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Disparities in Physical Activity and Depressive Symptoms among Young Adults in the Early Stage of the COVID-19 Pandemic

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ABSTRACT

Background of the study: The COVID-19 pandemic has deeply impacted people's daily lives, while the influence on behaviors and mental health among college students at the early stage of this pandemic is rarely studied. **Objective:** This study examined the impact of the COVID-19 pandemic in the early stage on college students' physical activity (PA), sedentary behavior, and depressive symptoms and its impact on sex and ethnic disparities in these outcomes. **Methods:** Using a cross-sectional design, 111 college students were recruited, and the data were collected before COVID-19 (n = 64) and in the early stage of the COVID-19 pandemic (n = 47), respectively. All participants completed a survey measuring depressive symptoms and wore an accelerometer to monitor PA behavior (light PA [LPA], moderate-to-vigorous PA [MVPA]), and sedentary behavior. **Results:** More MVPA engagement and lower levels of depressive symptoms were observed in the early-stage COVID-19 group compared to the before-COVID-19 group. The magnitude of the sex and ethnicity disparities in PA and depressive symptoms were reduced in the early-stage of the COVID-19 pandemic. **Conclusion:** Understanding college students' behaviors and mental health in the midst of a global crisis can be useful to determine appropriate strategies to address health and wellness in the chance of the lockdown returning and to further promote this vulnerable population's physical and mental wellness.

Key words: Ethnicity, Mental Health, Physical Movement, Sedentary Lifestyle, Sex Difference

INTRODUCTION

Starting from December 2019, the World Health Organization informed the initial cases of what would soon be known as COVID-19 (Centers for Disease Control and Prevention, 2022). Over the preceding two and half years, the global COVID-19 pandemic yielded over 515 million confirmed cases with over six million of deaths globally; specifically, the United States incurred over 81 million confirmed cases and nearly 1 million deaths (n=990,260) as of May 9th, 2022 (World Health Organization, 2022). Historically, pandemics similar to COVID-19 have happened over twenty times since 430 BC (Pitlik, 2020). Even with historical reference from previous pandemics, at the beginning of this new acute infectious virus, people were facing many unknown and not well-understood factors related to the COVID-19 spread, incubation, geographic reach, transmission rate, and the actual mortality rate, which have been shown to cause many mental health issues and behavioral changes (Guo et al., 2020; Ornell et al., 2020). Understanding how people reacted in the early stage of the COVID-19 pandemic and how this pandemic may influence already known health disparities is critical to help inform public health initiatives and tailor individuals' coping strategies for post-COVID-19 and beyond. Young adults' (18-30 years old) daily activities and mental health have been largely impacted in response to the social distancing and lockdown restrictions during the COVID-19 pandemic (Glowacz & Schmits, 2020; Meyer et al., 2020). Hence, it is crucial to explore if young adults' daily behaviors and mental health were impacted given that the early stage of the COVID-19 pandemic was full of bourgeoning information about the virus spread, magnitude, and its impact on businesses, schools, and daily life.

Emerging research measuring physical activity (PA) and sedentary behavior found that both children and adults reported being less active and more sedentary during the lockdown period than before the COVID-19 pandemic (Gu et al., 2022; Moore et al., 2020; Robinson et al., 2021; Savage et al., 2020; Tulchin-francis et al., 2021). However, these studies predominately used online self-reported surveys. Two studies have objectively measured PA in young adults which provided preliminary insights into the PA changes during the COVID-19 pandemic (Sañudo et al., 2020; Tison et al., 2020). Specifically, Sañudo and colleagues objectively in-

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vestigated PA (i.e., step counts) via commercial-based wristband along with self-reported sedentary behavior in 22 college students from Spain (Sañudo et al., 2020). Their results indicated that participants after the lockdown (on March 24, 2020) walked fewer steps and spent more time in sedentary behavior compared to pre-lockdown (Sañudo et al., 2020). Another study using deidentified smartphone-based data revealed that citizens in the United States had increased step counts before the lockdown order was enforced, and then had drastically decreased the number of steps since lockdown (Tison et al., 2020). However, the PA measures used in these two studies only focused on daily step counts and were not able to capture the intensity levels of PA participation, such as light intensity PA (LPA; e.g., walking slowly or light housework) and moderate-to-vigorous intensity PA (MVPA; e.g., fast walking, fast cycling, or carrying heavy groceries). Although the previous studies added valuable insights on tracking individual's PA changes during the pandemic, more robust measures of PA are warranted as disparities have been reported in different demographics before and even during the early stage of the COVID-19 pandemic (Gu et al., 2022).

