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Original Article

Effects of COVID-19 pandemic and quarantine period on physical activity and dietary habits of college-aged students

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ABSTRACT

The coronavirus disease 2019 (COVID-19) pandemic led to sudden extreme changes in lifestyle, potentially causing adverse changes in physical activity, sedentary behavior, and dietary habits. The objective of the study was to investigate the effects of COVID-19 quarantine on physical activity, dietary habits, and food insecurity among college students who were impacted by the quarantine periods and campus closures. The findings of the study will provide preliminary evidence on dietary, physical activity, and sedentary behavior changes induced by the pandemic among college students.

Participants (n = 403) completed a cross-sectional self-report online questionnaire, evaluating the physical activity, sedentary behavior, and dietary behaviors before- and during-COVID-19 campus closures (March–May 2020). Sociodemographic and descriptive information was also obtained from each participant. Wilcoxon signed-rank test was used to assess changes in physical activity, sedentary behavior, and dietary habits. McNemar's test was used to compare food insecurity changes. Data were presented as median and interquartile range.

A total of 291 participants who met the inclusion criteria were enrolled in the study (college-aged, 18–24 years). Physical activity decreased at vigorous (2 days/week to 1 day/week, $p < 0.001$), moderate (4 days/week to 1 day/week, $p < 0.001$), and light (4 days/week to 2 days/week, $p < 0.001$) intensity levels, while sedentary behavior increased (4 h/day to 7 h/day, $p < 0.001$) from pre-to during-COVID-19 quarantine period. Frequencies of meals at home and alcohol consumption increased ($Z = -3.911$ and $Z = -4.022$, $p < 0.001$), while frequency of fruit consumption decreased ($Z = -2.116$, $p < 0.001$) from pre-to during-COVID-19 quarantine period. Daily alcohol intake also increased during COVID-19 quarantine period ($Z = -4.442$, $p < 0.001$). Lastly, the percentage of individuals reporting food insecurity significantly increased during COVID-19 quarantine ($p < 0.001$).

College-aged students in quarantine significantly decreased physical activity participation and increased sedentary behavior. Changes in dietary habits were observed, including increased meals at home, alcohol consumption, and decreased fruit consumption. Food insecurity also doubled among college-aged students during quarantine. Public health strategies to attenuate these changes in lifestyle habits should be implemented during a global pandemic.

Introduction

The coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 virus), a novel coronavirus discovered in 2019, was declared a global pandemic on March 12, 2020 by the World Health Organization (WHO).[1] In order to attenuate the transmission of the CoV-19/SARS-CoV-2 infection, numerous countries worldwide began to enforce restrictions on outdoor activities, or even widespread quarantine periods, and travel bans. In early-mid March, national, state, and local governments began to intensify their public health responses by augmenting case detections, contact tracing, and quarantine periods.[2] During March 1-May 31, a majority of areas issued mandatory stay-at-home orders, affecting around 3 quarters of the U.S. counties.[3] Following the orders of local and state governments, universities and schools initiated campus-wide shutdowns, and either

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Abbreviation list

COVID-19	Coronavirus Disease 2019
SARS-CoV-2 virus	Severe Acute Respiratory Syndrome Coronavirus 2
WHO	World Health Organization
CDC	Centers for Disease Control and Prevention
NHANES	National Health and Nutrition Examination Survey
USDA	United States Department of Agriculture
NIH	National Institutes of Health
PA	Physical Activity
SB	Sedentary Behavior

canceled classes or moved them to an online format. Most primary schools and universities across the globe began closing in March of 2020, and it is unclear how mandated shutdowns affected physical activity and dietary habits among college students. It is well known that physical inactivity and poor diet are two of the most important risk factors for the development of major diseases (e.g., hypertension, diabetes, obesity, and heart disease) and, in this case, potentially the risk and severity of SAR-CoV-2 infection. The Centers for Disease Control and Prevention (CDC) have reported that a number of chronic diseases, such as those listed above, can increase the risks for severe infection and death, with COVID-19.[4] There is an urgent need to investigate how the quarantine periods impacted college students' lifestyle behaviors to aid public health guidance and future recommendations during a global pandemic.

