European Journal of Nutrition (2023) 62:1165–1184
https://doi.org/10.1007/s00394-022-03058-9

ORIGINAL CONTRIBUTION

Characterizing fluid intake and physical activity in university students within the United States during the COVID-19 pandemic

William M. Adams[1,2,3] · Mitchell E. Zaplatosch[3] · Shaylynn E. Glenn[4] · Cory L. Butts[4] · Samantha E. Scarneo-Miller[5]

Received: 6 March 2022 / Accepted: 16 November 2022 / Published online: 30 November 2022

Abstract

Purpose This study determined fluid intake and physical activity behaviors among college students during the COVID-19 pandemic.

Methods College students ($n = 1014$; females, 75.6%) completed an online survey during the Spring 2020 academic semester following the initial global response to the COVID-19 pandemic. Academic standing, habitation situation, and University/College responses to COVID-19 were collected. Participants completed the Godin Leisure-Time Exercise Questionnaire and a 15-item Beverage Questionnaire (BEVQ-15) to determine physical activity level and fluid intake behaviors, respectively.

Results Females (1920 ± 960 mL) consumed significantly less fluid than males (2400 ± 1270 mL, $p < 0.001$). Living off-campus ($p < 0.01$) and living with a spouse/partner ($p < 0.01$) was associated with increased consumption of alcoholic beverages. 88.7% of participants reported being at least moderately active; however, Black/African American and Asian participants were more likely to be less active than their Caucasian/White counterparts ($p < 0.05$). Participants reporting no change in habitation in response to COVID-19 had a higher fluid intake ($p = 0.002$); however, the plain water consumption remained consistent ($p = 0.116$). While there was no effect of habitation or suspension of classes on physical activity levels ($p > 0.05$), greater self-reported physical activity was associated with greater fluid intake (std. $\beta = 0.091$, $p = 0.003$).

Conclusions Fluid intake among college students during the initial response to the COVID-19 pandemic approximated current daily fluid intake recommendations. Associations between COVID-19-related disruptions (i.e., suspension of classes and changes in habitation) and increased alcohol intake are concerning and may suggest the need for the development of targeted strategies and programming to attenuate the execution of negative health-related behaviors in college students.

Keywords Water · Hydration · Alcohol · Exercise · Emerging adults

Introduction

Existing evidence [1–13] examining the impact of COVID-19 on health-related behaviors have reported that the associated lockdown measures have had a significant impact on behaviors, such as dietary intake and physical activity. Specifically, individuals tended to consume greater quantities of food or report increased eating frequency [3, 5, 6, 12, 13], consumption of greater quantities of alcohol [5, 12, 13], and increased consumption of either sweet foods or sugar-sweetened beverages [2–4]. These unhealthy behaviors were associated with those who also reported increased levels of stress, anxiety, or psychological or emotional disturbances [6, 10, 14, 15], whereas some individuals reported improvements in health-related behaviors during this time [1, 7, 10].

✉ William M. Adams
william.adams@usopc.org

1 Division of Sports Medicine, United States Olympic & Paralympic Committee, 1 Olympic Plaza, Colorado Springs, CO 80909, USA

2 United States Coalition for the Prevention of Illness and Injury in Sport, Colorado Springs, CO, USA

3 Hydration, Environment, and Thermal Stress Lab, Department of Kinesiology, University of North Carolina at Greensboro, Greensboro, NC, USA

4 Department of Exercise and Nutrition Sciences, Weber State University, Ogden, UT, USA

5 Division of Athletic Training, School of Medicine, West Virginia University, Morgantown, WV, USA

Health-related behaviors, such as engagement in physical activity and total fluid intake (i.e., hydration status), and their association with human health and performance outcomes have been extensively studied within the scientific literature. These data overwhelmingly support the associations of physical inactivity and low daily fluid intake, specifically total water intake, on increased risks of obesity [16–19], cardiovascular disease [20–22], and diabetes [20, 23–25]. Of particular interest regarding the impact of COVID-19 on health-related behaviors are emerging adults (18–29 years) enrolled in college/university, herein referred to as college students. In this stage of life, most college students are living away from home and are developing independent health-related behaviors for the first time. Evidence shows that college students have a decline in physical activity engagement and associated increase in sedentary behaviors compared to their previous behaviors [26, 27]. Furthermore, poor dietary intake (e.g., increased consumption of foods that are high in fat, sodium, and sugar, decreased consumption of fruits and vegetables, and evidence suggesting that college students are underhydrated) contribute to the increased risk profile for long-term health outcomes [26, 28–32]. While many universities/colleges have begun to integrate initiatives to improve student health and wellness, a college student's environmental context (e.g., food, physical, and social environment) may impact the development and maintenance of health-related behaviors [26, 28, 33–36]. However, with the changes Colleges and Universities had to make in response to COVID-19, these initiatives were likely unavailable to assist college students in improving health-related behaviors during the latter-part of the Spring 2020 academic semester.