To date, researchers have recognized small effect sizes of the COVID-19 pandemic on individuals' mental health, such as the sustained, increasing effects on depression after the lockdown (Bruine de Bruin, 2020; Cullen et al., 2020). Researchers found that depressive symptoms have increased almost 3-fold higher during the pandemic compared to before in adult populations (Ettman et al., 2020). Increased exposure to stressors, less economic stability, and induced loneliness have catastrophically compressed mental health and inadvertently elevated suicidal rates (Sher et al., 2020). Most recently, the United States National Health and Nutrition Examination Survey data suggested that mental health of young adults are heavily affected by the global pandemic (Daly et al., 2021). However, literature during the early stage of the pandemic regarding disparities in college students' PA and mental health were not well-documented, and studies were mainly focused on relationships with self-report surveys (Gu et al., 2022; Moore et al., 2020; Robinson et al., 2021; Savage et al., 2020; Tulchin-francis et al., 2021).One study conducted in the United Kingdom during their lockdown found that college students reported increased stress and sedentary behavior during the pandemic but did not posit an association with PA (Savage et al., 2020). Understanding depressive symptoms in United States young adults is warranted to further explain their mental status while they were in the early stages of the COVID-19 pandemic.

Before the spread of COVID-19, the disparities in PA behaviors and depression were persistently disparaging among vulnerable populations such as minority communities and females (Armstrong et al., 2018; Edwards & Sackett, 2016; Hawes et al., 2019; Ibrahim et al., 2013; Kuehner, 2017; Wilson & Bopp, 2021). For example, using a secondary data analysis, Wilson and Bopp examined over 200,000 college students and found that minority populations were the least likely to report sufficient PA levels and had lower odds of being physically active, compared to non-Hispanic White individuals (Wilson & Bopp, 2021). Both Hispanic male and female young adults were historically reported having the lowest PA participation compared to their non-Hispanic peers (i.e., White and Black; Dowda et al., 2003). Females have consistently reported engaging in less PA and posit greater susceptibility to exhibit depressive symptoms than males (Edwards & Sackett, 2016; Ibrahim et al., 2013; Kuehner, 2017). At the initial stage of the COVID-19 pandemic, college students' psychological and behavioral reactions may be directly related to their emotional distress and physical health throughout the pandemic. Understanding the behavioral pattern and mental changes at the early stage of COVID-19 would inform preventive strategies throughout the pandemic and for future preparations if similar global health crises occur again. It is also urgent to identify if ethnic and sex disparities existed during COVID-19 due to the documented evidence in the pre-pandemic literature (Edwards & Sackett, 2016; Ibrahim et al., 2013; Kuehner, 2017).

Therefore, the primary purpose of this study was to examine the impact of the COVID-19 pandemic (before COVID-19 vs. early-stage COVID-19 pandemic groups) on college students' PA (i.e., LPA, MVPA), sedentary behavior, and their depressive symptoms (i.e., depressed affect, somatic activity, positive affect, interpersonal relation). Then, the sex (male vs. female) and ethnic (Hispanic vs. non-Hispanic) disparities in these outcome variables were examined in both groups (before COVID-19 vs. early-stage COVID-19 pandemic groups).

