Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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short communication

Physical activity is positively associated with college students' positive affect regardless of stressful life events during the COVID-19 pandemic

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ABSTRACT

The study was designed to determine associations between physical activity (PA) and affect before and during COVID-19 stay-at-home orders and how change in PA predicted change in affect during this time. Before and during COVID-19 stay-at-home orders, college students (n = 107) completed assessments of PA, positive and negative affect, sleep quality, food insecurity, and stressful life events (during stay-at-home order only). Total minutes of PA was positively associated with positive affect before ($B = 0.01$, $p < 0.01$) and during ($B = 0.01$, $p = 0.01$) COVID-19 stay-at-home orders. Change in minutes of PA was positively associated with change in positive affect ($B = 0.01$, $p = 0.01$). Associations between PA and positive affect were not moderated by stressful life events. PA only predicted negative affect before COVID-19 stay-at-home orders ($B = -0.003$, $p = 0.04$). PA appears to enhance positive affect during a global pandemic. Findings have implications for PA as a tool for maintaining or enhancing mental health during a time of trauma and uncertainty.

The emergence of the COVID-19 pandemic resulted in mass quarantine to slow the spread of the disease. However, a recent review on previous quarantines (e.g., Severe Acute Respiratory Syndrome outbreak) suggests immediate and potentially long-lasting negative psychological effects may result (Brooks et al., 2020). Given the well documented effects of physical activity (PA) for positive mental health benefits (2018 Physical Activity Guidelines Advisory Committee, 2018), maintaining or initiating PA may be important for countering negative mental health consequences associated with the COVID-19 pandemic (Sallis & Pratt, 2020).

Only preliminary evidence is currently available following the immediate global and economic social change caused by the pandemic, with these data revealing acute declines in PA (Dunton et al., 2020; Gallo et al., 2020; Meyer et al., 2020). These changes are likely in part a result of not only sudden disruption to an individual's environment and daily routine, but also a result of diminished mental health (i.e., increased anxiety, stress, depression). This may be particularly true for college students who, without warning, lost access to campus recreation facilities and social support for PA following the nationwide closure of universities. Furthermore, college students face considerable mental health challenges, with students reporting stress, anxiety, and depression as three of the most common factors impacting their academic performance (American College Health Association, 2019), suggesting this population was already susceptible to experiencing poor mental health and well-being prior to COVID-19. Among college students in the Chinese province, Hubei, household income stability and living with parents were associated with lower likelihood of experiencing anxiety, whereas having a relative or acquaintance diagnosed with COVID-19 increased likelihood (Cao et al., 2020). Taken together, these findings suggest that mental health and well-being of college students, and the factors that influence these outcomes, are important to monitor during the COVID-19 pandemic.

Prior to the COVID-19 pandemic, PA had well-established relations with mental health and well-being (2018 Physical Activity Guidelines Advisory Committee, 2018). Meyer et al. (2020) found that adults (93% Caucasian) who were no longer meeting PA guidelines following COVID-19-related restrictions (pre-COVID-19 PA levels assessed retrospectively) experienced worse mental health (e.g., higher depressive symptoms and stress, lower positive mental health). Although these data are novel, they are limited by retrospective reporting that may be biased (i.e., remembering experiences as more favorable), especially during stressful life events (van Minnen et al., 2005). To our knowledge, no published studies have prospectively examined associations between PA and mental health or well-being during the COVID-19 pandemic in a

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racially diverse demographic sample.

The purpose of the present study was to determine associations between PA and affect among college students before and during COVID-19 stay-at-home orders and how change in PA predicts change in affect during this time. It was hypothesized that PA would be positively associated with positive affect before and during the COVID-19 stay-at-home orders and change in PA would be positively associated with change in positive affect during this time. We hypothesized that PA would be negatively associated with negative affect before and during the COVID-19 stay-at-home orders and change in PA would be negatively associated with change in negative affect. As an exploratory aim, this study sought to determine whether stressful life events during stay-at-home orders moderated associations between PA and affect. Stressful life events could lead to poor mental health during COVID-19 stay-at-home orders (Meyer et al., 2020). Given that PA has previously been found to attenuate poor mental health (2018 Physical Activity Guidelines Advisory Committee, 2018), associations between PA and affect may differ depending on the extent to which one experiences stressful life events (Sallis & Pratt, 2020).