Several studies have shown quarantine periods disrupt a number of nutritional and physical activity behaviors,[5–13] leading to significant reductions in physical activity and increases in sedentary behavior in various populations.[14–17] The most notable changes have been observed in moderate-to-vigorous physical activity, with significant decreases in these intensity levels among adult populations.[14,15] Observed decreases in moderate-to-vigorous physical activity have raised concerns as the U.S. Department of Health and Human Services and World Health Organization recommend that individuals perform at least 150-min of moderate-intensity or 75-min of vigorous-intensity for health benefits.[18,19] Currently in the U.S., it is estimated that one in two U.S. adults lives with a chronic disease, while only 53% of adults and 30%–50% of 18–24-year adults are meeting the physical activity guidelines.[20,21] The reduction of physical activity and an increase in sedentary behavior, during the COVID-19 pandemic, could have considerable short- and long-term health impacts, as well as affect the risk of severe infection from SARS-CoV-2.[22]

Data on dietary habits during the pandemic and quarantine periods are inconclusive as current literature is conflicting in observed changes in consumption of preferable and non-preferable foods.[5,17,23,24] While a few studies have shown an increase in consumption of preferable foods, such as fruits and vegetables,[5,23] others have reported a decrease in their consumption.[17,24] In addition to other dietary habits, alcohol intake and food insecurity are also crucial factors to pay attention to, during extended quarantine periods, as they present a potential for negative health effects. A majority of studies from non-U.S. populations reported decreases in alcohol consumption,[12,25] yet one study from the U.S. reported an increase in consumption of alcohol among adults in 2020 compared to 2019.[26] There were only two available studies that investigated food insecurity during the COVID-19 pandemic. One study from Northwestern University estimated that food-insecurity numbers more than doubled in the U.S.,[27] while the other reported no changes in food insecurity among their sample of college students.[28] These changes in physical activity, dietary intake, and food insecurity may be most notably attributed to daily travel/commute cessation, boredom during stay-at-home orders,[29] increases in psychological stress,[6] job status,[5,30] access to food, and loss of access to public facilities such as gyms and parks.[30]

To date, few studies have investigated the changes in physical activity and dietary behaviors in the college-aged population. In addition, of the studies assessing dietary changes during COVID-19 quarantine, only one has measured fruit and vegetable consumption, alcohol consumption, and food insecurity.[31] This study aims to investigate the effects of COVID-19 quarantine on the frequency of physical activity, frequency of dietary habits and food consumptions (i.e., meals-at-home, meals-out-of-home, intake of fruits, vegetables, and alcohol), and food insecurity among college-aged individuals. With the abrupt and potentially significant changes in lifestyle, it is important to explore how college students were impacted by the quarantine, as physical activity, sedentary, and dietary habits made during this life stage could influence their future habits and health throughout adulthood.[32–35] The findings of the study will also provide preliminary evidence on dietary and physical activity changes caused by the stay-at-home orders and subsequent quarantine period in response to the global pandemic, among college-aged students, and aid in future studies as well as the development of public health strategies to attenuate these negative impacts during a pandemic.

Materials and methods

Participants

The study was conducted at a public university in the Southwestern United States where, among all undergraduate students, only 8% of current students live in college-owned, operated, or affiliated housing, and 92% of students live in off-campus housing. First-year students are not required to live in a dorm or on-campus housing at the university. Participants were recruited from the general college-aged population living in the United States during the COVID-19 pandemic and subject to campus-wide university closure. A variety of recruiting strategies were used, such as announcements from professors, announcements to university-based student organizations, social media (e.g., Facebook, Twitter, Instagram, etc.), and word-of-mouth among students. Participants were given a link that directed them to a data-secure website where an informational consent, not requiring a signature, describing the study aims, procedures, risks, benefits, and contact information of the principal investigator of the study, the faculty advisor, and the Institutional Review Board (IRB) was displayed. The current study received approval through the Institutional Review Board on October 26th, 2020, as the current study procedures presented no more than minimal risk. Participants were automatically entered into a random drawing, via Qualtrics online survey platform, for two gift cards.

