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The impact of COVID-19 on cardiovascular health behaviors in student veterans

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Abstract *Background and aims:* Pandemics have previously resulted in increased cardiovascular morbidity and mortality. It is unclear if the effects of the COVID-19 pandemic will be amplified in individuals at high risk for cardiovascular disease, such as military populations, resulting in augmented cardiovascular events in Veterans. The purpose of this study was to determine if traditional behavioral risk factors for cardiovascular disease are amplified due to the COVID-19 pandemic and if risk factors are more prevalent in Veterans compared to non-Veterans.
Methods and results: Thirty-two student Veterans and 46 non-Veteran students between the ages of 18 and 35 completed a Qualtrics self-report questionnaire assessing health behaviors, physical activity, and mental health both before and during COVID-19. Veterans displayed worse pre-COVID cardiovascular health behaviors such as poor sleep habits, greater use of tobacco, alcohol, and energy drinks, and lower values of social engagement compared to non-Veterans. Many health behaviors remained unchanged in student Veterans during the pandemic. The non-Veteran group exhibited augmentation of cardiovascular health behaviors during COVID-19, shown through the worsening sleep habits, increased anxiety, and reduced physical activity.
Conclusion: Student Veterans demonstrate heightened risk for cardiovascular disease based on the pre-COVID elevation of behavioral risk factors. These behavioral factors continued to remain elevated during the COVID-19 pandemic. Non-Veteran students displayed amplification of behavioral risk factors for cardiovascular disease due to the COVID-19 pandemic. These results highlight the need for resources and interventions for our student veterans and suggest long-term cardiovascular consequences for all students who suffered through the COVID-19 pandemic.
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1. Introduction

Previous pandemics, such as the Spagnola pandemic in 1918, have been followed by an increase in cardiovascular events and deaths from coronary heart disease [1–4]. This may be due to the development and amplification of cardiovascular disease (CVD) risk factors during the pandemic. The COVID-19 pandemic has altered lifestyles and habits, leading to decreased physical activity, poor diet, and increased depression, loneliness, and stress [5–8], which are established risk factors for CVD [9–11]. Not surprisingly, countries significantly affected by COVID-19 are already displaying increased cardiovascular mortality [12].

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The burden of COVID-19 may be augmented in those who suffer a heightened risk of CVD, such as the military population. It is well established that Veterans display inferior cardiovascular health and a higher prevalence of CVD risk factors such as hypertension, sleep disorders, binge drinking, and mental health issues that far outweigh the prevalence in the civilian population [13,14]. Currently, the majority of Veteran-based cardiovascular studies are completed by The Department of Veterans Affairs and focus on older individuals and those with severe post-traumatic stress disorder. It is possible that even young Veterans will display heightened risk factors for CVD prior to the negative cardiovascular effects of aging [13]. Understanding onset of CVD risk may assist in the development of preventative measures in this vulnerable population, however, young Veterans remain unstudied. Further, response to a stressor, such as a global pandemic, may provide insight into future CVD risk [10].

This study assessed health habits linked with CVD in student Veterans and their non-Veteran student counterparts before and during COVID-19, including sleeping habits, social engagement, physical activity, and use of alcohol, energy drinks, and tobacco [15–20]. The purpose of this study was to determine if individuals with increased risk of CVD, such as Veterans, were more affected by the COVID-19 pandemic compared to the civilian population. Our hypothesis was that young Veterans would be more affected by the COVID-19 pandemic, shown through decreased physical activity, poorer mental health, and inadequate sleep and nutritional habits, more so than the non-Veteran population.

2. Methods

Data were obtained via Qualtrics (Provo, Utah) self-report questionnaire and responses were collected between February and March 2021. This study was determined to be exempt by the Appalachian State University Institutional Review Board. All participants provided electronic informed consent and data was collected anonymously without recording IP addresses.

