

# Screen Time, Physical Activity, and Anxiety in Honors College Students during the COVID-19 Pandemic

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## ABSTRACT

**Background:** The COVID-19 pandemic presented a unique opportunity to study the effects of increased screen time on student mental health, due to the transition to virtual learning across colleges and universities in the United States. Current literature suggests that college/university students, particularly those enrolled in Honors programs, are at an increased risk for symptoms of anxiety. Emerging research suggests that increased screen time increases anxiety but never had there been such a marked increase in screen time. **Purpose:** The aim of this pilot study was to observe the relationships between anxiety, screen time, and physical activity in Honors students during the COVID-19 pandemic. **Methods:** A REDCap survey, consisting of the GAD-7 measure of anxiety, screen time questionnaire, physical activity questionnaire, and self-reported impact of the pandemic, was distributed to Honors students. **Results:** Anxiety and screen time increased during the pandemic, while physical activity did not significantly change. Eighty-point-nine percent of respondents met GAD-7 scoring guidelines for mild to severe anxiety and 71.56% self-reported experiencing more anxiety than before the pandemic. Increased screen time was associated with increased GAD-7 score, independent of physical activity or COVID-19 impact. Increased physical activity was associated with decreased GAD-7 score. **Conclusion:** Anxiety and screen time increased in Honors students during COVID-19. Increases in screen time were associated with increased anxiety in Honors students, while physical activity was associated with decreased anxiety. Universities should consider strategies to mitigate negative effects of increased screen time, including the use of physical activity.

## KEYWORDS

COVID-19; Pandemic; Screen Time; Physical Activity; Anxiety; College Students; GAD-7; Technology; Media Effects; Children and Media

## INTRODUCTION

Anxiety disorders constitute the highest proportion of mental health disorders, with a lifetime prevalence of 31.6% in Americans over 13 years old.<sup>1</sup> Numerous studies have also established a high prevalence of anxiety in college students, ranging from 30-40%.<sup>2-5</sup> In fact, evidence points to a marked increase in anxiety in college students over the past decades.<sup>2,4,6</sup> A significant increase in the prevalence of anxiety in college students has been reported during the Coronavirus Disease 2019 (COVID-19) pandemic,<sup>7-13</sup> with one study reporting that almost one-third of the students in the cohort met criteria for anxiety according to the Diagnostic Statistical Manual – Fifth Edition (DSM-5).<sup>12</sup>

Emerging evidence suggests a relationship between screen time, defined as activities performed using or in conjunction with a digital device featuring a screen,<sup>14</sup> and anxiety. The American Academy of Pediatrics has found adequate evidence to support limiting screen time for children, but no clear guidelines exist for college students.<sup>15</sup> Studies have suggested a causal relationship between screen-based sedentary behavior and anxiety; however, due to an emphasis on television without great consideration to aggregate screen time, further research examining the effect of increased screen time on anxiety is needed.<sup>16-20</sup> Due to an explosion in the number of screen-based devices, it is important to consider screen time as an aggregate value versus focusing on one category of device. Of note, research suggests that emotion plays an important role in this relationship. In fact, regulation of emotion may reduce the suggested increase in anxiety correlated with screen time.<sup>18</sup> Studies conducted during COVID-19 have reported that the pandemic increased screen time and negative mental health symptoms.<sup>21-24</sup> A longitudinal study from Stanford demonstrated that the COVID-19 pandemic increased screen time in college students from 50.2% of their waking hours to 77.6%.<sup>25</sup> Additional research suggests a relationship between increased screen time and poor mental health in the context of the pandemic.<sup>22,26</sup>

There are a variety of ways that can help reduce anxiety, including physical activity, adequate sleep, meditation, connection with others, and lifestyle changes.<sup>27</sup> Of special interest to this present study is the impact of physical activity on anxiety. Multiple studies have demonstrated that exercise is effective in reducing anxiety symptoms in both the short- and long-term.<sup>28-31</sup> Most studies evaluating exercise and anxiety report that exercise reduces both anxiety prevalence and severity in college students, with some studies demonstrating a significant reduction in anxiety and improved mood after regular physical activity over the course of a semester.<sup>32-34</sup> Of note, any and all studied modes of physical activity have proven beneficial.<sup>31</sup> During COVID-19, studies have demonstrated that decreased exercise can lead to increased anxiety.<sup>35-39</sup> A systematic review of physical activity in university students during the COVID-19 pandemic found that nearly every study demonstrated a significant reduction in physical activity, with reductions in “light” physical activity and “high” physical activity of up to 365.5% and 52.8%, respectively.<sup>40</sup> The increased screen time during this time also contributed to reductions in physical activity.<sup>39</sup>