Physical activity [37–39] and hydration status [39–41] has been shown to positively impact immune function, potentially being useful in the prevention and mitigation of adverse disease outcomes, such as COVID-19. In particular, exercise-induced immunomodulation may improve the innate and adaptive immune responses to the COVID-19 virus [42]. It is also hypothesized that underhydration may increase the risk of COVID-19 infection via increased angiotensin-converting enzyme 2 receptors in the lung, resulting in increased capillary permeability in the lungs that promotes an environment that reduces the capacity for fluid transport out of the lung [43].

Although prior evidence has examined changes in health-related behaviors in college students throughout the college/university experience, no known literature that has examined the impact of a global pandemic (i.e., COVID-19) on levels of physical activity and fluid intake in this population. Furthermore, with the disruptions of in-person classes, and other associated university services (on-campus living, food services, health and wellness programs and recreation facility access) it is prudent that inquiry into these behaviors is ascertained to inform improved policy. Therefore, the primary aim of this study was to characterize fluid intake and physical activity behaviors in college students during the initial response to the COVID-19 pandemic. As a secondary aim, this study also sought to determine the impact of disruptions in normal living (i.e., suspension of in-person classes and/or a change in living situation [habitation]) on fluid intake and physical activity behaviors. Specifically, we included total fluid intake, exercise participation, and alcohol consumption as outcome variables. Based on the reported and predicted impacts of the COVID-19 pandemic on global mental health [44–46], we predicted that the COVID-19-specific disruptions in a college student's class structure and habitation status would impact health behaviors, such as fluid intake (including types of fluids consumed) and physical activity.

Materials and methods

For this study, college students enrolled in college/university in the United States during the Spring 2020 academic semester were recruited to complete an online survey (Qualtrics, Provo, UT, USA) investigating their daily fluid intake and physical activity behaviors during the initial response (March–May 2020) to the COVID-19 global pandemic. University email listservs, social media posts, and convenience sampling were used to recruit eligible participants. Given the inability to decipher the total number of individuals who received the link or saw the social media posts, we are unable to calculate a valid response rate. However, the initial dissemination of the survey using email listservs at the primary author's institution was sent to 8000 students that were enrolled in classes for the Spring 2020 academic semester. Consent was implied by participants clicking on the "I agree to participate" button at the bottom of the first information page and completing the study. This study was ruled exempt from review by the Institutional Review Board at the University of North Carolina at Greensboro (#20–0442).

Survey

The survey (Supplemental File) had three main parts: (1) participant characteristics and demographics, (2) fluid intake behaviors and (3) physical activity behaviors.

Participant characteristics and demographics. Participants indicated their sex, race and ethnicity, academic classification (i.e., Freshman, Sophomore, Junior, Senior, Graduate Student), habitation during the 2019–2020 academic year, change in habitation as a result of COVID-19, whether or not their university suspended in-person classes and the state in which the participant's college or university was located.

Habitual Fluid Intake. To assess fluid intake behaviors participants completed a validated 15-item Beverage Questionnaire (BEVQ-15) [47]. This questionnaire, used to determine one's typical beverage intake behaviors during the previous 30 days (one month), was not altered for this study and has shown sufficient construct validity and reproducibility to capture participant fluid intake against a 4-day dietary recall and the BEVQ-2 survey [47]. Participants were instructed to indicate the types of beverages they consumed on average during the previous month. Beverage types included water, beer, wine, hard liquor, coffee, energy drinks, milk, low fat milk, nut milk, fruit juice, sweetened juice beverages, soft drinks, diet soft drinks, sweet tea, and any additional beverages not included in the survey ("other"). For each beverage type, participants selected an option for how often ("never or less than 1 per week", "1 time per week", "2–3 times per week", "4–6 times per week", "1 time per day", "2 times per day", and "3 + times per day") and how much each time ("less than 6 fl oz [3/4 cup]", "8 fl oz [1 cup]", "12 fl oz [1.5 cups]", "16 fl oz [2 cups]", "20 fl oz [2.5 cups]", "> 20 fl oz"). Fluid intake volume for each beverage type and total fluid intake were calculated based on methods previously established [47].