2.1. Study population

Participants were recruited amongst the student population of Appalachian State University and qualified for the study if between the ages of 18 and 35, a current university student, and either had never served time in the military (non-Veteran) or had prior active duty service for a minimum of 3 years (student Veteran). Exclusion criteria included a history of cardiovascular, pulmonary, metabolic, or renal disease.

2.2. Self-report questionnaire

Participants self-reported demographics such as age, height, and weight. Race and ethnicity were reported using US Census questions, with multiple responses allowed.

Primary outcome measures were assessed utilizing a Likert scale. Participants were asked to reflect upon health and habit status prior to March 2020, considered the “Pre-COVID” timepoint, and their current health and habit status (February/March 2021), considered the “Post-COVID” timepoint. Health habits, such as obtaining 6–8 h of sleep, trouble sleeping, and use of alcohol, energy drinks, and tobacco were scored from 1 (never) to 5 (always). Social engagement was assessed utilizing questions regarding campus involvement and close friends. Responses were scored from 1 (disagree) to 5 (agree). Participants were asked to self-report their physical activity level from 1 (rarely or never perform physical activity) to 5 (vigorous physical activity weekly) and respond “Yes” or “No” if they engaged in resistance training and aerobic training. Anxiety symptoms were assessed using a Generalized Anxiety Disorder Questionnaire (GAD-7). The GAD-7 is a validated survey [21] which utilizes 7 questions to measure anxiety; for example, how often students were bothered by feelings of anxiety, worry, or annoyance. Answers are self-rated ranging from “Not at all” to “Most days.”

2.3. Statistical analysis

Descriptive characteristics were compared between groups using an independent *t*-test. A repeated measures ANOVA was conducted to determine the main effects of COVID (time) and Veteran status (group), and interaction (time x group). Any significant findings were followed up with two-tailed independent and dependent *t* tests. Because of sex difference in alcohol consumption guidelines, a post-hoc ANCOVA was performed controlling for sex in reported alcohol use. The relationship between anxiety severity and veteran status was assessed utilizing chi-squared test. Statistical significance was set a priori at $p < 0.05$. All data are reported as mean ± standard deviation. Data were analyzed using SPSS version 26 (IBM Corp, Armonk, NY, USA).

3. Results

Seventy-eight volunteers qualified for and completed the Qualtrics survey. Participant characteristics are described in Table 1. The student Veterans ($n = 32$) were comprised of 27 male and 5 females while the non-Veteran students ($n = 46$) consisted of 21 male and 25 female participants. The Veteran group performed an average of 5 years of active service and was significantly older, taller, and heavier than the non-Veteran group.

The health habits of Veteran and non-Veteran students are reported in Table 2. At pre-COVID the Veteran group reported more trouble sleeping and fewer hours of sleep compared to the non-Veteran group. The Veteran group saw no changes in their sleep habits due to COVID and continued to have worse sleep habits when compared to the non-Veteran group. The non-Veteran group displayed an increase in trouble sleeping and a decrease in hours of sleep during the pandemic. The Veteran group displayed higher alcohol use both pre- and post-COVID compared to

Table 1 Participant characteristics.

	Veterans(n = 32)	Non-Veterans(n = 46)	p-value
Male (%)	84	46	
Age (years)*	27 ± 3	21 ± 2	0.001
Height (cm)*	178.8 ± 7.7	171.6 ± 11.0	<0.001
Weight (kg)*	93.1 ± 19.5	72.4 ± 14.3	<0.001
BMI (kg/m^2)*	29.0 ± 5.1	24.5 ± 4.1	<0.001
White (%)	91	89	
Hispanic or Latino (%)	9	4	
Black or African American (%)	3	4	
Asian/Pacific Islander (%)	3	3	
Multiple races (%)	3	4	

*p < 0.05, significant differences between student Veterans and Non-Veterans. BMI, Body Mass Index.

non-Veterans (Cohen's d = 0.92). Neither group had changes in alcohol use during COVID. Because the non-Veteran group had more female respondents, we performed a post-hoc analysis and found that Veterans continued to have significantly higher alcohol use, both pre- and post-COVID, compared to non-Veterans even after controlling for sex. Finally, veterans reported more energy drink usage both pre- and post-COVID, and more tobacco use pre-COVID when compared to the non-Veteran group. The Veteran group showed a significant decrease in both energy drink and tobacco use during COVID while the non-Veteran group displayed no change.

