.20
	Inactive	5.92 ± 0.33			6.29 ± 0.32		

Note: Positive and negative affect derived from Positive and Negative Affect Schedule. High values for positive affect and low values for negative affect indicate better mood. Phys Inactive (Physically Inactive, selected rating of 0-5) and Phys Active (Physically Active, selected rating of 6–10) derived from the Physical Activity Rating survey. TMD (total mood disturbance), TEN (tension), ANG (anger), FAT (fatigue), DEP (depression), ERA (esteem related affect), VIG (vigour) and CON (confusion) reflect scores calculated from the Profile of Moods Questionnaire short form (POMS). Bold highlight results that reach statistical significance ($p < 0.05$).

active participants (13.25 ± 2.14 vs. 6.93 ± 1.97; $p = 0.02$) and also scored higher in fatigue (7.11 ± 0.44 vs. 6.01 ± 0.38; $p = 0.04$) (Table 2). Negative affect, tension, anger, depression and confusion did not differ between participants categorized as physically active or physically inactive during the pandemic (all $p > 0.05$; Table 2).

3.4 | Impact of change in physical activity during the pandemic

Multiple regression models were used to assess associations between change in physical activity and mood and emotions during the pandemic. Gender and age were included as covariates in each model. Change in physical activity was positively associated with positive affect ($b = 1.06$), esteem-related affect ($b = 0.33$), and vigour ($b = 0.53$). Further, change in physical activity was negatively associated with negative affect ($b = -0.47$), total mood disturbance ($b = -2.60$), tension ($b = -0.31$), anger ($b = -0.24$), fatigue ($b = -0.54$), depression ($b = -0.50$) and confusion ($b = -0.23$) (Table 3). These results suggest that increasing physical activity benefited mood and emotions, whereas decreasing physical activity led to worse mood and emotions.

4 | DISCUSSION

The primary finding of this study was that greater levels of physical activity during the SARS-CoV-2 pandemic related to better mood and emotions during the pandemic. In contrast, the amount of physical activity in the three months preceding the pandemic had no significant impact on mood and emotions during the pandemic except vigour, which was significantly greater in participants classified as physically active before the pandemic. Further, maintaining or increasing physical activity during the SARS-CoV-2 pandemic was

TABLE 3 Effects of change in physical activity on mood and emotions adjusted for age and gender

	Adjusted R^2	$F_{(df)}$	Coefficient p	Change in physical activity	S.E.	Model p
Positive affect	0.09	7.67 (7,322)	**<0.001**	1.06	0.19	**<0.001**
Negative affect	0.13	8.04 (7, 321)	**0.006**	−0.47	0.17	**<0.001**
TMD	0.13	7.69 (7, 305)	**<0.001**	−2.60	0.60	**<0.001**
TEN	0.08	5.32 (7,323)	**0.011**	−0.31	0.12	**<0.001**
ANG	0.06	3.96 (7,324)	**0.026**	−0.24	0.11	**<0.001**
FAT	0.14	8.43 (7,316)	**<0.001**	−0.54	0.12	**<0.001**
DEP	0.09	5.51 (7,322)	**<0.001**	−0.50	0.13	**<0.001**
ERA	0.09	5.78 (7, 322)	**<0.001**	0.33	0.09	**<0.001**
VIG	0.13	8.08 (7, 322)	**<0.001**	0.53	0.09	**<0.001**
CON	0.11	6.89 (7, 324)	**0.01**	−0.23	0.09	**<0.001**

Note: Change in physical activity reflects difference in self-report physical activity (Physical Activity Rating survey) during the pandemic from before the pandemic. Positive and negative affect derived from Positive and Negative Affect Schedule. High values for positive affect and low values for negative affect indicate better mood. TMD (total mood disturbance), TEN (tension), ANG (anger), FAT (fatigue), DEP (depression), ERA (esteem related affect), VIG (vigour), and CON (confusion) reflect scores calculated from the Profile of Moods Questionnaire Short Form (POMS). Bold highlight results that reach statistical significance ($p < 0.05$).

important for mood and emotions during the pandemic. Those who decreased their physical activity during the pandemic reported worse mood and emotions compared to those who maintained or increased their physical activity. Collectively, our data imply that in addition to regular physical activity having many desirable physical health impacts, it may be of particular importance for mental health to meet physical activity recommendations and maintain physical activity during periods of disruption and potentially heightened psychological stress.