Physical Activity. Participants were instructed to self-report their levels of physical activity during the 7 days prior to completing the survey. To quantify amount of physical activity, the Godin Leisure-Time Exercise Questionnaire was used [48, 49]. This self-reported physical activity questionnaire provides a valid and reliable assessment of individuals who are classified as 'active', 'moderately active', and 'insufficiently active' [50] and is based on current physical activity recommendations by the American College of Sports Medicine [51]. Participants are asked to report the frequency (times per week) of strenuous, moderate, and mild/light exercise performed for a minimum of 15 consecutive minutes during the previous 7-day period. The frequency was multiplied by a metabolic equivalent (MET; strenuous = 9, moderate = 5, and mild/light = 3) with these arbitrary units summed to give a classification of activity. A score ≥ 24 was interpreted as active, 14–23 as moderately active, and < 14 as insufficiently active/sedentary. This questionnaire demonstrates sufficient reliability and concurrent validity [48].

Statistical analyses

All data analyses were conducted using R statistical software [52]. For the primary aim, robust multiple regression models were run using the "rlm" function in R to assess whether academic classification, habitation, sex, and race/ethnicity were predictors of fluid intake (total and beverage type volume) using iterated re-weighted least squares. This analysis followed this equation for volume of each type of beverage consumed (Y):

$$Y = \beta_1(\text{Academic Classification}) + \beta_2(\text{Habitation}) + \beta_3(\text{Sex}) + \beta_4(\text{Race}) + \beta_5(\text{Ethnicity}) + \int \quad (1)$$

A multinomial logistic regression was run with age, academic classification, habitation, sex, and race/ethnicity as predictors of self-reported physical activity level category ("active", "moderately active", or "insufficiently active"):

$$\ln\left(\frac{P(PA = \text{active})}{P(PA = \text{insufficiently active})}\right) = \beta_{10}(\text{Academic Classification}) + \beta_{11}(\text{Habitation}) + \beta_{12}(\text{Sex}) + \beta_{13}(\text{Race}) + \beta_{14}(\text{Ethnicity}) + \int_1 \quad (2)$$

$$\ln\left(\frac{P(PA = \text{moderately active})}{P(PA = \text{insufficiently active})}\right) = \beta_{20}(\text{Academic Classification}) + \beta_{21}(\text{Habitation}) + \beta_{22}(\text{Sex}) + \beta_{23}(\text{Race}) + \beta_{24}(\text{Ethnicity}) + \int_2 \quad (3)$$

For the second aim, path analysis models were created using the "Lavaan" package in R to explore the impact of the suspension of university classes, as mediated by a change in habitation and moderated by academic classification, on total fluid intake and physical activity classification. The model was adjusted for race/ethnicity and sex (Fig. 1). Significance was set at a-priori at $p < 0.05$ for all analyses. The indirect effect (moderated mediation) for each of these models was calculated as the product of the regression coefficient for the effect of a suspension of in-person classes on a change in habitation moderated by different levels of academic classification, with the effect of a change in habitation on the outcome variable of interest. The total effect of each model was calculated as the addition of the indirect effect and the direct effect (effect of suspension of in-person classes on the outcome variable without mediation or moderation). Additional models following this format were created with specific beverages of interest as outcome variables, specifically total fluid, alcohol, and water. Figure 1 displays the model with Total Fluid (mL) as the outcome variable. The same model was used with plain water, beer, wine, and hard liquor as outcome variables (see supplementary figures). A separate model was run with physical activity classification as a moderator of Total Fluid intake (Fig. 2). Such path analysis models have the advantage of examining both the direct influence of one independent variable on the dependent variable, as well as chains of influence, whereby the independent variable may or may not influence an intermediate variable which affects the outcome of interest (indirect effect)[53].