Social engagement parameters are displayed in Table 3. There were no group differences in campus involvement or school stress pre- or post-COVID and both groups decreased campus involvement and increased school stress during the pandemic. The Veteran group displayed less school excitement pre-COVID and both groups decreased school excitement during COVID. The Veteran group reported having a less enjoyable major both before and during COVID and neither group demonstrated changes in their major's enjoyability during COVID. Veterans reported fewer close friends pre-COVID when compared to the Non-Veterans and both groups reported a decrease in close friends during COVID.

Participants were asked about their general physical activity level prior to and during COVID Both groups self-reported engaging in moderate physical activity weekly prior to COVID, and the non-Veteran group reduced their physical activity level to "light" during COVID (p = 0.007) while Veterans maintained their level of weekly physical activity (p = 0.195), resulting in group differences during COVID (p = 0.01). Further, participants were asked if they performed resistance and/or aerobic training prior to and during COVID. The Veteran and non-Veteran group reported similar engagement in resistance training pre-COVID (81% versus 63%, respectively), however, the non-Veteran group reported a significant decrease (p < 0.001) in resistance training during COVID with only 30% engaging in resistance training, while Veterans maintained training (72%), resulting in group differences post-COVID (p < 0.001). Both the Veteran and non-Veteran groups reported similar prevalence of aerobic training prior to COVID (78% versus 73%), and both decreased aerobic training during COVID (53% for both groups).

There were no group differences pre- or post-COVID for overall generalized anxiety scores (p = 0.09; data not shown), however the non-Veteran group experienced a significant increase in anxiety levels from pre- to post-COVID (p = 0.02) while Veterans had no change

Table 2 Health habits.

	Veterans		Non-Veterans		Time	Interaction	Group
	Pre-COVID	*Post-COVID*	*Pre-COVID*	*Post-COVID*	*p-value*		
6–8 Hours of Sleep	3.1 ± 1.0*	3.0 ± 1.0*	3.9 ± 0.7	3.6 ± 1.0#	**0.021**	0.184	**0.001**
Trouble Sleeping	3.7 ± 0.9*	3.7 ± 0.8*	2.6. ± 0.9	3.2 ± 1.0#	**0.004**	**0.009**	**0.001**
Alcohol Use (>3 per sitting)	3.5 ± 1.0*	3.2 ± 1.1*	2.4 ± 1.2	2.4 ± 1.2	0.390	0.288	**0.001**
Energy Drink Use	3.2 ± 1.2*	2.8 ± 1.3*#	1.8. ± 1.1	1.7 ± 1.3	0.065	0.155	**0.001**
Tobacco Use	2.4 ± 1.4*	2.0 ± 1.4#	1.6 ± 1.1	1.8 ± 1.3	0.318	**0.023**	0.053

Scale: 1 = never; 2 = hardly ever; 3 = sometimes; 4 = often; 5 = always. *p < 0.05, significant differences between student Veterans and Non-Veteran students; #p < 0.05, significantly different from Pre-COVID; significant p values displayed in bold font.

Table 3 Social engagement.