The inclusion criteria for completion of the questionnaire were college-aged students (18–24 years old), currently enrolled in classes (undergraduates and graduates), and perceived a change in their physical activity and/or dietary habits during the quarantine period/campus-wide closure. The age range criterion was set at 18–24 years as this is the traditionally recognized age range for college-aged students at a majority of four-year public and private institutions.[36]

Questionnaire

Participants were provided a link to the online survey questionnaire which was completed through the Qualtrics online survey platform (www.qualtrics.com). The questionnaire took approximately 5–8 min to complete and was provided in English. To reach the greatest number of potential participants, the questionnaire could be completed either on their mobile phone, tablet, or desktop device. No identifiable information was recorded, and all questionnaire responses were anonymous.

The structured content of the research questionnaire contained 3 main sections with a total of 21 items, which presented questions to the participants in the following order: sociodemographic and descriptive information, physical activity habits, and dietary habits. Participants were first asked if their physical activity or eating habits changed during

the COVID-19 pandemic and only proceeded if their response was "yes". All questions were closed-ended (requiring yes or no answers, Likert scale, or single-response multiple choice). Questions were designed to compare the physical activity and dietary habits of individuals before and after the date of campus-wide university closures (March 15th), due to local ordinances, with answer choices for each time point. The online questionnaire was available for students to respond to from November 4th, 2020 to November 23rd, 2020.

Sociodemographic information

Participants were asked to complete a sociodemographic and descriptive information section containing 9 items (e.g., age, sex, height, weight, academic classification, area of study).

Physical activity/exercise habit changes

The participants were presented with a physical activity/exercise habits section containing 5 items (i.e., gym access, frequency of involvement in vigorous, moderate, and light exercise in a week, and time of sedentary behavior in a day), designed to assess the individual's general physical activity and sedentary behaviors. Vigorous physical activity was described as activity that greatly increases your heart rate and breathing (e.g., jogging or running, walking/hiking uphill, cycling $\geq$10 mph, aerobic dancing, HIIT, boxing, most competitive sports, swimming laps, rowing, etc.). Moderate physical activity was defined as activity that increases your heart rate and breathing moderately (e.g., weightlifting, brisk walking, light hiking, leisure roller skating, light at-home exercise, light-pace stair climber, golf, baseball/softball, leisure swimming, etc.). Light physical activity was described as activity that slightly elevates your heart rate and/or breathing (e.g., stretching, general home activities, sexual activities, slow walking, fishing, slow dancing, etc.). Lastly, sedentary behavior was defined as times being physically inactive (e.g., watching T.V., phone use for entertainment, playing video games, sitting on the couch, reading, lying in bed, etc.).

Dietary habit changes

The dietary habits section contained 7 items (i.e., food insecurity, frequency of meals outside of the home, frequency of meals inside the home, consumption of fruits, vegetables, and alcoholic beverages) and was designed to assess general dietary habits and food insecurity. Student dietary habit and food-security measures were adapted from the National Health and Nutrition Examination Survey (NHANES) Dietary Screener Questionnaire[37] and the United States Department of Agriculture (USDA) U.S. Household Food Security Survey, respectively.[38]

To calculate the estimated average fruit and vegetable servings per day (pre- and during-COVID-19 quarantine), responses for frequency of consumption (i.e., < once per week, 1 to 3 times per week, 4 to 6 times per week, once to twice per day, 3 to 4 times per day, and >4 times per day) were first converted to daily frequencies. Daily frequencies were multiplied by standard daily servings (cup-equivalents) established for males and females aged 18–25 years, to determine estimated daily servings of fruits and vegetables for participants. Conversion values are according to values provided by the NHANES dietary screener via the National Institutes of Health (NIH).[39,40]

Data analysis

Nonparametric statistical tests were used to assess changes in physical activity, sedentary behavior, and dietary habits from pre-to during-COVID-19 quarantine period, as the data were not normally distributed. Descriptive statistics were reported as median and interquartile range for physical activity, sedentary, and dietary behaviors. To compare physical activity and sedentary behavior, and dietary intake between pre- and during-COVID-19 quarantine, Wilcoxon signed-rank tests were used. When investigating sociodemographic differences (i.e., sex, employment status, gym access, and area of study) in physical activity, sedentary behavior, and dietary intake pre-vs. during-COVID-19 quarantine, Kruskal-Wallis tests were used. McNemar test was used to compare frequencies for dichotomous (repeated measures) data (i.e., Food security—yes or no; pre-vs. during-COVID-19 quarantine). Effect sizes were determined as small (0.1–0.29), medium (0.3–0.49), and large ($\geq$0.5). The p-value was set at $p < 0.05$ for statistical significance.