Despite strong evidence of an association between screen time, physical activity, and mental health, there is limited research examining these relationships primarily among college students. In two studies, high screen time was positively correlated with anxiety, independent of physical activity.<sup>41,42</sup> One study found that screen time greater than two hours is a risk factor for anxiety symptomology independent of physical activity, and that a low level of physical activity and a high level of screen time work synergistically to increase the risk for psychological diagnoses.<sup>43</sup> Additional research suggests that screen time greater than four hours influences the prevalence of anxiety disorders in college students.<sup>44,45</sup>

In an environment where college students are already at an increased risk for anxiety, increased screen time and decreased physical activity could antecede additional mental health symptomology.<sup>41</sup> The COVID-19 pandemic presented a unique opportunity to study the association between screen time and mental health at a time when screen time was necessarily increased. The primary objective of this study was to observe symptoms of anxiety, screen time, and physical activity during the COVID-19 pandemic in Honors university students. The secondary objective of this study was to investigate the association between screen time and/or physical activity and anxiety. It was hypothesized that during the COVID-19 pandemic, physical activity mediated the relationship between screen time and anxiety, with increased screen time leading to decreased physical activity, which subsequently contributed to elevated anxiety levels.

## METHODS AND PROCEDURES

### *Design*

This Institutional Review Board (IRB)-approved (STUDY00001534) study used a cross-sectional survey design that incorporated both quantitative and qualitative data collection.

### *Subjects*

Nine hundred and fifty-nine students in the Honors college of a medium-sized New England public university were invited to participate in the research survey. This population was selected because Honors students display increased incidence of perfectionism, academic achievement, and social stress.<sup>46-49</sup> Students had varied academic majors. No compensation was provided for participating in the study. See **Table 1** for details below.

### *Measures*

The survey included four separate questionnaires, consisting of demographics, anxiety, screen time, and physical activity, in the order listed. The first questionnaire was demographics, consisting of sex, undergraduate year, and specific college enrolled at the University of Vermont. These served as groups in data analysis and were used to determine the representativity compared to the overall Honors college population at the University of Vermont.

**Anxiety.** The Generalized Anxiety Disorder Assessment (GAD-7) tool was used to assess anxiety, as this tool provides a short clinical measure for assessing generalized anxiety disorder (GAD).<sup>50</sup> The GAD-7 consists of seven items, each scored on a 4-point Likert scale ranging from 0 (“not at all”) to 3 (“nearly every day”). Total scores range from 0 to 21, with higher scores indicating greater anxiety severity. Cut-off points for the GAD-7 categorize anxiety severity as follows: 0–4 (minimal anxiety), 5–9 (mild anxiety), 10–14 (moderate anxiety), and 15–21 (severe anxiety).<sup>50</sup> This tool has satisfactory reliability and criterion, construct, factorial, and procedural validity.<sup>50</sup> In addition, the GAD-7 tool is substantiated for use with populations and as an index of general anxiety severity.<sup>51</sup>

**Screen Time.** This study used a measure of screen time adapted from Vizcaino.<sup>52</sup> “Mandatory activity screen time” was defined as screen time used for school or work, rather than leisure. “Leisure activity screen time” was defined as screen time used for leisure, rather than school or work. “Weekday” was defined as between the time an individual wakes up until the time they go to bed on Monday through Friday. Finally, “weekend day” was defined as between the time an individual wakes up until the time they go to bed on Saturday and Sunday. The questions themselves were self-reported based on provided brackets of total time, asking the

respondent to report the average time spent on screens over the past two weeks, separated by weekday/weekend and mandatory/leisure activity screen time. This measure was used to obtain an aggregate measure of screen time.

**Physical Activity.** In the survey, exercise was defined as physical activity that is planned, structured, and repetitive for the purpose of conditioning any part of the body used to improve health and maintain fitness.<sup>53</sup> “Weekday” and “weekend day” were defined as above. The questions themselves were self-reported based on provided brackets of total time, asking the respondent to report the average time exercising over the past two weeks. This questionnaire was used to obtain a measure of physical activity.