METHODS

Participants and Study Design

A total of 111 college students (73% female; mean age = 22.24, SD = 4.01) were recruited from one Hispanic-serving university in this study (see demographic information in Table 1). Among them, 64 students (82.8% female; 65.6% non-Hispanic origin; mean age = 22.84, SD = 3.70 years) were recruited throughout September-November, 2019 (before COVID-19 group). Another 47 students (59.6% female; 53.2% non-Hispanic origin; mean age = 22.68, SD = 4.52 years) were recruited throughout February-March 2020 (early-stage COVID-19 group). All participants were above 18-year old college students and completed all of the measures, thus no participants were excluded. In the before COVID-19 group, there were 56.5% third-year college students, followed with 17.7% first-year, 14.5% fourth-year, and 11.3% second-year college students. In the early-stage COVID-19 group, 43.5% were third-year college students, followed with 23.9% first-year, 21.7% second-year, and 10.9% fourth-year college students. Most of the participants (73.4%) in the before COVID-19 group were from the Department of Kinesiology, majoring in kinesiology, athletic training, and exercise science; the remaining participants were from the Department of Nursing. All participants in the early-stage COVID-19 group were from the Department of Kinesiology.

As a cross-sectional study, participants in both groups completed the measurements on PA, sedentary behavior, and depressive symptoms (dependent variables). The group

Table 1. Descriptive statistics of before COVID-19 group and early-stage COVID-19 group

Variables	Before COVID-19 (n = 64)			Early-stage COVID-19 (n = 47)		
	M	SD	95% CI	M	SD	95% CI
Sedentary behavior	0.28	0.09	0.26-0.31	0.29	0.10	0.26-0.32
Light physical activity	0.56	0.07	0.54-0.58	0.53	0.07	0.51-0.55
MVPA	0.16	0.06	0.14-0.17	0.18	0.08	0.16-0.21
Somatic depression	5.73	3.42	4.89-6.58	4.87	2.97	3.88-5.50
Depressed affect	3.98	4.47	2.82-5.05	2.06	2.52	1.20-2.50
Interpersonal relation	0.68	0.96	0.42-0.89	0.49	0.78	0.20-0.63
Positive affect	3.94	3.07	2.91-4.40	3.23	2.31	2.63-3.98
Depression total score	14.31	9.14	11.83-16.39	10.96	6.12	8.78-12.18

MVPA = moderate-to-vigorous physical activity; M = mean; SD = standard deviation; CI = confidence interval

factors including COVID-19 periods (before vs. the early-stage), sex (male vs. female), and ethnicity (non-Hispanic vs. Hispanic) were independent variables. The University of Texas at Arlington's institutional review board approval and participants informed consent forms were obtained before collecting data.

Procedures

The same research protocol was followed for both groups. Before COVID-19, most participants were recruited from classrooms, and a few were recruited from flyers who came to the research lab on campus. During the early stage of COVID-19, most participants were recruited via flyers and came to the research lab (just before stay-at-home-orders). Participants filled out a survey regarding their social demographic information and depressive symptoms. After that, they were assigned a numbered accelerometer to wear for a day for seven consecutive days to measure PA and sedentary behavior. After seven days, participants returned their assigned accelerometers to the research lab. Data in the accelerometers were processed using ActiLife 6.0 software.

Measurements

Physical activity and sedentary behavior

Participants' LPA, MVPA, and sedentary behavior were assessed using the ActiGraph GT9X accelerometers (ActiGraph LLC, Florida, USA). Participants wore a designated accelerometer on their wrists for a week with their basic data (i.e., height, weight, age, sex) pre-uploaded in the accelerometer. The accelerometer was set up using 60-second epochs and a sample rate 30Hz. The data with at least eight hours per day for a minimum of three days was used in analysis. Using Troiano et al.'s cut-off recommendation (Troiano et al., 2008), we extracted participants' LPA using 100-2019 counts per minute, MVPA using ≥ 2020 counts per minute, and sedentary behavior using 0-99 counts per minutes. Participants' average percentage of time per day on LPA, MVPA, and sedentary behavior were calculated based on the total wearing time and days and were then used in the data analysis. It was well-documented that ActiGraph accelerometer is a valid and reliable tool in measuring different intensity levels of PA among adults (Chang et al., 2020; Clevenger et al., 2020; Montoye et al., 2017).