Results

Sociodemographic of participants

On the November 23, 2020, the online questionnaire was concluded, and the collected data was analyzed. A total of 403 U.S. college-aged participants responded to the online questionnaire, and 27.8% ($n = 112$) of participants did not meet the inclusion criteria as they were not current college-aged students (i.e., <18 years or > 24 years). A total of $n = 291$ met the inclusion criteria and had an average age of 21.2 ($\pm$1.56) years old. Additionally, among included responders, 69.8% are female ($n = 203$) and 30.2% are male ($n = 88$). The participants' characteristics are presented in Table 1.

Table 1
Sociodemographic information.

	n	*Mean/SD*	sample %
	291		
Age (years)		21.2 ±1.56	
18	12		4.1
19	27		9.3
20	62		21.3
21	81		27.8
22	44		15.1
23	40		13.7
24	25		8.6
Sex			
Male	88		30.2
Female	203		69.8
Classification			
Freshman	14		4.8
Sophomore	39		13.4
Junior	82		28.2
Senior	119		40.9
Graduate student	37		12.7
Area of Study			
Architecture, Construction, and Planning	15		5.2
Business	45		15.5
Liberal & Fine Arts	34		11.7
Education & Human Development	30		10.3
Engineering	12		4.1
Health, Community, & Policy	101		34.7
Sciences	50		17.2
University College	4		1.4
Living Location			
On-campus	27		9.3
Off-campus	130		44.7
Off-campus with family	134		46.0
Employment status			
Unemployed	130		44.7
Employed	110		37.8
Employed (working from home)	51		17.5
Previous Activity Level			
Sedentary	72		27.7
Lightly Active	83		31.9
Moderately Active	63		24.2
Highly Active	42		16.2

Changes in physical activity and sedentary behavior

A total of 260 participants (89%), out of all participants ($n = 291$), reported changes in their physical activity and sedentary behavior during COVID-19 quarantine. A Wilcoxon signed-rank test indicated significant reductions in all intensities of physical activity and a significant increase in sedentary behavior (Table 2). No significant differences were found between/among groups based on sociodemographic factors for all physical activity intensity levels or sedentary behavior. The amount (days/week) of physical activity significantly reduced for vigorous- (2 day/week to 1 day/week, $p < 0.001$), moderate- (4 days/week to 1 day/week, $p < 0.001$), and light-intensity (4 days/week to 2 days/week, $p < 0.001$) levels pre-vs. during-COVID-19 quarantine period (Table 2). Effect sizes of these changes were large for moderate and light intensities, $r = 0.59$ and $r = 0.55$, and medium for vigorous intensity, $r = 0.49$. Additionally, the amount (hours/day) of sedentary behavior was increased from 4 h/day pre-COVID-19 to 7 h/day during the COVID-19 quarantine period, $p < 0.001$, with a large effect size of $r = 0.70$ (Table 2).