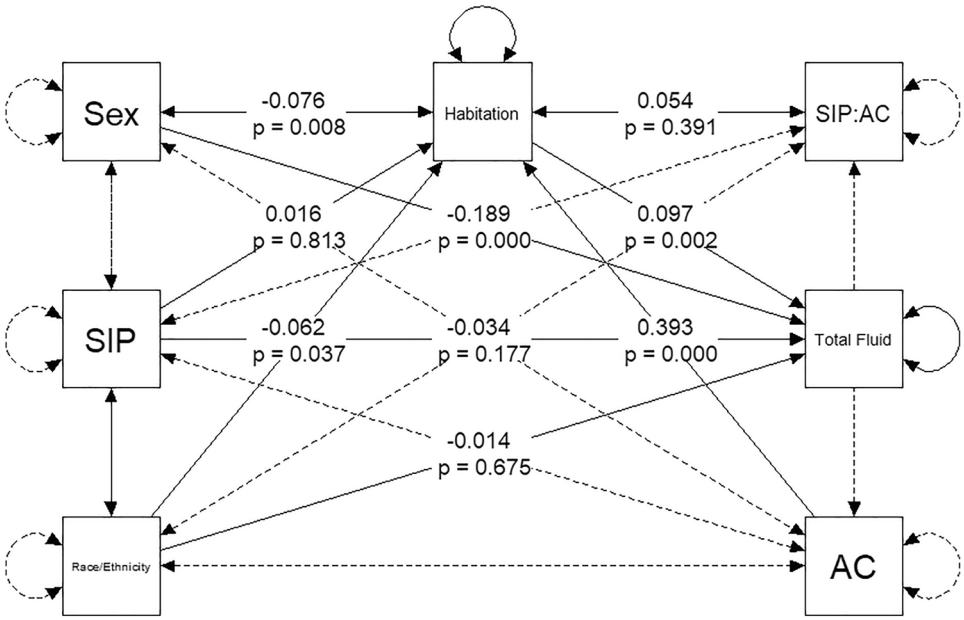

Fig. 1 Moderated Mediation model examining the influence of a Suspension of In Person Classes (SIP) as Mediated by Change in Habitation and moderated by Academic Classification (AC) on Total fluid Intake. Solid lines represent estimated parameter for the predicted standardized change in the exogenous variable for every one unit change in the predictor variable, when holding other variables constant. For example, a 1 standard deviation change in sex (i.e., females) predicted a −0.189 standard deviation decrease in total fluid intake, when controlling for SIP, Race/Ethnicity, Habitation, and the moderating effect of SIP and AC. SIP coded as "No suspension of in-person classes" = 0, "Suspension of in-person classes" = 1. Race/Ethnicity coded as "White/Caucasian" = 0, "Non-white" = 1. Sex coded as "Male" = 0. "Female" = 1. Habitation coded as "No living change" = 0, "Living Change" = 1. AC used as a continuous moderator with '0' representing the lowest academic classification "Freshman". Dashed lines represent covariance between variables. Dashed circular arrows represent variance of exogenous variables. Solid circular arrows represent error variance for endogenous variables

Inclusion of the moderator academic classification allowed us to assess whether the strength of the relationship between a suspension of in-person university classes and total fluid intake and physical activity levels varied across academic school year.

Results

A total of 1156 participants began the survey, from which 141 were excluded based on limited completion (< 80% of questions completed), leaving 1014 for analysis (Table 1). Self-reported fluid intake across each race and sex are displayed in Table 2. The study population primarily identified as being female [$n = 766$ (75.6%) vs $n = 241$ (23.8%) male]. Participants self-reported primarily consuming water ($n =$, 47.9%), followed by sweet beverages (16.9%), caffeinated beverages (12.1%), milk or milk alternatives (6.5%), and alcohol (5.6%). The level of self-reported physical activity is depicted in Table 3. Among the responses included for analysis, 75.7% of participants were classified as "active", 13% as "moderately active", and 11% as "insufficiently active/sedentary".

Fluid intake behaviors

Multiple regression models incorporating sex, race/ethnicity, academic classification, habitation, and exercise participation as predictors of self-reported total fluid intake and a type of fluids consumed are displayed in Table 4. Females self-reported consuming significantly less daily total fluid, as well as less beer, hard liquor, coffee, energy drinks, milk, sweetened juice beverages, and soft drinks compared to males ($p < 0.001$), but consumed more nut milk ($p < 0.05$). Compared to participants identifying as White/Caucasian, there were no significant differences in total fluid intake between races ($p > 0.05$). Black/African American participants consumed less beer, coffee, soft drinks, and diet soft drinks but more nut milk, fruit juice, and sweetened juice beverages ($p < 0.05$). Asian participants consumed less beer, energy drinks and soft drinks ($p < 0.05$). American Indian participants consumed more wine, milk, nut milk, soft drinks, sweet tea, and other beverages ($p < 0.05$). Native Hawaiians consumed less beer and low-fat milk ($p < 0.05$). Participants of Hispanic/Latino/Spanish origin consumed more nut milk and fruit juice but less soft drinks and sweet tea ($p < 0.05$).