For all three questionnaires, questions regarding the impact of the COVID-19 pandemic were included. These questions asked respondents to indicate if the pandemic had subjectively impacted the three variables of interest and were intended to gauge the self-perceived impact of the pandemic.

See Appendix for the survey questions.

#### *Procedures*

Study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at the University of Vermont.<sup>54,55</sup> REDCap is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources. The invitation to participate was sent out to all 959 students in the Honors College within one year of the start of the COVID-19 pandemic.

#### *Analyses*

After the survey data were collected from the respondents, the anonymized data were downloaded from REDCap for analysis. All analyses were done with Statistical Package for the Social Sciences (SPSS) Version 29.0.2.0. Demographics were compared to the population by the Honors College to determine if the sample was representative. Next, the physical activity and screen time variables were transformed into numeric values using the midpoint of categorical ranges. For screen time, the midpoint values were 0 hours for 0 hours, 1 hour for 0-2 hours, 3 hours for 2-4 hours, 5 hours for 4-6 hours, 7 hours for 6-8 hours, and 8 hours for more than 8 hours. These values were calculated for weekday leisure, weekday mandatory, weekend leisure, and weekend mandatory screen time and summed to determine total screen time. For Physical Activity, the midpoint values were 0 minutes for 0 minutes, 15 minutes for 1-30 minutes, 45 minutes for 31-60 minutes, 75 minutes for 61-90 minutes, and 90 minutes for more than 90 minutes. These values were calculated for both weekday and weekend day physical activity and summed to determine total physical activity. A composite COVID-19 impact variable was then calculated by assigning numerical values to each response category (*more* = 3, *same* = 2, *less* = 1) and computing an average of these variables to create a single composite variable. A mean-split was then performed to split the respondents into “High Impact” (1) and “Low Impact” (0).

For all tests, the significance level used was  $p < .05$ . After checking for the assumptions of linear regression, linear regression was performed to examine the relationships between total screen time, total exercise time, and anxiety (GAD-7 total score). Moderated mediation analysis using regression was performed to test the hypothesized model that physical activity mediated the relationship between screen time and anxiety symptomology. Finally, moderation analysis using linear regression was performed to determine if the COVID-19 impact variable moderated the results.

## RESULTS

A total of 225 out of 959 (23.5%) complete responses were recorded. According to the University of Vermont Honors College, the demographics of the sample were representative of the population. **Table 1** provides key descriptive data. The mean GAD-7 score was 9.62 (SD = 5.26). Eighty-point-nine percent of respondents reported mild to severe anxiety (**Table 1**). For the final question of the GAD-7 (“If you checked off any problems, how difficult have these made it for you to do your work, take care of things at home, or get along with other people?”), 56.0% of respondents reported that their anxiety had made these tasks “somewhat difficult” and a further 24.9% indicated that their anxiety had made these tasks “very difficult.” After midpoint value conversion and summation, the mean total physical activity time was 71.67 minutes (SD = 51.05). Mean total screen time was 16.89 hours (SD 4.81).

Sex		
Sex	Frequency	Percent (%)
Male	57	25.3
Female	155	68.9
Other	12	5.3
Prefer not to Answer	1	0.4
<b>Total</b>	<b>225</b>	<b>100.0</b>

  

College Year		
College Year	Frequency	Percent (%)
First year	76	33.8
Second year	61	27.1
Third year	47	20.9
Fourth year	41	18.2
<b>Total</b>	<b>225</b>	<b>100.0</b>

  

GAD-7 Category		
GAD-7 Category (Score Range)	Frequency	Percent (%)
Minimal Anxiety (0-4)	43	19.1
Mild Anxiety (5-9)	78	34.7
Moderate Anxiety (10-14)	59	26.2
Severe Anxiety (15-21)	45	20.0
<b>Total</b>	<b>225</b>	<b>100.0</b>

  

COVID Impact Group		
COVID Impact	Frequency	Percent (%)
Low Impact	146	64.9
High Impact	79	35.1
<b>Total</b>	<b>225</b>	<b>100.0</b>

**Table 1.** Key Descriptives. Summary of respondent demographics. Frequencies and relative percentages are reported for all responses to demographic questions, GAD-7 categories, and COVID impact group.