Changes in dietary behavior

A total of 232 participants (80%), out of all participants ($n = 291$), reported changes in their dietary behavior during COVID-19 quarantine. The median values reported in Table 3 are values assigned for different ordinal categories and are as follows, for meals in/out of the home and alcohol consumption, 1 = < once/week; 2 = 1 to 3 times/week; 3 = 4 to 6 times/week; 4 = once to twice/day; 5 = ≥ 3 times/day, and for fruit and vegetable consumption, 1 = < once/week; 2 = 1 to 3 times/week; 3 = 4 to 6 times/week; 4 = once to twice/day; 5 = 3 to 4 times/day; 6 = > 4 times/day. A significant increase in frequency of meals eaten at home was observed from pre- (*Mdn* = 3, 4 to 6 times/week) to during- (*Mdn* = 3, 4 to 6 times/week) COVID-19 quarantine period, $Z = -3.911$, $p < 0.001$, with a small effect size ($r = 0.18$). No significant change was revealed for weekly number of meals eaten outside of the home. Regarding frequency of alcohol consumption, a significant increase was found from pre- (*Mdn* = 1, < once/week) to during- (*Mdn* = 1, < once/week) COVID-19 quarantine period, $Z = -4.022$, $p < 0.001$, with a small effect size ($r = 0.26$). Frequency of fruit consumption showed significant reduction from pre- (*Mdn* = 2, 1 to 3 times/week) to during- (*Mdn* = 2, 1 to 3 times/week) COVID-19 quarantine period, $Z = -2.116$, $p = 0.034$, with a small effect size $r = 0.14$. There was no significant change found for weekly vegetable consumption (Table 3). The daily servings intake for alcohol (drinks/day), fruits and vegetables (cup-equivalents/day), after converted from weekly frequencies, are reported in Table 4. Daily alcohol intake also increased from pre- (*Mdn* = 0.058 drinks/day) to during- (*Mdn* = 0.058 drinks/day) COVID-19 quarantine period, $Z = -4.442$, $p < 0.001$, with a small effect size $r = 0.29$. No significant changes were found for daily servings of fruits and vegetables. Lastly, no significant changes were found between/among groups based on sociodemographic factors for all dietary behaviors.

Changes in food security

To evaluate the changes in food security from pre-to during-COVID-19 quarantine period, frequencies were calculated for each time period (Table 5). Individuals who indicated not being able to afford healthy food or balanced meals significantly increased by 54%, $p < 0.001$. Additionally, those who reported skipping meals or eating less than they felt they should because of lacking money or food increased by 68%, $p < 0.001$. The results indicated that the number of college students experiencing being unable to afford healthy or balanced meals and/or skipping meals has doubled during COVID-19 quarantine.

Discussion

The outbreak of SARS-CoV-2 led to the COVID-19 global pandemic in early March of 2020.[1] Extreme sudden changes to the way of life significantly impacted the lifestyle behaviors of all individuals worldwide. Many recent studies have begun to investigate the potential effects of the pandemic and quarantine periods on physical activity and dietary behaviors in different populations around the world.[5,7,12,15,17] This preliminary study is one of the first studies to investigate the impact of the effects of COVID-19 quarantine and campus closures on physical activity, sedentary behavior, and dietary habits among college students. It is important to understand the severity of these impacts across different populations to help better understand how to combat the potential unfavorable changes.[41] The current study presents preliminary data from an

Table 2
Frequency of Self-reported Physical Activity and Sedentary Behavior Pre-vs During-COVID-19.

Physical Activity	Medians (*IQ*)		Ranks[a]	*n*	Mean Rank	Sum of Ranks	*Z*[b]	*p*-value	Effect Size[c]
	Pre-COVID-19	During-COVID-19							
Vigorous (days/week)	2 (1–4)	1 (0–2)	(−) Ranks	169	105.91	17899.5	−7.973	**< 0.001**	**0.49**
			(+) Ranks	40	101.14	4045.5			
			Ties	51					
			Total	260					
Moderate (days/week)	4 (2–5)	1 (1–3)	(−) Ranks	194	120.99	23471.5	−9.444	**< 0.001**	**0.59**
			(+) Ranks	40	100.59	4023.50			
			Ties	26					
			Total	260					
Light (days/week)	4 (3–5)	2 (1–4)	(−) Ranks	177	120.59	21344.5	−8.896	**< 0.001**	**0.55**
			(+) Ranks	48	85.01	4080.5			
			Ties	35					
			Total	260					
Sedentary Behavior (hours/day)	4 (2–5)	7 (5–9)	(−) Ranks	25	77.24	1931.0	11.248	**< 0.001**	**0.70**
			(+) Ranks	204	119.63	24404.0			
			Ties	31					
			Total	260					

Wilcoxon signed-rank test was used to compare changes in physical activity & sedentary behavior pre- and during-COVID-19 quarantine. Data were presented as median and interquartile range. Statistical significance was accepted when $p < 0.05$.