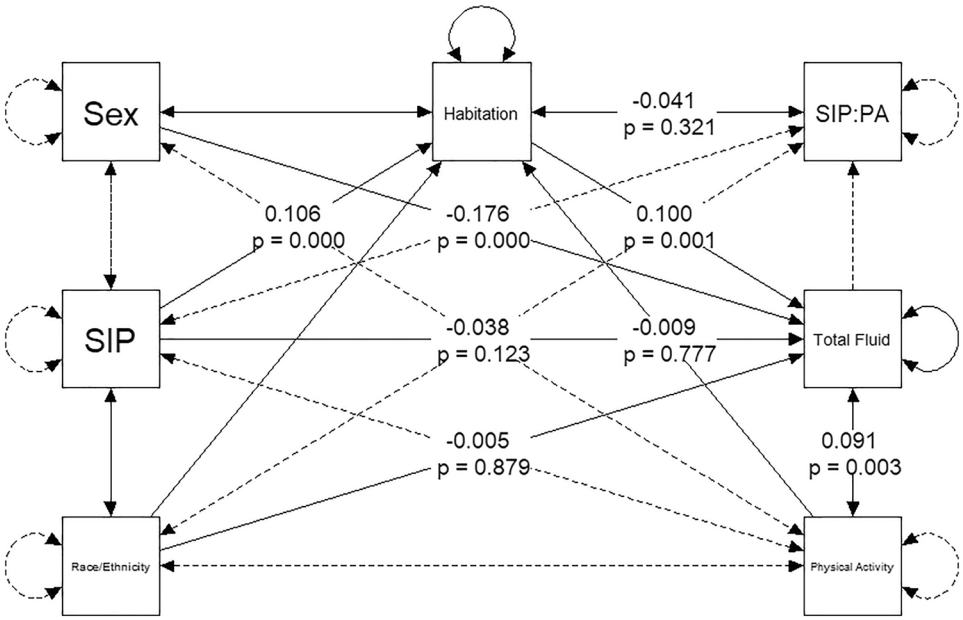

Fig. 2 Moderated Mediation examining the influence of a Suspension of In Person Classes (SIP) as Mediated by Change in Habitation and moderated by Physical Activity (PA) on Total Fluid Intake, covaried by Sex and Race/Ethnicity. Solid lines represent estimated parameter for the predicted standardized change in the exogenous variable for every one unit change in the predictor variable, when holding other variables constant.. SIP coded as "No suspension of in-person classes" = 0, "Suspension of in-person classes" = 1. Race/Ethnicity coded as "White/Caucasian" = 0, "Non-white" = 1. Sex coded as "Male" = 0. "Female" = 1. Habitation coded as "No living change" = 0, "Living Change" = 1. PA was a continuous moderating variable of physical activity score based on the Godin questionnaire. Dashed lines represent covariance between variables. Dashed circular arrows represent variance of exogenous variables. Solid circular arrows represent error variance for endogenous variables

When examining associations of fluid intake by academic classification and habitation, those of higher academic classification (i.e., graduate student > senior > junior > sophomore > freshman) had increased water ($p < 0.05$), beer ($p < 0.05$), coffee ($p < 0.001$), and wine consumption ($p < 0.001$), but less energy drink ($p < 0.05$), fruit juice ($p < 0.05$), sweetened juice beverage ($p < 0.05$), soft drink ($p < 0.05$) and sweet tea consumption ($p < 0.05$). Living off campus was associated with greater total fluid intake ($p < 0.05$), including more beer ($p < 0.01$), wine ($p < 0.001$), hard liquor ($p < 0.01$), and low-fat milk consumption ($p < 0.05$) compared to living on campus. Living with a spouse/partner was associated with increased total fluid intake ($p < 0.01$), including more wine ($p < 0.01$), and coffee consumption ($p < 0.01$), but less milk consumption ($p < 0.05$) compared to living on campus. Living with a parent(s)/guardian(s) was associated with increased energy drink consumption ($p < 0.05$) compared to living on campus.