Depressive symptoms

The 20-item Center of Epidemiologic Studies Depression Scale (CES-D) was used to assess participants' depressive symptoms (Radloff, 1977). The CES-D scale comprises of four domain depressive symptoms, including depressed affect (e.g., lonely, blue, depressed, sad, cry, etc.; 7-item), somatic activity (e.g., bad appetite, sleepless, can't get going; get bothered, etc.; 7-item), positive affect (e.g., happy, good, hopeful, enjoy, etc.; 4-item), and interpersonal relation (e.g., unfriendly, dislike, etc.; 2-item). Participants reported how often they have experienced these symptoms in the past week from 0 (less than one day) to 3 (5-7 days). Specifically, four items of the positive affect were reversely coded, and the higher score represents the lower levels of positive affect symptoms. The items of all four domains were summed up to represent the final score (the higher score, the more severe of depressive symptoms). The overall depressive symptoms score (CES-D score) was the summary of all subdomains ranging from 0 to 60. The value of Cronbach's alpha is 0.74 indicating an acceptable internal consistency.

Statistics and Data Analysis

The data was analyzed using SPSS version 26.0. First, descriptive statistical analysis was conducted to examine the mean and standard deviation of study variables: PA (MVPA, LPA), sedentary behavior, and depressive symptoms (i.e., depressed affect, somatic activity, positive affect, interpersonal relation, and total CES-D score) for both Before COVID-19 and Early-stage COVID-19 groups. A series of one-way multivariate analyses of variance (MANOVA) was used to examine the sex (male vs. female) and ethnicity (Hispanic vs. non-Hispanic) differences, respectively, in PA, sedentary behavior, and depressive symptoms in the before COVID-19 group and early-stage COVID-19 group separately. A power analysis was conducted to evaluate the sample size for testing the most complicated model. Specifically, we evaluated the MANOVA models including 2 groups and five dependent variables (depression variables). The power analysis results

indicated the sample size of the before COVID-19 group met the sample requirement and the early-stage COVID-19 group marginally met the sample requirement (n=50) to achieve 80% power for detecting a medium to large effect (effect size $f^2 = 0.30$) at an alpha level of 0.05. The Box's M test results for these MANOVAs ranging from 5.10 to 25.87 ($ps > 0.05$) indicate equal covariance matrices. We reported effect size using partial eta square (η^2; small effect: 0.01; medium effect: 0.06; large effect: 0.14). We used an alpha level of 0.05 for all statistical analyses.

RESULTS

In the before COVID-19 group, participants spent on average 56%, 16%, and 28% of their wake-up time in LPA, MVPA, and sedentary behavior, respectively. Participants in the early-stage COVID-19 group spent 53%, 18%, and 29% of their wake-up time in LPA, MVPA, and sedentary behavior, respectively. The before COVID-19 group reported an average of 14.31 on the CES-D scale with 32.8% of these participants reporting depressive symptoms (CES-D score ≥16; Radloff, 1977).The early-stage COVID-19 group reported an average of 10.96 on the CES-D scale with 25.5% of these participants reporting depressive symptoms (CES-D score ≥16). Overall, the early-stage COVID-19 group showed more MVPA engagement and lower levels of depressive symptoms than the before COVID-19 group. More details are presented in Table 1.

There were no significant sex differences in PA behaviors, but medium effect sizes were observed in both the before COVID-19 group ($\eta^2 = 0.056$) and the early-stage COVID-19 group ($\eta^2 = 0.054$). Specifically, a decreased sex disparity was found in MVPA participation (i.e., less sex difference on MVPA in the early-stage COVID group compared to that in the before COVID-19 group; see Figure 1). In the before COVID-19 group, female students engaged in more MVPA than male students (female: mean = 16%; male: mean = 13%; $\eta^2 = 0.048$) whereas in the early-stage COVID-19 group, male and female students had similar engagement of MVPA (female: mean = 18%; male: mean = 19%; $\eta^2 < 0.001$). No significant ethnicity disparities in behaviors were observed but there was a small effect size ($\eta^2 = 0.015$) in the before COVID-19 group and a large effect size ($\eta^2 = 0.101$) in the early-stage COVID-19 group. Specifically, in the before COVID-19 group, non-Hispanic students participated in slightly more MVPA than Hispanic students (non-Hispanic: mean = 16%; Hispanic: mean = 15%; $\eta^2 = 0.013$). However, in the early-stage COVID-19 group, Hispanic students engaged in more MVPA than non-Hispanic peers (non-Hispanic: mean = 17%; Hispanic: mean = 21%; $\eta^2 = 0.08$). Table 2 and Figure 1 display these results.