[a] Ranks: (−) rank = frequency during quarantine < frequency pre quarantine; (+) rank = frequency during quarantine > frequency pre quarantine.

[b] Z = the Wilcoxon signed-rank test statistic value based on the sum of ranks comparison.

[c] Effect size criteria: 0.1 = small, 0.3 = medium, 0.5 = large.

Table 3
Self-Reported Frequencies of Dietary Behavior Pre-vs During-COVID-19.

Dietary Behavior	Medians (*IQ*)[a]		Ranks[b]	*n*	Mean Rank	Sum of Ranks	*Z*[c]	*p*-value	Effect Size[d]
	Pre-COVID-19	During-COVID-19							
Meals at home	3 (2–4)	3 (2–4)	(−) Ranks	52	62.85	3268.0	−3.911	**< 0.001**	**0.26**
			(+) Ranks	91	77.23	7028.0			
			Ties	89					
			Total	232					
Meals outside of the home	2 (1–2)	2 (1–2)	(−) Ranks	80	81.49	6519.0	−0.146	0.884	0.01
			(+) Ranks	82	81.59	6684.0			
			Ties	70					
			Total	232					
Average Alcohol Consumption	1 (1–2)	1 (1–2)	(−) Ranks	31	54.68	1695.0	−4.022	**< 0.001**	**0.26**
			(+) Ranks	77	54.43	4191.0			
			Ties	124					
			Total	232					
Average Fruit Consumption	2 (2–3)	2 (2–3)	(−) Ranks	65	54.39	3535.5	−2.116	**0.034**	**0.14**
			(+) Ranks	42	53.39	2242.5			
			Ties	125					
			Total	232					
Average Vegetable Consumption	3 (2–4)	3 (2–4)	(−) Ranks	63	56.80	3578.5	−0.024	0.981	0.002
			(+) Ranks	56	63.60	3561.5			
			Ties	113					
			Total	232					

Wilcoxon signed-rank test was used to compare changes in dietary habits pre- and during-COVID-19 quarantine. Data were presented as median and interquartile range. Statistical significance was accepted when $p < 0.05$.

[a] Meals in/out of home & Alcohol consumption: 1 = < once/week; 2 = 1 to 3 times/week; 3 = 4 to 6 times/week; 4 = once to twice/day; 5 = ≥ 3 times/day; Fruit/Vegetable consumption: 1 = < once/week; 2 = 1 to 3 times/week; 3 = 4 to 6 times/week; 4 = once to twice/day; 5 = 3 to 4 times/day; 6 = > 4 times/day.

[b] Ranks: (−) rank = frequency during quarantine < frequency pre quarantine; (+) rank = frequency during quarantine > frequency pre quarantine.

[c] *Z* = the Wilcoxon signed-rank test statistic value based on the sum of ranks comparison.

[d] Effect size criteria: 0.1 = small, 0.3 = medium, 0.5 = large.

Table 4
Self-Reported Daily Frequency of Dietary Servings Pre-vs During-COVID-19.

Dietary Behavior	Medians (*IQ*)		Ranks[a]	*n*	Mean Rank	Sum of Ranks	*Z*[b]	*p*-value	Effect Size[c]
	Pre-COVID-19	During-COVID-19							
Average Alcohol Intake (drinks/day)	0.058 (0.058–0.286)	0.058 (0.058–0.286)	(−) Ranks	31	48.81	1513.0	−4.442	**< 0.001**	**0.29**
			(+) Ranks	77	56.79	4373.0			
			Ties	124					
			Total	232					
Average Fruit Intake (servings/day)	0.283 (0.217–0.707)	0.217 (0.057–0.707)	(−) Ranks	65	50.42	3277.5	−1.21	0.226	0.08
			(+) Ranks	42	59.54	2500.5			
			Ties	125					
			Total	232					
Average Vegetable Intake (servings/day)	0.352 (0.141–0.739)	0.352 (0.141–0.739)	(−) Ranks	63	54.14	3411.0	−0.422	0.673	0.03
			(+) Ranks	56	66.59	3729.0			
			Ties	113					
			Total	232					

Wilcoxon signed-rank test was used to compare changes in daily consumption of alcohol, fruits, and vegetables pre- and during-COVID-19 quarantine. Data were converted from weekly frequencies of food consumptions, according to NHANES dietary screener, and presented as median and interquartile range. Statistical significance was accepted when $p < 0.05$.