	Veterans		Non-Veterans		Time	Interaction	Group
	Pre-COVID	*Post-COVID*	*Pre-COVID*	*Post-COVID*	*p-value*		
Campus Involvement	3.0 ± 1.5	2.2 ± 1.4#	3.5 ± 1.3	2.8 ± 1.4#	**0.001**	0.851	**0.044**
School Stress	3.5 ± 1.0	4.0 ± 1.1#	3.5 ± 1.1	4.1 ± 1.2#	**0.001**	0.634	0.733
School Excitement	3.1 ± 1.4*	2.6 ± 1.5#	3.7 ± 1.2	2.7 ± 1.4#	**0.001**	0.110	0.184
Enjoyable Major	3.7 ± 1.3*	3.6 ± 1.4*	4.3 ± 0.9	4.1 ± 1.1	0.416	0.762	**0.013**
Close Friends	3.0 ± 1.4*	2.4 ± 1.4#	3.7 ± 1.2	3.0 ± 1.5#	**0.001**	0.926	**0.024**

Scale: 1 = disagree; 2 = disagree somewhat; 3 = neutral; 4 = agree somewhat; 5 = agree *p < 0.05, significant differences between student Veterans and Non-Veteran students; #p < 0.05, significantly different from Pre-COVID; significant p values displayed in bold font.

($p = 0.20$). There were no group differences pre- ($p = 0.09$) or post-COVID ($p = 0.42$). The breakdown of anxiety rating (none, mild, moderate, severe) is included in Table 4, highlighting that prior to COVID, a higher percentage of Veterans exhibited some form of anxiety compared to Non-Veterans (94% versus 78%, respectively), although this did not reach statistical significance, $X^2(1) = 0.28$, $p = 0.59$. Veterans were more likely to experience severe anxiety compared to non-Veterans (25% vs 8%) pre-COVID, $X^2(1) = 3.85$, $p = 0.04$.

4. Discussion

This study sought to determine if the COVID-19 pandemic led to a worsening of cardiovascular health behaviors in a student Veteran population more so than a civilian student population. The main findings of this study were 1) several cardiovascular health behaviors, including sleep habits, anxiety, and alcohol use were unaltered by the pandemic in the Veteran cohort; and 2) non-Veteran students appeared to be more affected by the COVID-19 pandemic, shown through the deterioration of cardiovascular health behaviors such as worsening sleep habits, amplified anxiety, and reduced physical activity, when compared to Veteran students. Furthermore, the results of this study highlight that Veterans, even at a young age, are reporting cardiovascular health behaviors associated with CVD, including poor sleep and health habits, elevated anxiety, and low levels of social engagement.

4.1. Sleep habits

Veterans reported higher rates of sleep trouble and fewer hours of sleep, which are associated with an increased risk of CVD such as coronary artery disease, heart failure, and hypertension [22]. Insufficient sleep can alter autonomic modulation, resulting in higher sympathetic and lower parasympathetic tone [23], which are linked to CVD [24]. Post-COVID, Veterans reported the same poor sleep habits as pre-COVID, while non-Veterans, although still reporting better sleep than Veterans, worsened sleep habits. Sleep plays a crucial role in supporting the immune system [25] and sleep loss has been shown to reduce natural killer cell activity, generate inflammatory cytokines, and increase risk of infection [26–28]. Further, because low sleep efficiency is associated with decreased immunity to the common cold [29], this relationship between sleep and immunity not only increases future CVD risk, but may make those with sleep disturbances more susceptible to COVID [30].

Table 4 Generalized anxiety disorder prevalence.

	Veterans		Non-Veterans	
	Pre-COVID	*Post-COVID*	*Pre-COVID*	*Post-COVID*
No anxiety (%)	6	9	22	9
Mild (%)	44	35	46	30
Moderate (%)	25	31	24	26
Severe (%)	25	25	8	35

4.2. Health habits

The Veterans in this study reported they were more likely to consume higher amounts of alcohol compared to non-Veterans, who hardly ever consumed 3 or more alcoholic drinks in one sitting. Although light to moderate alcohol consumption may reduce the risk of CVD, heavy drinkers (2 or more drinks per day for women; 3 or more drinks per day for men) have the highest risk of CVD [31,32]. Heavy drinking is associated with increased cardiovascular mortality, coronary heart disease, hypertension, cerebrovascular events, arrhythmias, and cardiomyopathy [18,33,34]. There were no changes in alcohol usage in either group with COVID, which is in contradiction to preliminary data demonstrating increased alcohol usage during COVID [35]. However, many students were forced to move out of dorms and in with parents/guardians, resulting in fewer social opportunities for drinking. Although there was not a decrease in drinking, the lack of increase in heavy drinking may be partially due to respondents' change in housing. Indeed, there was a reduction in student quantity of drinking during the COVID-19 pandemic due to residing with parents [36].