There were no significant sex differences in depressive symptoms, but large effect sizes were observed in both the before COVID-19 group ($\eta^2 = 0.123$) and the early-stage COVID-19 group ($\eta^2 = 0.192$). Marginal differences between sex in depressive symptoms (except somatic depression) were observed in the early-stage COVID-19 group. Consistent higher levels of depressive symptoms were found in females in both groups (i.e., depressive affect: $\eta^2 = 0.064$ and $\eta^2 = 0.102$; overall CES-D score: $\eta^2 = 0.062$ and $\eta^2 = 0.109$). However, the disparity in somatic depression was larger in the early-stage COVID-19 group ($\eta^2 = 0.136$; females had a higher level of somatic depression than males) compared to that in the before COVID-19 group. In both groups, Hispanic and non-Hispanic students had subtle differences in depressive symptoms (η^2 ranged from 0 to 0.021). Table 2 and Figure 2 display these findings.

DISCUSSION

This study examined the impact of COVID-19 in the early stage on college students' accelerometer-assessed PA (LPA, MVPA), sedentary behavior, and depressive symptoms. One significant contribution of this study was to examine the sex and ethnic disparities in PA behaviors and depressive symptoms by comparing two independent groups regarding the impact of COVID-19 pandemic (before COVID-19 vs. early-stage COVID-19 groups). Indeed, we found the magnitude of the sex and ethnicity disparities in PA and depressive symptoms were reduced during the transition of the early-stage of COVID-19. Moreover, we observed more MVPA participation and lower levels of depressive symptoms in the

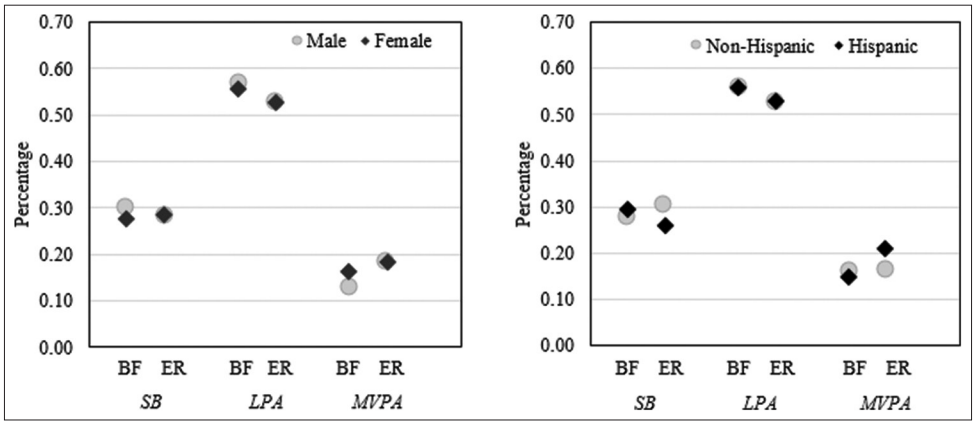

Figure 1. Sex and ethnicity disparities in physical activities and sedentary behavior
BF = the before COVID-19 group; ER = the early-stage COVID-19 group; SB = sedentary behavior; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity

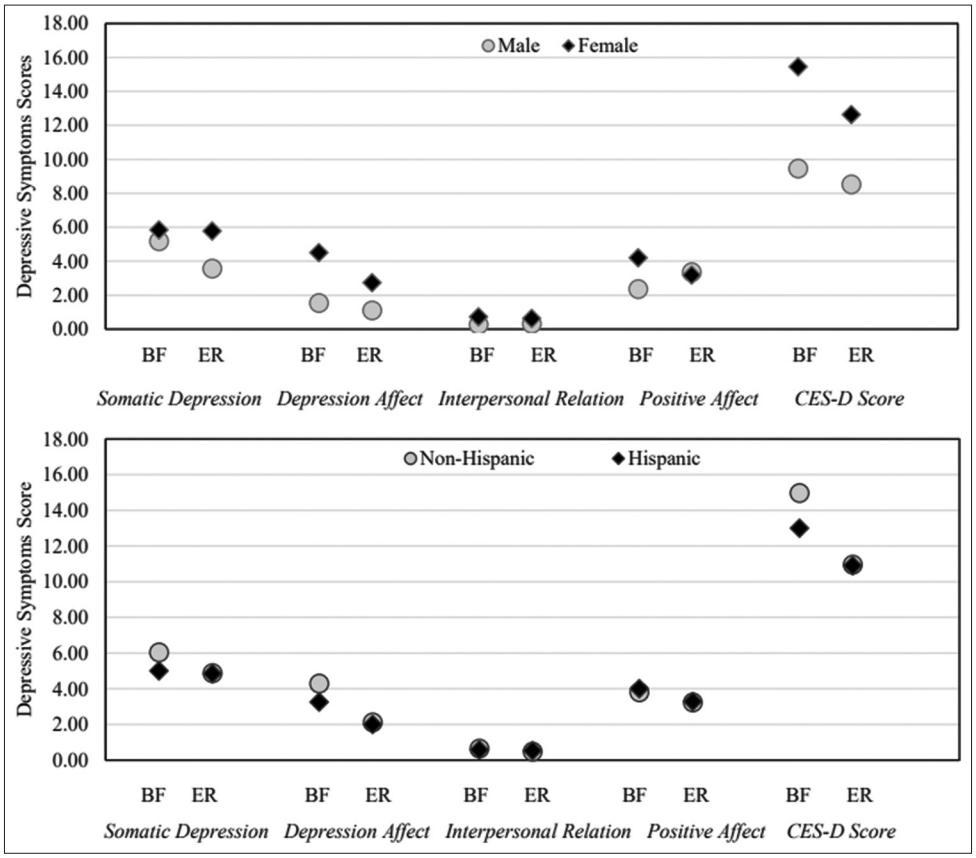

Figure 2. Sex and ethnicity disparities in depressive symptoms
BF = the before COVID-19 group; ER = the early-stage COVID-19 group

Table 2. MANOVA results of sex and ethnicity disparities in physical activities, sedentary behavior, and depressive symptoms

Variable	Male	Female	η^2	non-Hispanic	Hispanic	η^2
	M(SE)	M(SE)		M(SE)	M(SE)	
The before COVID-19 group	(n = 11)	(n = 53)		(n = 42)	(n = 22)	
Sedentary behavior	0.30 (0.03)	0.28 (0.01)	0.009	0.28 (0.01)	0.29 (0.02)	0.005
Light physical activity	0.57 (0.02)	0.56 (0.01)	0.004	0.56 (0.01)	0.56 (0.02)	<0.001
MVPA	0.13 (0.02)	0.16 (0.01)	0.048	0.16 (0.01)	0.15 (0.01)	0.013
Somatic depression	5.18 (1.04)	5.84 (0.49)	0.006	6.05 (0.53)	5.00 (0.79)	0.021
Depressed affect	1.55 (1.35)	4.51 (0.64)	0.064*	4.29 (0.72)	3.26 (1.05)	0.011
Interpersonal relation	0.27 (0.28)	0.71 (0.13)	0.034	0.66 (0.15)	0.58 (0.22)	0.002
Positive affect	2.36 (0.89)	4.20 (0.42)	0.057	3.80 (0.47)	4.00 (0.69)	0.001
Depression total score	9.45 (2.76)	15.45 (1.31)	0.062*	14.98 (1.47)	13.00 (2.16)	0.010
The early-stage COVID-19 group	(n =19)	(n =28)		(n = 25)	(n = 22)	
Sedentary behavior	0.28 (0.02)	0.29 (0.02)	<0.001	0.30 (0.02)	0.26 (0.02)	0.046
Light physical activity	0.53 (0.02)	0.53 (0.01)	<0.001	0.53 (0.01)	0.53 (0.02)	<0.001
MVPA	0.19 (0.02)	0.18 (0.02)	<0.001	0.17 (0.01)	0.21 (0.02)	0.080
Somatic depression	3.58 (0.64)	5.78 (0.54)	0.136*	4.88 (0.60)	4.86 (0.66)	<0.001
Depressed affect	1.11 (0.56)	2.74 (0.47)	0.102*	2.12 (0.52)	2.00 (0.56)	0.001
Interpersonal relation	0.32 (0.18)	0.63 (0.15)	0.040	0.48 (0.16)	0.52 (0.17)	0.001
Positive affect	3.37 (0.54)	3.19 (0.45)	0.002	3.24 (0.47)	3.29 (0.51)	<0.001
Depression total score	8.53 (1.35)	12.63 (1.14)	0.109*	10.96 (1.25)	10.90 (1.36)	<0.001