4.1 | Physical activity before versus during the pandemic

The time at which physical activity was reported impacted the observed relationships of physical activity with mood and emotions. Although we hypothesized that physical activity before the pandemic would be related to several mood states and emotions, being physically active before the pandemic was related to a single subscale, vigour. That is, people who were physically active before the pandemic reported higher levels of vigour during the pandemic. Our hypothesis was based on studies linking previous exercise to current mood and emotion. For example, that stationary bicycling led to better emotional recovery after a stressor (Bernstein & McNally, 2017). There are numerous studies relating the positive effect of exercise on vigour, but typically change in vigour is reported as a result of current exercise training or following a single exercise session (Dishman et al., 2010; Hoffman & Hoffman, 2008; Puetz et al., 2008). The data here indicate that past physical activity may also yield increased feelings of vigour. In contrast to our findings of the lack of relationships between physical activity before the pandemic and mood and emotion, physical activity during the pandemic was associated with several mood and emotion subscales. Specifically, physically active individuals reported greater positive affect, esteem-related affect and vigour, compared to the physically inactive. Total mood disturbance was also lower in the physically active, reflecting lower negative mood attributes relative to positive mood attributes. Negative moods and emotions (negative effect, tension, anger, fatigue, depression, confusion) were not related to physical activity. This suggests that physical activity is more closely related to positive moods and emotions than negative moods and emotions. The greater number of relationships between mood and emotion with physical activity during the pandemic (i.e., positive affect, esteem related affect, vigour, total mood disturbance) compared to physical activity before the pandemic (i.e., only vigour) was somewhat surprising. For example, young adults who regularly exercise reported better mood states, as measured by the POMS, at rest and during exercise compared to those who do not regularly exercise (Hallgren et al., 2010). This previous study led us to hypothesize that pre-pandemic physical activity would protect against pandemic-related mood impacts; this hypothesis was only partially supported. Results differing from our hypothesis may be due to inaccuracies in reporting physical activity from an earlier time period (3 months before the pandemic began), where recall may be more accurate with more recent physical activity (during the pandemic). Other studies have also failed to find a relationship between self-reported regular physical activity and psychological responses to an acute stressor (Mücke et al., 2018). Our results could also mean that physical activity has the most benefit for improved mood and emotion during mentally and emotionally challenging periods. That is, the proximal mood and emotional benefits of exercise may not be observed in baseline conditions but become apparent in stressful situations or periods of mood disturbance. In support of this, an exercise intervention among caregivers of chronically ill family members found aerobic exercise training resulted in significantly reduced perceived stress (Puterman et al., 2018). Further, in a systematic review of 35 exercise interventions in people with depression, the participants in the exercise groups had a moderate decrease in depression (Cooney et al., 2013). Evidence from acute exercise studies also support this assertion. For example, a single session of exercise prior to a laboratory stressor were related to better emotional recovery (Bernstein & McNally, 2017) and enhanced emotional resilience (Bernstein & McNally, 2018). Collectively, this underscores the priority people should place on maintaining or increasing their physical activity during periods of mental stress.

4.2 | Change in physical activity

When assessing the associations between change in participants' physical activity level from before to during the pandemic with mood and emotion, there was a significant relationship with every outcome variable. Participants who increased their physical activity had higher scores on the positive moods and emotions and lower scores on the negative moods and emotions. For example, each unit increase in physical activity level was associated with a 0.5 unit increase in vigour and a 0.5 unit decrease in fatigue (subscale ranges 0–20), when holding the effects of gender and age constant. These associations are perhaps more remarkable considering that it reflects any change in self-report physical activity level, not just change in physical activity classification. Very few participants changed physical activity classification from active to inactive ($n = 34$, 10.1% of sample) or from inactive to active ($n = 33$, 9.8% of sample). Two recently published studies also examined the effect of exercise changes during the SARS-CoV-2 pandemic on mood (Brand et al., 2020; Chang et al., 2020). Similar to the current results, both report that maintaining physical activity level during the pandemic is associated with better mood. Specifically, in a cross-sectional study that included survey respondents from 18 countries, those who decreased the number of days per week they exercised had a worse mood state than those who maintained or increased the number of days per week that they participated in exercise (Brand et al., 2020). The relationship between maintenance of physical activity frequency and better mood state was also reported in a study that only included participants from Taiwan (Chang et al., 2020).

4.3 | Study strengths

Although this study was conducted during the SARS-CoV-2 pandemic, it may be applicable to other periods of disruptions and uncertainty. One of the strengths of this study was that rather than manufacturing a stressful situation in a controlled laboratory setting or enrolling participants as they encountered stress and uncertainty in their lives, all participants experienced the same overarching stressful event—the SARS-CoV-2 global pandemic. There are differences in how it may have impacted the individuals, but the event itself (the pandemic) was the same. This makes it reasonable to extrapolate the results to other stressful life events. Specifically, the results support maintaining or increasing physical activity during periods of stress may have beneficial effects on mood and emotions. In support of this, Roth et al. (1987) randomized young adults who reported negative life events to exercise training, relaxation training, or no treatment. After 5 weeks, the participants in the exercise training group reported reduced depressive symptoms but the participants in the other two groups did not (Roth & Holmes, 1987). Further, a 1-year intervention that increased moderate to vigorous physical activity among women also reported reductions in depression symptoms and perceived stress (Mendoza-Vasconez et al., 2019).