The Veteran group demonstrated higher energy drink usage, which has many negative cardiovascular implications to include sudden cardiac arrest, myocardial infarction, spontaneous coronary dissection, and increased systolic blood pressure [20]. Energy drink usage is widespread in military personnel and nearly half of deployed troops consume energy drinks daily [37]. Our findings highlight that energy drink usage remains amplified following deployment. Due to the relationship between energy drink use, sleep, and mental health problems [37], Veteran's energy drink usage may also contribute to increased mental health and sleep disorders, further amplifying CVD risk.

Tobacco use, a leading cause of premature death from CVD and the cause of coronary heart disease, cerebrovascular disease, aortic aneurysm, and heart failure [38,39], was more prevalent in the Veteran group pre-COVID compared to non-Veterans. This study's findings are similar to other studies showing increased tobacco use in Veterans compared to civilians [13,40]. It is unclear what caused the decreased use of tobacco products post-COVID; if it was preventative because of the increased risk of severe COVID-19 in smokers [41], due to financial concerns, or some unknown factor; however, it is worth noting that no amount of tobacco use is safe and even one cigarette per day leads to an increased risk of disease [42].

4.3. Social engagement

The decline in social engagement (reduced campus involvement, school excitement, and close friends, along with an increase in school stress) in both groups during the pandemic was expected due to social distancing guidelines and a shift from in-person to online learning [43]. In one study, 89% of university students reported difficulty in concentrating, 82% reported increased concerns about academic performance, and 86% reported

decreased social interactions [44]. The Veteran group reported lower levels of social engagement prior to COVID, shown through less school excitement, the lack of an enjoyable major, and less close friends. Social engagement has a protective effect against cardiovascular mortality [17] and social isolation and a lack of friends and community engagement is associated with an increased risk of CVD and stroke [45,46]. Older Veterans experience more loneliness and social isolation when compared to the general population [47,48] and the current study highlights that these feelings are present in young Veterans.

4.4. Exercise

Aerobic exercise training decreased during COVID in both groups, which is concerning not only due to the link between physical inactivity and CVD incidence and mortality [49,50], but also because exercise is beneficial in addressing risk factors highlighted in this study, including anxiety [51], tobacco use [52], and sleep [53].

4.5. Mental health

Although there were no overall group differences in general anxiety disorder scores, Veterans were more likely to experience severe anxiety pre-COVID. Previous studies have reported increased anxiety during COVID in university students [54] and support our findings of increased school stress and decreased school enjoyment and close friends, which are further linked with anxiety [44]. Poor mental health is associated with an increased risk of CVD, via several mechanisms including increased sympathetic nervous activity, increased blood pressure, and endothelial dysfunction [46]. Additionally, severe anxiety is associated with the development and progression of coronary artery disease and heart failure [55]. The higher frequency of anxiety, specifically severe anxiety, in the student Veteran cohort is in agreement with previous research demonstrating an increased prevalence of mental health disorders in Veterans [13].

Overall, the results of this study suggest that student Veterans have an increased risk of developing CVD, demonstrated through elevated risk factors not displayed in civilian students. These findings support previous literature showing Veterans display heightened risk factors for CVD when compared to their civilian counterparts [14,56], but further contributes that these risk factors are present in college-aged students. Contrary to our hypothesis, the Veteran group did not exhibit an increase in cardiovascular risk factors when compared to the civilian population during the COVID-19 pandemic. Although Veterans and non-Veterans were affected similarly by the pandemic in school stress, social engagement, and aerobic exercise, the non-Veteran group reported several significant changes in sleeping habits, overall anxiety, and resistance exercise training, which remained unchanged in Veterans. The worsening of these CVD risk factors suggest that non-Veteran students demonstrate an increased risk of CVD due to the COVID-19 pandemic.