MVPA = moderate-to-vigorous physical activity; M = mean; SE = standard error; η^2 = effect size; * = $p < 0.05$

early-stage COVID-19 group compared to their peers in the before COVID-19 group. This result highlighted college students' positive reactions to coping with the health risks at the early stage of a global pandemic. College students' optimistic intentions during the early stage of COVID-19 may have reduced the disparity in PA and depression among groups with different demographics.

At the beginning of the pandemic, college students may have had a sense of urgency to be more physically active as increasing countries and states were enforcing policies of closing gyms, sports, studios, and parks while people were generally increasing awareness to stay active for a healthier immune system to combat the virus. The improved PA levels in the current study were consistent with Tison's findings that the citizens in the United States had increased step counts between the start of the COVID-19 pandemic to the lockdown, as well as Savage et al.'s findings among university students in the United Kingdom (Savage et al., 2020; Tison et al., 2020). Some universities, such as the Department of Psychiatry from the University of Michigan, and the university where the studied participants were enrolled, distributed guidelines on the benefits of exercise and PA during the pandemic (University of Michigan, 2020). The increased awareness of staying physically active at the beginning of the pandemic may have influenced college students to be more active. However, some other evidence using survey investigation showed that young adults, including college students, decreased PA and increased sedentary behaviors after the pandemic progressed for 2-10 months (Meyer et al., 2020; Robinson et al., 2021). Determining how to maintain college students' healthy movement behaviors during a long period of a health crisis such as COVID-19 seemed to be a challenge, however, with emerging evidence, more insights may be drawn to understand young adults' behaviors and activities for future policy guideline influence.

In addition to the improved PA levels during COVID-19, this study also demonstrated a reduction of sex disparities in PA and sedentary behavior in the early-stage COVID-19 group compared to their peers before the pandemic. The narrow of disparity in activity levels between males and females is encouraging, especially when both sexes had higher MVPA engagement in the early-stage COVID-19 group. However, this result needs to be interpreted with caution due to recruiting of more female participants in the before COVID-19 group compared to the early-stage COVID-19 group. Participating students were also within the major of Kinesiology, or in a related field which could also explain the lack of sex differences since both sexes would receive the same information in the curriculum on the importance of exercise on well-being. It is interesting to note the untraditional ethnic disparity in PA behaviors between Hispanic and non-Hispanic students in both groups; in the early-stage COVID-19 group, Hispanic students engaged in more MVPA and less sedentary time compared to their non-Hispanic peers. This may be explained by the university being a Hispanic-serving institution where school administrators and stakeholders may have put more effort into promoting PA engagement for minority students, specifically Hispanic students. Meanwhile, the outbreak of COVID-19 is a global challenge to public health, which also raises awareness and actual behaviors of PA participation among college students. Nevertheless, proactively establishing guidelines earlier during the pandemic to guide college students' PA, possibly ethnically tailored, may have supported students' resiliency in facing adversity at the early stage of the COVID-19 pandemic.

It is an unexpected finding that the early-stage COVID-19 group had lower levels of depression symptoms, although the COVID-19 pandemic caused many inconveniences and health hazards to student's daily life (Bruine de Bruin, 2020; Cao et al., 2020). The onset of this unexpected pandemic may have encouraged college students to spend more time with family members and significant others, which in turn, might have provided more social support to college students and also strengthened their deeper personal understanding of relationships with family, friends, colleagues, and classmates (Liu et al., 2020). Researchers pointed out that positive thinking (i.e., supportive relationships and resilience) may mediate one's mental health during the COVID-19 pandemic (Bono et al., 2020; Yang et al., 2020). This might explain the lower levels of depressive symptoms among the students in the early-stage COVID-19 group compared to the before COVID-19 group. On the other hand, as the restrictions from the pandemic persisted and the quarantine duration lasted, individuals' mental health worsened (Prati & Mancini, 2021). Findings of the current study bring a new insight into how the students reacted to the pandemic in the early stage and thus provide implications of how public health can support the sustainability of positive mental health support across different stages of a pandemic and as students get antiquated with normalcy.