[a] Ranks: (−) rank = daily servings during quarantine < daily servings pre-quarantine; (+) rank = daily servings during quarantine > daily servings pre-quarantine.

[b] *Z* = the Wilcoxon signed-rank test statistic value based on the sum of ranks comparison.

[c] Effect size criteria: 0.1 = small, 0.3 = medium, 0.5 = large.

online questionnaire examining the changes of lifestyle habits of 291 college-aged (18–24 years) students before and during-COVID-19 quarantine periods.

Our study represents and reflects general college students' physical activity levels because the baseline of time spent engaging in moderate (4 days/week) and vigorous (2 days/week) physical activity of our sample is similar to other studies among college populations.[42] Barry et al. reported from a sample of 26,062 U.S. college students, the average days of moderate and vigorous physical activity per week were 3.42 and 2.66 days, respectively.[42] Approximately 89% of our sample (n = 260) reported changes in their physical activity and sedentary behavior. These findings are consistent with recent studies highlighting a large number of individuals (>50%) who reported changes in their physical activity and an increase in their sedentary behavior.[12,17,24] The reductions in average days per week engaging in all intensity levels of physical activity are similar to those findings reported from other countries, showing an average reduction of 30%–60%.[14,15,24,31] Potentially the most important, among limited studies investigating the impact of COVID-19 quarantine

Table 5
Food security statistics.

	n		Sample %		
	Pre COVID-19	During COVID-19	Pre COVID-19	During COVID-19	*p*-value
Unable to afford healthy food or balanced meals	26	57	8.9%	19.6%	< 0.001
Skipped meals or ate less because of not enough money or food	14	44	6.0%	19.0%	< 0.001

McNemar's test was used to compare the frequency of reported food insecurity pre- and during-COVID-19 quarantine. Data were presented as numbers of responders and percentages reporting changes in dietary habits ($n = 232$). Statistical significance was accepted when $p < 0.05$.

period on college students, our findings show consistency with their reported reductions of moderate-to-vigorous physical activity per week.[28,31] Reductions in moderate-to-vigorous physical activity have the most potential to limit the benefits of physical activity as optimal health benefits are achieved by engaging in these specific intensities for a minimum amount of time per week.[18,19]

The baseline average amount of time spent per day on sedentary behavior (4 h/day) of our sample corresponds to previous findings that showed an average of ≥ 4-h per day of sedentary behavior among college students.[43–45] In our current study, a large effect size ($r = 0.70$) was found for sedentary behavior with an average increase of 3 h/day for sedentary time, which is the same change as a recent study shown among Canadian college students.[31] These findings are also in agreement with other recent studies as all have shown relatively large increases in sedentary behavior, across all populations, during quarantine periods.[7,16,17,25,30,46] The observed increases in sedentary behaviors are concerning due to the negative effects on health from sedentary behavior, regardless of physical activity levels.[47,48] College students are known to engage in large amounts of these activities, regardless of the pandemic,[44,45,49] so it appears the quarantine has exacerbated these unfavorable habits. The findings of the current study, in conjunction with others, highlight the urgent need for public health strategies to help attenuate the negative impacts of quarantine periods on physical activity and sedentary behaviors.