1. Methods

1.1. Participants and procedures

Participants were enrolled in an upper-level, undergraduate kinesiology course at a minority-serving institution in the southeast United States. Participants completed online questionnaires (Qualtrics, Provo, UT) for a class assignment between January 21 and March 11, 2020 (T1) and again for extra credit between April 17 and May 5, 2020 (T2). It should be noted that T1 occurred before significant widespread life-changing events, including the World Health Organization (WHO) characterizing COVID-19 as a pandemic (March 11, 2020), campus closure (March 13, 2020), executive orders banning mass gatherings and closure of non-essential businesses (March 25, 2020 for the state), and mandatory stay-at-home orders (March 30 to May 8, 2020 for the state). Informed consent was obtained from all participants included in the study at both time points. All procedures performed were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

1.2. Measures

All measures were completed at T1 and T2 except the Social Readjustment Rating Scale (T2 only) and demographic information (T1 only). Measures at T2 that typically evaluate the previous month (or more), were adjusted to identify March 13, 2020 (campus closure) as the reference. More details on measures are available in the electronic supplementary materials.

Affect was assessed using the Positive and Negative Affect Schedule (Crawford & Henry, 2004; Watson et al., 1988). Participants reported how they felt in the past 7 days on 20 affect terms (10 positive affect and 10 negative affect terms) using a 1 (“very slightly”) to 5 (“extremely”) scale. Positive and negative affect scores were derived using standard scoring procedures (Watson et al., 1988).

PA occurring in bouts ≥10 min was assessed using the International Physical Activity Questionnaire – Short Form (IPAQ-SF; Craig et al., 2003). The IPAQ-SF is a validated and reliable measure of PA (Craig et al., 2003). Standard scoring and truncating procedures were used (IPAQ Research Committee, 2005). PA was operationalized as total minutes of moderate-to vigorous-intensity PA (MVPA) in the past week.

Sleep quality was assessed at T1 (past month) and T2 (since March 13, 2020) utilizing the Pittsburgh Sleep Quality Index (Buysse et al., 1989). The 19-item index is a validated measure of sleep quality (Carpenter & Andrykowski, 1998). Items were scored using standard scoring procedures (Buysse et al., 1989). Lower scores indicated better sleep quality.

Food security was self-reported at T1 (past 12 months) and T2 (since March 13, 2020) with the U.S. Household Food Security Survey Module (Bickel et al., 2000). The validated 18-item food security measure consists of three components: household, adult, and child-related items (Carlson et al., 1999). All participants responded to the household and adult stages, totaling 10 items. If participants indicated that they had children living in the household, they also completed the child stage questionnaires (8 items).

Stressful life events was assessed only at T2 (since March 13, 2020) with the Social Readjustment Rating Scale (Holmes & Rahe, 1967). The 43-item assessment is a validated measure of stressful life events (Rahe et al., 1970). Response options were either “yes” or “no”. Responses were scored based on standard scoring procedures (Holmes & Rahe, 1967).

Demographic factors assessed included age, gender, race, height, and weight. Height and weight were used to calculate BMI (kg/m^2). At T2, participants reported any change-in-residence when campus closed, the state they were currently living in, and if the state they resided in was currently under a stay-at-home order. Questionnaires were time-stamped to determine when assessments were completed and number of days between assessments.

1.3. Data analysis

Data collection at T2 was originally unplanned and initiated in response to the unanticipated events resulting from COVID-19. Thus, a post-hoc power analysis was conducted to determine if our sample size was adequate to detect an effect equivalent to those of a recent meta-analysis on leisure-time PA and positive affect associations (Wiese et al., 2018). Given a sample of 107 participants and assuming power of 0.80 and alpha of 0.05, this study was able to detect a medium sized effect ($f^2 = 0.20$).

Analyses were conducted in SPSS Version 26 (SPSS Inc., Chicago, Ill., USA). Paired t-tests examined changes in variables across both time points. Linear regression models examined the associations between PA and affect at T1 and T2 and the associations between changes in these variables. Regression models controlled for various demographic (i.e., sex, age, race, BMI), behavioral (i.e., sleep quality, food insecurity), and temporal (i.e., T1 survey completion date, time between surveys) factors, which could potentially confound associations between PA and affect (Seidlitz & Diener, 1998; Troiano et al., 2008). All variables were entered into the linear regression simultaneously. Significance was set at alpha = 0.05.