**Table 2** provides correlation data between GAD-7 score, total physical activity time, and total screen time. Increased physical activity was associated with lower GAD-7 scores. Increased screen time was associated with increased GAD-7 scores.

Pearson Correlations			
	GAD Total Score	Total Physical Activity	Total Screen Time
GAD-7 Total Score	1.00	-0.20*	0.27*
Total Physical Activity	-0.20*	1.00	-0.12
Total Screen Time	0.27*	-0.12	1.00

**Table 2.** Correlation Table. Summary of Pearson correlations between key variables. Statistical significance is determined at the  $p < .05$  level and are marked with an asterisk (\*).

See **Table 3** for screen time response percentages. Twelve-point-nine percent of respondents reported that they had not exercised in the past two weeks. See **Table 4** for exercise time response percentages.

Mandatory Screen Time Response Percentage (%)						
	0 Hours	0-2 Hours	2-4 Hours	4-6 Hours	6-8 Hours	More than 8 Hours
Weekday	0.00	2.22	16.89	35.11	33.33	12.44
Weekend	0.44	18.67	37.33	28.00	9.78	5.78
Leisure Screen Time Response Percentage (%)						
	0 Hours	0-2 Hours	2-4 Hours	4-6 Hours	6-8 Hours	More than 8 Hours
Weekday	0.00	21.33	40.44	26.22	6.67	5.33
Weekend	0.00	20.89	36.89	26.22	11.56	4.44

**Table 3.** Screen Time Response Percentages. Summary of screen time question response percentages.

Physical Activity Time Response Percentage (%)					
	0 Minutes	1-30 Minutes	31-60 Minutes	61-90 Minutes	More than 90 Minutes
Weekday	12.44	32.44	35.56	12.44	7.11
Weekend	20	29.33	28.89	12.89	8.89

**Table 4.** Physical Activity Time Response Percentages. Significance of Levene’s Test is .261, so equal variances are assumed.

Self-report of COVID-19 impact was recorded for anxiety, screen time, and physical activity. Seventy-one-point-fifty-six percent of respondents reported that the COVID-19 pandemic had led to more anxiety than before, while 24.89% of respondents answered that they experienced the same anxiety as before and 3.56% of respondents reported that they experienced less anxiety than before the pandemic. Ninety-eight-point-sixty-seven percent of respondents reported that they spent more time on screens for school and/or work than before the pandemic. Only 0.89% responded that they spent the same time on mandatory screen time as before the pandemic, and 0.44% reported that they spent less time on mandatory screen time than before the pandemic. In addition, 61.33% of respondents reported that they spent more time on screens for leisure use than before the pandemic, while 29.78% responded that their leisure screen time was the same as before and 8.89% answered that they spent less time on leisure screen time than before the pandemic. For physical activity, 38.67% of respondents reported that they spent the same amount of time on physical activity as before the pandemic, 33.78% responded that they spent less time on physical activity than before, and 27.56% of survey respondents reported that they spent more time on physical activity than before the pandemic.

An independent samples *t*-test was conducted to compare GAD-7 scores between individuals who engaged in regular exercise (*n* = 196) and those who did not (*n* = 29) (**Table 5**). The assumption of homogeneity of variances was tested using Levene’s Test and was not violated ( $F = 0.072, p = 0.789$ ). The results showed that individuals who exercise have significantly lower GAD-7 scores ( $M = 9.17, SD = 5.14$ ) compared to those who do not exercise ( $M = 12.62, SD = 5.17$ ),  $t(223) = 3.37, p < .001, d = 0.67$ . The 95% confidence interval for the mean difference ranged from 1.43 to 5.46, indicating a moderate effect size.

GAD-7 Score and Exercise Status							
	t	df	Sig.	Mean Difference	95% CI (Lower)	95% CI (Upper)	Cohen’s d
GAD-7 Total Score	3.37	223	<.001	3.45	1.43	5.46	0.67

**Table 5.** Independent Samples *t*-Test Results.

A linear regression was conducted to examine the relationship between total GAD-7 score and total screen time (**Table 6**). The overall model was significant,  $F(1,223) = 16.89, p < .001$ , explaining 7.0% of the variance in GAD-7 score ( $R^2 = 0.070$ , Adjusted  $R^2 = 0.066$ ). Total screen time significantly predicted GAD-7 score ( $B = 0.290, SE = 0.071, \beta = 0.265, t(223) = 4.110, p < .001$ ). Higher screen time levels were associated with higher GAD-7 scores.