The lack of effect of the pandemic on the Veteran group's risk factors may be due to a few reasons, the first being a blunted stress response. Veterans demonstrate blunted cortisol concentrations to a social stress test compared to civilians [57] and this finding is similar in individuals with post-traumatic stress disorder [58,59]. These attenuated stress responses may be due to an altered hypothalamic-pituitary-adrenal (HPA) axis and sympathetic nervous system. In individuals who experience chronic stress or those who have experienced trauma, there is a lack of responsiveness to stimuli that would otherwise stimulate the HPA axis and create a stress response, such as increased cortisol [60]. Veterans in the current study displayed a significantly higher prevalence of anxiety pre-COVID, especially severe anxiety, compared to their fellow civilian students. This amplified pre-stimulus (pre-COVID) risk factor may contribute to a chronic stress response. It is possible with the presence of already heightened risk factors, the pandemic may not have been able to evoke substantial changes, resulting in a blunted response.

Another possible explanation could be due to Veterans' maintenance of resistance training. During times of high stress and change, such as on deployment, Veterans display increases in muscle strength and power, reflective of resistance training, while decreasing aerobic performance [61]. It is possible that the continuation of resistance training during this time of stress may have helped to curb the impact of the COVID-19 pandemic and could explain the lack of increase in overall anxiety, as resistance exercise training is associated with improved anxiety levels and symptoms [15].

Finally, the Veteran group may have better psychological resilience. Psychological resilience is the ability to adapt well to a crisis, and traumatic events and major life stressors are required for the development of resilience [62]. Veterans are exposed to substantial traumatic events while deployed and reintegrating back into civilian life, as well as transitioning to college, results in significant stress [63]. Indeed, studies show that Veterans who are exposed to trauma display higher levels of psychological resilience and emotional stability [64,65]. Therefore, student Veterans may be better able to deal with a stressor such as a global pandemic more so than the non-Veteran population. While further studies are needed, psychological resilience may help explain why the Veteran group demonstrated little to no amplification of CVD risk factors during the COVID-19 pandemic.

4.6. Limitations

These are several limitations of the present study. The study's main findings were assessed via Qualtrics self-report questionnaire. Although widely used and valid, the responses could be reflective of bias in self-reporting [66]. Furthermore, health status and behaviors from pre-COVID were assessed approximately one year later and it is possible participants did not accurately recall health habits prior to COVID. The number of respondents was low, due

to the accessibility of the targeted population of student Veterans and the limited data collection period due to the changing pandemic. However, this is the first study to assess CVD risk factors in student Veterans and determine the effects of COVID on a young, student population, although future studies should utilize a larger group of participants. A final limitation was a significant difference in age between groups. Psychological resilience does have an age-related component in which older adults display increased levels of resilience when compared to young adults [67]. However, it is more likely any discrepancies in resilience between groups is due to the trauma endured during deployment and in transitioning back to civilian life, and further study is needed in this area.

In conclusion, this study highlights that young, otherwise healthy student Veterans are displaying behavioral risk factors for cardiovascular disease even prior to the detrimental effects of aging on cardiovascular health. Further, following a stressor such as a global pandemic (COVID-19), civilian students worsened their cardiovascular health behaviors more so than student Veterans. The lack of response in student Veterans due to COVID-19 may be due to the presence of amplified risk factors and chronic stressors prior to the pandemic, or their psychological resilience due to previously experienced trauma. Because limited data exists assessing the cardiovascular health of student Veterans, this knowledge may help to improve resources, both at the University and the government level, for our student Veterans. Further, it is important to understand the response to stressors, such as COVID-19, as this provides insight into future cardiovascular disease risk, not only in student Veterans, but also civilian students.

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Declaration of competing interest

The authors declared no conflicts of interest to disclose.

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