2. Results

A total of 107 students completed the survey at T1 on or prior to March 11, 2020 (14% completed on March 11, 2020). Of those 107 students, all students completed the additional survey at T2. On average participants were 21.7 years old (SD = 2.6, Range 18–34). Approximately two-thirds of the sample identified as female and 54% of the sample identified as Caucasian (35.5% African American or Black, 4.7% Asian, 5.6% other). A small portion of the sample identified as Hispanic/Latino (12.1%). Average Body Mass Index (BMI; kg/m^2) was 25.8 (SD = 5.1; 52.3% classified as overweight/obese). Participants completed the T1 and T2 surveys 39–104 days apart (82% completed the T1 and T2 surveys at least two months apart). Approximately 40% of participants moved residences once the university transitioned online and 86% of those who moved remained in the same state. All participants indicated that their state had a stay-at-home order in place for non-essential individuals at T2.

Descriptive statistics for PA, affect, stressful life events (T2 only), sleep quality, and food insecurity at T1 and T2 are displayed in Table 1. Classification according to stressful life events as measured by the Social Readjustment Rating Scale indicated that 51.4% and 20.6% of the

Table 1
Descriptive statistics for key variables prior to and during COVID-19 stay-at-home order.

	Prior to COVID-19 Stay-at-home order (T1)			During COVID-19 Stay-at-home order (T2)			Correlations					
Variable	Mean (St. Dev)	Min	Max	Mean (St. Dev)	Min	Max	1.	2.	3.	4.	5.	6.
1. Positive Affect	30.50 (8.77)	10	49	24.13 (6.95)	11	40		−0.09	0.32*	–	−0.33*	−0.18
2. Negative Affect	17.06 (5.40)	10	41	21.82 (7.74)	10	45	−0.25*		−0.11	–	0.17	0.15
3. Moderate- to Vigorous-Intensity Physical Activity (min/week)	424.57 (371.97)	0	1800	324.71 (316.57)	0	1300	0.49*	−0.15		–	−0.14	−0.01
4. Stressful Life Events	–	–	–	220.91 (104.40)	31	538	−0.22*	0.26*	−0.10		–	–
5. Sleep Quality	4.44 (2.41)	0	14	5.80 (3.16)	1	20	−0.37*	0.44*	−0.15	0.36*		0.01
6. Food Security	0.84 (1.10)	0	3	0.65 (1.03)	0	3	−0.01	0.15	0.04	0.19	0.19*	

Note. One participant did not complete the affect assessment at T1 resulting in an analytic sample of 106 students at T1 and 107 students at T2. Stressful life events was only assessed at T2. Composite score ranges, based on standard scoring procedures, are as follows: positive and negative affect (10–50), stressful life events (0–1466), sleep quality (0–21), food security (0–3). For sleep and food security measures higher scores indicate poorer sleep or more food insecurity, respectively. Stressful life events scores ≤150 are classified as a relatively low amount of life change and a low susceptibility to stress-induced health breakdown, scores between 151 and 299 are classified as a 50% chance of health breakdown in the next 2 years, scores ≥300 are classified as an 80% chance of health breakdown in the next 2 years. For correlations, correlations at T2 (i.e., during COVID-19 stay-at-home order) are below the diagonal and correlations among the change scores from T1 to T2 are above the diagonal. Change scores are calculated as T2-T1.
*$p < 0.05$.

sample had a 50% or 80% chance of a major health breakdown in the next two years, respectively. Paired t-tests revealed that there was a significant decrease in minutes of MVPA (t (106) = -2.4, $p = 0.02$), positive affect (t (105) = -6.93, $p < 0.001$), and sleep quality (t (106) = 5.14, $p < 0.001$; higher scores indicate worse sleep quality) from T1 to T2. Negative affect significantly increased from T1 to T2 (t (105) = 6.29, $p < 0.001$). Food insecurity did not significantly change from T1 to T2 (t (106) = -1.83, $p = 0.07$).