GAD-7 Score and Total Screen Time					
	Unstandardized Coefficient		Standardized Coefficient		
	B	Std. Error	Beta	t	Sig.
(Constant)	4.712	1.241		3.797	<.001
Total Screen Time	0.290	0.071	0.265	4.110	<.001

Table 6. Linear Regression Coefficients for Screen Time. Linear regression of GAD-7 score and total screen time.

A linear regression was conducted to examine the relationship between total GAD-7 score and total physical activity (Table 7). The overall model was significant,  $F(1,223) = 9.10, p = .003$ , explaining 3.9% of the variance in GAD-7 score ( $R^2 = 0.039$ , Adjusted  $R^2 = 0.035$ ). Total physical activity significantly predicted GAD-7 score ( $B = -0.020, SE = 0.007, \beta = -0.198, t(223) = -3.016, p = .003$ ). Higher physical activity levels were associated with lower GAD-7 scores.

GAD-7 Score and Total Physical Activity					
	Unstandardized Coefficient		Standardized Coefficient		
	B	Std. Error	Beta	t	Sig.
(Constant)	11.080	0.595		18.631	<.001
Total Physical Activity	-0.020	0.007	-0.198	-3.016	0.003

Table 7. Linear Regression Coefficients for Physical Activity. Linear regression of GAD-7 score and total physical activity.

Mediation analysis was conducted to test whether physical activity mediated the relationship between screen time and anxiety. The results showed that screen time did not significantly predict physical activity ( $a = -1.295, p = 0.068$ ) (Table 8). Physical activity significantly predicted anxiety, controlling for screen time ( $b = -0.017, p = 0.009$ ) (Table 9). The total effect of screen time on anxiety was significant ( $c = 0.290, p < .001$ ) (Table 6), but the direct effect was reduced when physical activity was included in the model ( $c' = 0.268, p < .001$ ) (Table 9). The indirect effect ( $a*b = 0.022$ ) was tested using the Sobel test and found not to be significant ( $Z = 1.464, p = 0.143$ ) (Table 10). These results suggest that physical activity does not mediate the relationship between screen time and anxiety.

Total Screen Time and Total Physical Activity					
	Unstandardized Coefficient		Standardized Coefficient		
	B	Std. Error	Beta	t	Sig.
(Constant)	93.539	12.398		7.545	<.001
Total Screen Time	-1.295	0.706	-0.122	-1.834	0.068

Table 8. Linear Regression Coefficients for Screen Time and Physical Activity. Linear regression of total screen time and total physical activity.

Total Screen Time, Total Physical Activity, and GAD-7 Score					
	Unstandardized Coefficient		Standardized Coefficient		
	B	Std. Error	Beta	t	Sig.
(Constant)	6.333	1.372		4.614	<.001
Total Physical Activity	-0.017	0.007	-0.168	-2.619	0.009
Total Screen Time	0.268	0.070	0.245	3.813	<.001

Table 9. Linear Regression Coefficients for Screen Time, Physical Activity, and GAD-7 Score. Results of the regression analysis where the mediator and independent variable predict the dependent variable.

Mediated Model Summary			
Effect	B	Std. Error	Sig.
Total Effect ( <i>c</i> )	0.290	0.071	<.001
Direct Effect ( <i>c'</i> )	0.268	0.070	<.001
Indirect Effect ( <i>a*b</i> )	0.022	0.015	0.143

Table 10. Summary of the Mediated Model. Summarizes the direct, indirect, and total effects in one table.

Moderation analysis using linear regression was performed to determine if COVID-19 impact moderated the effect of screen time on GAD-7 score (Table 11). The overall model was significant,  $F(3,221) = 5.886, p < .001$ , explaining 7.4% of the variance in GAD-7 score ( $R^2 = 0.074$ , Adjusted  $R^2 = 0.061$ ). Total screen time significantly predicted GAD-7 score ( $B = 0.346, SE = 0.097, \beta = 0.316, t(221) = 3.578, p < .001$ ). COVID impact did not have a significant independent effect on GAD-7 score ( $B = 1.613, SE = 2.542, \beta = 0.147, t(221) = 0.634, p = .526$ ). In addition, the interaction between COVID impact and total screen time did not show a moderation effect ( $B = -0.114, SE = 0.143, \beta = -0.195, t(221) = -0.798, p = 0.426$ ), meaning the relationship between total screen time and GAD-7 total was consistent across COVID impact group.