In addition to physical activity and sedentary behavior, changes in dietary behavior have been of large concern during the COVID-19 quarantine periods.[10,11] Maintaining healthy nutritional intake during quarantine is crucial for necessary immune health during a global pandemic.[50] To the best of the investigator's knowledge, this is one of the first studies to investigate dietary behaviors among U.S. college students during COVID-19 quarantine. Preliminary findings of recent studies among all populations have indicated that dietary habits have demonstrated significant changes during quarantine periods around the world.[5,10,51]

Of all participants, approximately 80% ($n = 232$) have reported changes in their dietary habits during COVID-19 quarantine. In accordance with other recent studies showing an increase in the frequency of meals cooked and prepared at home,[5,10,17,52] a significant number of individuals in our study increased their average weekly number of meals being cooked and prepared at home. However, in contrast to previous studies, our participants showed no significant change in their frequency of meals from outside of the home. In regards to average weekly alcohol consumption, while a majority of studies from outside the U.S. have indicated a decrease in alcohol consumption,[12,23,25] the current study has shown that college-aged students increased their alcohol intake during COVID-19 quarantine. Notably, these findings are consistent with a most recent U.S. study showing an increase in alcohol consumption among U.S. adults.[26] Additionally, while the World Health Organization has recommended that fruits and vegetables are the best food items to consume during quarantine and extended homestays, recent studies investigated during COVID-19 quarantine showed conflicting results.[5,17,23,24] The results from the current study found most college students are not meeting the recommended dietary intake for fruits and vegetables.

Lastly, current food insecurity rates among college students, before COVID-19 quarantine, was estimated to be between approximately 33% and 43.5%.[53,54] It has been logically assumed that this number would rise during COVID-19 quarantine due to the financial stress it has placed on individuals and their families. The findings from our study support this notion, as the number of individuals unable to afford healthy meals and/or skipping meals or eating less than they felt they should due to lacking money or food more than doubled from pre-to during-COVID-19 quarantine. Approximately 9% of students in this study reported not being able to afford preferable food or meals before COVID-19 and increased to 19.6% during-COVID-19 quarantine. Our findings contradict a study among U.S. college students, during COVID-19 quarantine, that reported no significant changes in food insecurity.[28] It is possible that the increase in food insecurity is due to college students losing their jobs and/or having to move back in with family members that have lost their jobs. Also, the socioeconomic status of the responders and local city are important factors determining food insecurity during the quarantine period. In fact, previous literature has revealed that with an increasing demand for food during this challenging time, families may have difficulties providing enough food for the entire family.[55]

The present study shows innovative findings on physical activity, sedentary, and dietary behavior changes in college-aged students, however, it does possess some limitations. Although our study enrolled college-aged students with diverse backgrounds, this population only represented a small sample of individuals attending a university. In addition, physical activity levels, sedentary behavior, and dietary behaviors were assessed using self-reported questionnaires which may result in under- or over-estimated values from responders.[56]

Conclusion

This study presented preliminary evidence of the impacts of the university-wide campus closures due to the COVID-19 pandemic on physical activity, sedentary behavior, and dietary habits among college-aged students. Participation time in all intensity levels of physical activity decreased while sedentary behavior increased during the COVID-19 quarantine period. In addition, dietary habits among college-aged students also changed during quarantine, including increased meals at home, alcohol consumption, and decreased fruit consumption. Lastly, food insecurity also doubled during COVID-19 quarantine after campus closure. With the observed impacts of COVID-19 quarantine on college-aged students, future studies investigating changes in lifestyle and public health strategies improving college students' health and wellness should be implemented to address these adverse changes.

Submission statement

This article has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), is not under consideration for publication elsewhere, has been approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and, if accepted, it will not be published elsewhere, including electronically in the same form, in English, or any other language, without the written consent of the copyright holder.

Authors' contributions

CS conducted the study, formulated the design and methodology, and performed the data analysis. CS wrote the manuscript with critical review

and editing from TZ, SU, and KC. SU contributed to the data analysis, formulation of the structure, and methodology. TZ supervised the project while providing important input, review, and editing for each section. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

Ethical approval statement

Approval was obtained from the University of Texas at San Antonio Institutional Review Board (IRB number 21-021E), on October 26th, 2020, as the current study procedures presented no more than minimal risk. Participants were given a link that directed them to a data-secure website where an Institutional Review Board approved informational consent, not requiring a signature, describing the study aims, procedures, risks, benefits, and contact information of the principal investigator of the study, the faculty advisor, and the Institutional Review Board (IRB) was provided to each participant. Participants were automatically entered into a random drawing, via Qualtrics online survey platform, for two gift cards.

Conflict of interest

The authors declare that they have no competing interests.

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