Unstandardized regression coefficients are displayed in Table 2. MVPA was positively associated with positive affect at T1 ($B = 0.01$, $p < 0.01$) and T2 ($B = 0.01$, $p = 0.01$). Change in MVPA was positively associated with change in positive affect ($B = 0.01$, $p = 0.01$). Associations between PA and positive affect were consistent regardless of stressful life events (i.e., no significant interaction) at T2 and in the change model. All associations were significant after controlling for sleep quality, food insecurity, stressful life events (or change in these factors), time of assessments (or between assessments), and demographic factors. MVPA was negatively associated with negative affect at T1 only ($B = -0.003$, $p = 0.04$). Stressful life events did not moderate associations between PA and negative affect at T2 or in the change model.

3. Discussion

To the authors' knowledge, this is the first study to prospectively examine changes in PA, affect, and other behavioral factors during COVID-19 stay-at-home orders and associations between changes in PA and affect during this time. The findings from this study indicate significant decreases in PA, positive affect, and sleep quality and an increase in negative affect during COVID-19 stay-at-home orders. Furthermore, PA was associated with affect before (i.e., positive and negative affect) and during (i.e., positive affect only) COVID-19 stay-at-home-orders, and prospectively assessed changes in PA were positively associated with changes in positive affect (but not negative) during the stay-at-home orders. This study overcomes limitations of other research that retrospectively assessed PA and positive and negative aspects of mental health prior to the COVID-19 pandemic (e.g., Meyer et al., 2020). Compared to retrospective assessment (potentially biased by current life circumstances), our prospective approach afforded self-assessment of behavioral and psychological well-being prior to significant widespread life-changing events due to the COVID-19 pandemic. Not surprisingly, the COVID-19 pandemic and subsequent quarantine resulted in increased negative affect and decreased positive affect. While PA was unable to protect against or attenuate increases in negative affect, findings suggest initiating or increasing PA levels during this time may help to preserve or bolster positive affect.

Findings from this study have important implications for PA as a tool for maintaining or enhancing positive mental health during a time of unprecedented challenge in a vulnerable population. Particularly alarming is that stressful life events experienced in our sample after the university closed campus and transitioned online indicated that almost three-fourths of those students had at least a 50% chance of having a major health breakdown in the next two years. Despite this concerning trend, PA had a uniform effect on positive affect regardless of stressful life events. Therefore, PA promotion efforts may be particularly valuable during this time as a method to not only enhance positive mental health but to accrue additional health-promoting benefits such as increased immunity among college students (Sallis & Pratt, 2020; Simpson & Katsanis, 2020).

Many universities have taken steps to promote PA during the pandemic by developing or curating collections of online fitness classes; however, lack of motivation and preoccupation with other concerns or demands may be major barriers to utilizing these resources and engaging in PA. Given that hedonic effects of PA are implicated as critical motivators of behavior (Ekkekakis & Zenko, 2016) and affective messaging is an effective strategy for promoting PA (Williamson et al., 2020), campus recreation programs may want to emphasize the affective benefits of PA during the pandemic. Additional PA promotion strategies previously found to be effective, such as self-regulatory techniques (e.g. self-monitoring, action planning) (Michie et al., 2009), could be considered in a virtual format.

The strengths of this study include assessments of PA and affect before and during COVID-19 stay-at-home orders in a diverse sample of college students. However, the limitations should be noted. First, participants were limited to one undergraduate class at one institution in the southeastern United States, which may limit the generalizability of findings to all university students or adults. Second, this study used a self-report measure of PA. Despite the IPAQ's well-established validity (Craig et al., 2003), this may lead to overestimation of PA, which is a well-established limitation of self-report measures (Prince et al., 2008), and potential attenuation of associations between PA and affect. The PANAS also has limitations such as insufficiently capturing low activation states (Ekkekakis, 2013). Finally, though we assessed associations between chronic PA and affect, our study design is unable to determine affective response to acute bouts of PA during the COVID-19 pandemic.

In conclusion, results from the current study suggest that PA promotion efforts during the COVID-19 pandemic are needed to enhance positive mental health and well-being, particularly as phased re-

Table 2
Results of linear regressions predicting affect.