Total Screen Time, COVID Impact, and GAD-7 Score					
	Unstandardized Coefficient		Standardized Coefficient		Sig.
	B	Std. Error	Beta	t	
(Constant)	3.912	1.655		2.364	0.019
Total Screen Time	0.346	0.097	0.316	3.578	<.001
COVID Impact Group	1.613	2.542	0.147	0.634	0.526
Total Screen Time COVID Interaction	-0.114	0.143	-0.195	-0.798	0.426

Table 11. Linear Regression Coefficients for Screen Time, COVID Impact, and GAD-7 Score. Results of the regression analysis evaluating the impact of COVID group on screen time's effect on GAD-7 score.

Moderation analysis using linear regression was performed to determine if COVID-19 impact moderated the effect of physical activity on GAD-7 score (Table 12). The overall model was significant,  $F(3,221) = 3.327, p = .021$ , explaining 4.3% of the variance in GAD-7 score ( $R^2 = 0.043$ , Adjusted  $R^2 = 0.030$ ). Total physical activity significantly predicted GAD-7 score ( $B = -0.025, SE = 0.009, \beta = -0.238, t(221) = -2.868, p = .005$ ). COVID impact did not have a significant independent effect on GAD-7 score ( $B = -0.028, SE = 1.455, \beta = -0.003, t(221) = -0.019, p = .985$ ). In addition, the interaction between COVID impact and total physical activity did not show a moderation effect ( $B = 0.008, SE = 0.015, \beta = 0.077, t(221) = 0.515, p = 0.607$ ), meaning the relationship between total physical activity and GAD-7 total was consistent across COVID impact group.

Total Physical Activity, COVID Impact, and GAD-7 Score					
	Unstandardized Coefficient		Standardized Coefficient		Sig.
	B	Std. Error	Beta	t	
(Constant)	11.132	0.675		16.489	<.001
Total Physical Activity	-0.025	0.009	-0.238	-2.868	0.005
COVID Impact Group	-0.028	1.455	-0.003	-0.019	0.985
Total Physical Activity COVID Interaction	0.008	0.015	0.077	0.515	0.607

Table 12. Linear Regression Coefficients for Physical Activity, COVID Impact, and GAD-7 Score. Results of the regression analysis evaluating the impact of COVID group on physical activity's effect on GAD-7 score.

## DISCUSSION

The COVID-19 pandemic presented challenges to university students on many levels. Anxiety and screen time in Honors university students has increased during the pandemic. Increased screen time was found to be associated with increased anxiety, while increased physical activity was found to be associated with decreased anxiety. The pandemic presented an unprecedented opportunity to look at the effect of both physical activity and screen time on anxiety.<sup>16,17,20,22,34,42,43</sup>

The results of this research suggest the prevalence of anxiety symptomology in college students increased during the COVID-19 pandemic, with 80.9% of respondents having clinically elevated levels of anxiety and 20% having “severe” anxiety, according to the GAD-7 clinical assessment of anxiety.<sup>50</sup> In contrast, studies before the pandemic reported a prevalence of anxiety between 30-40% with a prevalence of “severe” anxiety around 15%.<sup>2,3,5,34</sup> In addition, 71.56% of survey respondents reported that the COVID-19 pandemic had led to them experiencing more anxiety than before the pandemic. This statistic was similar to the findings of other studies conducted during this time.<sup>7,10</sup> Notably, the majority of respondents reported that anxiety made everyday tasks difficult or very difficult. This could be due to increased stress during the pandemic, such as worrying about illness, the future, financial stress, or other factors related to COVID-19. An interview study reported that the factors that impacted mental health were concerns regarding health and academic performance, disrupted sleep, financial difficulties, and other similar themes.<sup>7</sup>