One important finding is that there was no reported ethnic disparity in both COVID-19 groups. Some research showed minority groups, especially Black and Hispanic groups, were disproportionally influenced by COVID-19 (Andrasfay & Goldman, 2021; Poulson et al., 2021). This study showed that at the beginning of the COVID-19 pandemic, both Hispanic and non-Hispanic college students demonstrated similar levels of PA participation and similar levels of depressive symptoms. Although there was a consistent sex disparity in depressive symptoms in the before COVID-19 and the early-stage COVID-19 groups, the differences in many of the depressive symptoms between female and male students were decreased in the early-stage COVID-19 group. As mentioned earlier, increased communications with family, friends, and supportive relationships might contribute to relieving the stress and anxiety induced from in-person school coursework during its early stage of COVID-19. The sex disparity in somatic depression was higher in the early-stage COVID-19 group, where males reported lower scores on somatic depression than females. Somatic depression, different from other psychological symptoms, refers to symptoms of physical responses, such as lack of energy or general aches and pains (Simon et al., 1999). It is likely that male students in the early-stage COVID-19 group perceived less physical worry and discomfort than females when faced with the adversity brought by COVID-19. This suggests different phys-

ical responses to adversity between male and female young adults, and more attention is needed to explore this.

This study provides empirical evidence to the literature as regards to the impacts of COVID-19 on the sex and ethnicity disparities in PA, sedentary behavior, and depressive symptoms. One strength of this study is using objective measures on PA and sedentary behavior, which is critical to help researchers and practitioners contextualize college students' behavioral differences in before and the early stage of COVID-19 groups. If pandemics similar to COVID-19 happen again in the future, findings of this study provide practical implications to schools, organizations, and public health departments; that is, establishing early guidelines and coping strategies of daily behaviors and activities as early as possible when dealing with population-wide pandemics. From an individual's perspective, each college student may experience the pandemic differently, so keeping an active lifestyle and establishing/maintaining positive mentalities are crucial practices in the early stage of a pandemic. Further research is warranted to provide insightful and successful strategies to sustain these good practices within young adults.

There are some limitations to be acknowledged. First, we compared two cross-sectional data sources that assessed different individuals. Hence, the sex and ethnicity disparities in PA, sedentary behavior, and depression between the two time periods may in part be driven by differences such as demographic characteristics and personal experience. However, both the before and early-stage COVID-19 groups completed an identical procedure of data collection: they were from the same institution and received similar curriculum training, and both groups had similar distributions in terms of grade and ethnicity (but not sex). Given two groups' similarities and the small sample size against the large college population, we also recognize the limited generalizability of these findings in other departments and schools. Since COVID-19 has impacted individuals worldwide, it's hard to generalize these objective findings to other college students around the nation and the world. Second, we had an unbalanced sex distribution (> 80% females) in our sample pertaining to the before COVID-19 group, which may cause a skew of the results when comparing sex disparities in behaviors and depression. Lastly, although using objective measure to investigate PA and sedentary behavior is a strength of this study, we were not able to collect more data due to time consumption and high cost of these measures.

CONCLUSION

The COVID-19 pandemic has deeply affected student's daily lives. College students in the early stage of COVID-19 pandemic showed a more active lifestyle and exhibited lower levels of depressive symptoms compared to their peers before the COVID-19 pandemic. Although we found lower sex and ethnic disparities in the early stage of the COVID-19 pandemic, the long-term effects and other potential disparities among different groups are also important to identify and further investigate (see these sample reviews of long-term effects of COVID-19 pandemic: Bourmistrova et al., 2022; Marconcin et al., 2022; Wunsch et al., 2022). Given that COVID-19 remains an active aspect of daily life, more efforts are needed to promote active lifestyles and reduce mental health illness.

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