	Predicting Affect at T1 (Model 1)	Predicting Affect at T2 (Model 2)	Predicting Change in Affect (Model 3)
	Unstandardized B (Std. Error)	Unstandardized B (Std. Error)	Unstandardized B (Std. Error)
Predictor Variables in Positive Affect Models			
Intercept	32.28[c] (2.36)	23.60[c] (2.22)	8.30 (4.90)
Stressful Life Events	–	0.00 (0.01)	−0.01 (0.01)
Physical Activity[a]	0.01[c] (0.002)	0.01[c] (0.005)	0.01[c] (0.004)
Stressful Life Events × Physical Activity[a] Interaction	–	0.00001 (0.000)	0.00003 (0.000)
Sleep Quality[a]	−0.51 (0.37)	−0.66[c] (0.19)	−0.73[c] (0.32)
Food Security[a]	−1.30 (0.78)	0.28 (0.56)	−1.04 (0.77)
Gender (Male)	−0.45 (1.78)	2.61[c] (1.27)	3.95[c] (1.77)
Age (centered)	0.29 (0.33)	0.30 (0.22)	−0.11 (0.32)
BMI (centered)	−0.16 (0.17)	−0.04 (0.11)	0.06 (0.16)
Race (Caucasian)	−1.29 (1.76)	0.13 (1.22)	0.45 (1.64)
Time[b]	−3.14 (2.48)	2.09 (1.68)	−0.16[c] (0.05)
Predictor Variables in Negative Affect Models			
Intercept	15.85[c] (1.47)	15.77[c] (2.72)	7.90 (4.64)
Stressful Life Events	–	0.001 (0.01)	0.004 (0.01)
Physical Activity[a]	−0.003[c] (0.001)	−0.007 (0.006)	−0.003 (0.004)
Stressful Life Events × Physical Activity[a] Interaction	–	0.00002 (0.000)	0.000001 (0.000)
Sleep Quality[a]	0.39 (0.23)	0.89[c] (0.24)	0.40 (0.30)
Food Security[a]	−0.07 (0.49)	0.80 (0.70)	1.27 (0.74)
Gender (Male)	−0.33 (1.11)	−1.75 (1.57)	−1.24 (1.68)
Age (centered)	0.02 (0.21)	−0.23 (0.27)	−0.21 (0.30)
BMI (centered)	0.13 (0.11)	0.17 (0.14)	0.05 (0.16)
Race (Caucasian)	2.15 (1.09)	2.15 (1.49)	−1.33 (1.55)
Time of or between assessments[b]	−1.82 (1.54)	2.40 (2.06)	−0.05 (0.05)

Note. One participant did not complete the affect assessment at T1 resulting in an analytic sample of 106 students at T1 and 107 students at T2. Stressful life events was not assessed at T1. Sleep quality and food insecurity compositive variables had meaningful zeros were entered as continuous variables. Age and BMI were grand mean centered. Gender and race were dummy coded with male and Caucasian as the reference group, respectively. R^2 for models predicting positive affect: Model 1 $R^2 = 0.16$, Model 2 $R^2 = 0.40$, Model 3 $R^2 = 0.33$. R^2 for models predicting negative affect: Model 1 $R^2 = 0.15$, Model 2 $R^2 = 0.27$, Model 3 $R^2 = 0.10$.

[a] In regression analyses predicting change (Model 3), predictors are the change in those constructs. Change scores were calculated as T2 – T1.

[b] In Models 1 and 2, time of assessments is a dummy-coded for T1 completion date with participants who completed the T1 assessment on March 11, 2020 serving as a reference group. In Model 3, time between assessments is defined as the number of days between T1 and T2 completion dates.

[c] $p < 0.05$.

openings continue, COVID-19 hotspots emerge, and new quarantines and closures potentially loom. Although additional research is needed in other populations of adults and using device-based measures of behavior, these findings indicate the value of PA for promoting health and well-being during a time of trauma and uncertainty.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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.

Informed consent

Informed consent was obtained from all individual participants included in the study.

CRediT authorship contribution statement

Jaclyn P. Maher: Conceptualization, Methodology, Formal analysis, Writing - original draft, Supervision. **Derek J. Hevel:** Investigation, Formal analysis, Writing - original draft. **Erin J. Reifsteck:** Conceptualization, Writing - original draft. **Eric S. Drollette:** Conceptualization, Methodology, Formal analysis, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2020.101826.

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