Screen time was a primary focus of this study. The results of this study are in line with what is to be expected when colleges shifted to primarily remote learning, corroborating other studies conducted during the COVID-19 pandemic.<sup>22-26,56</sup> The results of the survey indicated that 98.67% of respondents reported that they spent more time on screens for school and/or work and 61.33% of respondents reported that they spent more time on screens for leisure than before the pandemic. These results are in line with other findings during the COVID-19 pandemic, with one study showing that 94.7% of students reported increased screen use, with two-thirds increasing their usage by over 51%.<sup>22</sup> This study also indicated that 28.7% of the respondents believed their increase in emotional issues were due to increased screen time.<sup>22</sup> Self-reported impact of COVID-19 on screen time is also in line with prior findings demonstrating that screen time has increased during the pandemic.<sup>22-26</sup> This study discovered that increases in both mandatory and recreational screen time occurred during the pandemic, a significant additive that impacted the mental health of the cohort. These increases may be due to increased social isolation, increased leisure time, or a desire to increase social connectiveness due to isolation.<sup>57</sup>

Pearson correlation analysis and linear regression both suggest that increased screen time is significantly associated with total GAD-7 score. These results support previous research surrounding anxiety and screen time, with other research suggesting that high screen time is correlated with anxiety.<sup>20,41-45,56</sup> Previous research focused on specific devices, such as television or smart phones, rather than aggregate screen time.<sup>20,42</sup> Furthermore, these findings are in line with current research which has suggested that increases in screen time during COVID-19 have led to more mental health symptomology in college students, including anxiety.<sup>22,23,26</sup> In addition, the results of this study suggest that COVID-19 impact group did not mediate this relationship, meaning that increases in screen time were associated with increased anxiety independent of reported COVID-19 impact. The hypothesis that physical activity mediated the relationship between screen time and anxiety, with increased screen time leading to decreased physical activity, which subsequently contributed to elevated anxiety levels was rejected in this study. Instead, increases in screen time were independently associated with increased GAD-7 score, regardless of physical activity. During a time when mandatory screen time was necessarily increased, studying the association between screen time and anxiety led to results that lend evidence to the current literature.

Most respondents reported engaging in physical activity, these results indicate that the sample studied exercised more than other college student cohorts noted in prior literature who demonstrated a marked decrease in exercise.<sup>36,37,40,58</sup> Both Pearson correlation and linear regression suggested that increased physical activity was associated with decreased GAD-7 score. In addition, exercise status in the past 2 weeks was significantly correlated with total GAD-7 score, with those who had exercise displaying a lower average GAD-7 score. These findings suggest that increased physical activity is associated with decreased anxiety. Prior literature corroborates this finding, demonstrating that increasing exercise can help decrease feelings of anxiety.<sup>28-33,39,43</sup> COVID-19 impact group did not mediate this relationship, meaning that the observed relationship was independent of COVID impact. During COVID-19, other studies demonstrated that decreased exercise and increased sedentary time have led to greater anxiety in college students.<sup>35-38,58</sup> These are important findings to disseminate among colleges and universities to support the development of programs that promote exercise opportunities for students.

The results of the survey question regarding self-reported impact of the COVID-19 pandemic on physical activity supported findings that the aggregate exercise time of students at the University of Vermont Honors College had not significantly decreased during the pandemic, as compared to similar studies conducted elsewhere. This is in contrast to the dramatic decrease in exercise reported from other studies conducted on college students during the pandemic.<sup>36,37,40,58</sup> One hypothesis that could explain the difference in findings is that the University of Vermont has a strong commitment to physical activity and was able to keep the



university's fitness center open during the school year, while other areas may not have had the same access to gyms. Another hypothesis is proximity to the university fitness center, as the students in the survey were part of the Honors College at University of Vermont. The housing provided for honors students is next to the fitness center, making access easier than other parts of the college campus. Finally, the University of Vermont is in a state with great access to outdoor recreation and physical activities, promoting activity and providing an expansive outdoor space to recreate.