Several other studies on physical activity and exercise during the SARS-CoV-2 pandemic were recently published (Brand et al., 2020; Chang et al., 2020; Constandt et al., 2020; Ingram et al., 2020; Wood et al., 2021). However, the present study contributes in two distinct ways. One is that the physical activity survey instrument used here does not focus on the frequency (days per week) of physical activity, but rather collects information about total weekly physical activity. It is possible for someone to change total amount of weekly physical activity without changing the frequency of physical activity within the week. Importantly, ACSM and WHO exercise and physical activity recommendations are related not only to the frequency but also the total exercise and physical activity per week (American College of Sports Medicine et al., 2018; *WHO guidelines on physical activity and sedentary behaviour*, 2020). The second contribution is that this study only includes participants from a single country (the United States), unlike larger global surveys (Brand et al., 2020). This implies that the participants in the current study were facing the same national response to the SARS-CoV-2 pandemic. Although there were regional differences in the infection rate, the economic and broad personal challenges (i.e., food and personal item shortages) were thus more similar across our participants. Our study is also strengthened by the relatively short data collection time span. This was by design, in an attempt to collect data when there was little variation in the national pandemic response. Since the data collection period, our knowledge of SARS-CoV-2 and its treatment has changed markedly. However, the death and economic tolls have also climbed as the pandemic continues. We did not attempt to differentiate between sources of disruptions arising from the pandemic, and so the results, although resulting from a narrow collection window, are likely still relevant.

4.4 | Study limitations

A limitation to this study is the study design. This is a cross-sectional study, and as such we cannot determine the direction of the relationship. For example, we found that those who were physically active during the pandemic, or those who increased physical activity during the pandemic, reported lower fatigue and higher vigour. This may indicate that being physically active prevented fatigue or preserved vigour, but it is just as possible that those who had low fatigue and high vigour were more likely to be physically active. The latter possibility is supported by literature finding that psychological distress/heightened psychological stress decreases physical activity (Olive et al., 2016; Stults-Kolehmainen & Sinha, 2014). However, intervention studies manipulating physical activity during psychological stress also support the possibility that exercise during a stressful period—such as a pandemic—can lead to positive mood and emotion (Puterman et al., 2018). A second limitation of this study is the low diversity in the sample population. Our sample may not be representative. Although income and age were distributed, our sample largely reported being woman/trans woman and white. Further, it is important to note that we did not directly measure stress in the current study, and it is possible that not all participants were experiencing heightened stress at the moment of taking the survey. However, we posit that wide-spread 'stay at home' orders and health-specific uncertainties in place during the time of the survey (May 2020) at a minimum were disruptive to pre-pandemic ways of life. Nonetheless, we are unable to explore potential relationships between physical activity, mood and emotion, and stress.

We also acknowledge limitations related to our reliance on self-reported physical activity. Self-reported physical activity generally only shows moderate associations with direct and indirect physical activity measures (Durante & Ainsworth, 1996); more objective measures (e.g., accelerometers) were not possible in the current study. Other physical activity questionnaires, such as the International Physical Activity Questionnaire were also considered. We chose the PA-R in the current study as it includes descriptions of both incidental physical activity (using stairs, walking vs. driving), house and yard work, as well as exercise-based physical activity. The PA-R has also typically been used to ascertain physical activity in the prior six months (George et al., 1997; Jackson et al., 1990; Kramer et al., 2020); data in the current study fell within this window. However, we acknowledge that there may be differences in the accuracy of physical activity recall between that reported before and during the pandemic, as accuracy may be greater when less time has elapsed (Durante & Ainsworth, 1996). Additionally, it may be that other variables not measured in the current study, such as level of education attainment, urbanicity, alcohol and drug use, and ongoing inflammatory disease, influence physical activity and/or mood. We also did not survey the reasons for change in physical activity in those participants reporting increased or decreased physical activity during relative to before. A recent study reported a small yet significant negative predictive effect of the experience of daily hassles (stressors) on physical activity levels post-lockdown in New Zealand (Hargreaves et al., 2021). It is intriguing to wonder if a similar result would have been found here, especially given bidirectional relationships between the experience of daily stressors and physical activity (Stults-Kolehmainen & Sinha, 2014). Finally, our results do not preclude the potential effects of physical activity before and during the pandemic on other aspects of mental health besides mood and affect that were not measured here.

5 | CONCLUSIONS

In conclusion, physical activity was associated with better mood and emotion during the SARS-CoV-2 global pandemic, a period of mental stress and uncertainty. The positive effects of physical activity were particularly apparent when surveying activity levels during the pandemic, rather than in the months leading up to the pandemic. Increasing or maintaining the same level of physical activity during the pandemic was important for positive mood and emotion.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data will be made available upon request.

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