Some hypotheses can be used to better understand these results. Emotion regulation, defined as a "process by which individuals regulate their emotions based on the environment," is essential for one's experience of emotion.<sup>18</sup> It has been hypothesized that low levels of emotion regulation can lead to less "flexibility" in regulating one's emotions while utilizing screens, which can increase the experience of negative emotions.<sup>18</sup> As it is influenced by both internal and external factors, it is possible that the COVID-19 pandemic increased negative emotions, which, exacerbated by elevated screen time, increased the prevalence of anxiety symptomology. Emotion regulation and emotional reactivity are also influenced by physical activity. Another study conducted during the pandemic illuminated that physical activity may act as a mediating mechanism between regulation of emotion levels and "emotion reactivity," concluding that physical activity can improve emotion regulation levels.<sup>39</sup>

Another hypothesis that could explain the correlations between screen time, anxiety, and physical activity is sedentary behavior.<sup>16,18,19,56,59,60</sup> It is important to note that physical activity did not mediate the observed relationship between screen time and GAD-7 score in this study. However, a prior study among South Korean college students demonstrated that increased sedentary behavior elevated stress, anxiety, and depression.<sup>59</sup> It is reasonable to assume that the increased screen time observed in this study led to increased sedentary behavior, which in turn increased anxiety. This can also impact time spent socially, yet another factor that influences anxiety.<sup>59</sup> Additionally, time spent alone was found to attenuate the association between screen time and anxiety in a longitudinal study performed in the United Kingdom.<sup>19</sup>

Sleep offers another hypothesis, as inadequate sleep can worsen, or even spark, anxiety.<sup>61</sup> Functional magnetic resonance imaging studies have demonstrated that sleep loss increases electrical activity within the limbic system and salience network (the "fear network"); sleep loss also impairs "medial prefrontal cortex activity and associated connectivity with extended limbic regions."<sup>61</sup> In addition, the adenosinergic system, which underlies sleep-arousal regulation, may be involved in the molecular basis of anxiety.<sup>61</sup> Clearly, sleep, and lack thereof, plays a key role in anxiety; inversely, anxiety can also decrease sleep quality. Sleep disturbance was quite common during the pandemic, with one study reporting that 33% of higher education students experienced poor sleep.<sup>13</sup> Increased screen time could displace time normally spent sleeping, increasing, and even causing, anxiety. One review sums these sentiments: "excessive screen time... may delay bedtime... [and] blue light from digital devices could suppress melatonin and lead to circadian rhythm disorder, which ultimately causes poor sleep outcomes."<sup>56</sup> A study conducted during the COVID-19 pandemic noted that participants with worse sleep quality experienced more anxiety symptomology, and the effect of sleep was more pronounced than screen time and physical activity.<sup>56</sup> Finally, the authors also mention the impact of the pandemic on delayed sleep patterns, as individuals did not need to wake up early to go to work or school. This can increase anxiety through circadian rhythm disruptions.<sup>56</sup>

## CONCLUSIONS

This study did have some limitations. First, the population studied was Honors students at one university, which means the results cannot be applied to all students. No data was collected for non-Honors students, limiting comparisons and preventing analysis of the attenuated effect of Honors status. Future research should be conducted to follow up with students during the COVID-19 pandemic to quantify the long-term effects of the pandemic on both mental and physical health. It will be important to use any future findings to address the mental health impacts on students who were in college during this unique time in history. Second, the measure of physical activity did not line up with other measures in previous research, making comparisons difficult. Future research should work to determine a dose-response relationship between physical activity and anxiety. Another limitation of the study was the use of self-reported measures rather than objective measurement techniques. It is possible that individuals with high screen time were predisposed to high anxiety, or vice versa. It is noted that screens can aid in avoidance-coping in high-stress individuals through distraction and relaxation.<sup>62</sup> Perhaps individuals with high anxiety were using high screen time to cope with mental health symptoms, confounding results. During the pandemic, screens became ubiquitous for social connection. Individuals predisposed to high anxiety may have used screens more to communicate with others to cope with their stress. In addition, because of the lack of quantitative values, a dose-response relationship was not able to be determined for screen time versus anxiety. Therefore, further research attempting to quantify a dose-response relationship should be conducted.

In conclusion, this study provides novel findings regarding the association between screen time and anxiety in Honors university students during a time when screen time was necessarily increased to prevent the spread of COVID-19. The significant increases in screen time observed in this cohort were associated with increases in anxiety. In addition, this study found an association between physical activity and anxiety, a relationship that is important to discuss as screen time increases due to changes in the

world around us. Additional research should be conducted to further support these findings and investigate strategies to support mental health for student populations spending great amounts of time behind a screen.

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#### PRESS SUMMARY

Due to mandates during the COVID-19 pandemic, screen time in Honors college students increased. This presented an opportunity to study the effects of increased screen time on student mental health. The pandemic also impacted the physical activity of students, which is known to impact mental health.