Greater exercise participation predicted greater total fluid intake ($p < 0.001$), including more water ($p < 0.001$), energy drink ($p < 0.001$), milk ($p < 0.001$), and nut milk ($p < 0.05$) intake but less soft drink ($p < 0.01$) and sweet tea ($p < 0.05$) intake.

Physical activity behaviors

Multinomial logistic regression models incorporating sex, race, academic classification, and habitation as predictors of self-reported physical activity level are displayed in Table 5. Black/African American participants were less likely to be active than Caucasian/White respondents ($p < 0.001$). Native Hawaiian participants were less likely to be moderately active ($p < 0.001$), but more likely to be active ($p < 0.001$) than Caucasian/White respondents. Asian participants were less likely to be classified as active ($p < 0.05$) compared to Caucasian/White respondents. Participants living off-campus were more likely to be moderately active ($p = 0.05$) and active ($p < 0.01$) compared to those living on campus.

Moderated mediation analyses

Moderated mediation analyses were conducted with "suspension of in-person classes" as a predictor of total fluid intake, mediated by whether students experienced a change in habitation, and moderated by academic classification (Table 6). This model included Sex and Race/Ethnicity (where 0 = non-Hispanic White, 1 = non-White) as covariates for the prediction of total fluid intake (Fig. 1). The chi-square test of model fit showed this model was not a perfect

Table 1 Respondent demographic information

	Overall ($N = 1014$)
Sex	
Female	766 (75.5%)
Male	241 (23.8%)
Prefer not to answer	6 (0.6%)
Missing	1 (0.1%)
Race	
American Indian	26 (2.6%)
Asian	54 (5.3%)
Black or Black/African American	168 (16.6%)
Native Hawaiian	1 (0.1%)
Other	32 (3.2%)
White or Caucasian	724 (71.4%)
Missing	9 (0.9%)
Ethnicity	
Hispanic or Latino or Spanish Origin	98 (9.7%)
Not Hispanic or Latino or Spanish Origin	907 (89.4%)
Missing	9 (0.9%)
Academic Classification	
Freshman	59 (5.8%)
Graduate student	289 (28.5%)
Junior	264 (26.0%)
Senior	245 (24.2%)
Sophomore	139 (13.7%)
Missing	18 (1.8%)
Self-reported physical activity level	
Sedentary	113 (11.1%)
Moderately active	133 (13.1%)
Active	768 (75.7%)
Habitation (Start of 2019–2020 Academic Year)	
Off campus	388 (38.3%)
On campus	253 (25.0%)
Other	13 (1.3%)
Parent/guardian	182 (17.9%)
Spouse/partner	177 (17.5%)
Missing	1 (0.1%)
Change in habitation	
No	587 (57.9%)
Yes	426 (42.0%)
Missing	1 (0.1%)
New habitation location (As a result of COVID-19)	
Off campus	15 (1.5%)
On campus	7 (0.7%)
Parent/guardian	358 (35.3%)
Spouse/partner	21 (2.1%)
Missing	613 (60.5%)
In-person Classes Suspended?	
No	12 (1.2%)
Yes	1000 (98.6%)
Missing	2 (0.2%)

fit (chi-square = 8556.186, df = 11, $p = 0.000$). However, the comparative fit index (CFI) and Tucker–Lewis Index (TLI) both suggested a good model fit (CFI = 1.000, TLI = 1.001). This fit was also supported by an RMSEA of 0.000 (90% CI 0.000–0.065) and SRMR of 0.001, both of which suggest a good model fit. Thus, this model was considered acceptable for further interpretation. Both the total and indirect effects were not statistically significant (indirect effect, $p = 0.489$; total effect, $p = 0.182$). However, participants who did not experience a change in habitation reported greater total fluid intake than those who experienced a change in habitation, when controlling for sex, race/ethnicity, and academic standing ($p = 0.002$). Individuals of higher academic classification (grad student > senior > junior > sophomore > freshman) were less likely to experience a change in habitation due to COVID-19 disruptions ($p < 0.001$).

Separate moderated mediation analyses were conducted with different categories of alcohol (Beer, Wine, Hard Liquor, see: "Supplementary Figures") as outcome variables, when controlling for sex and race/ethnicity. The model for Beer (Fig. S1) produced good global fit (chi-square = 1.070, $p = 0.301$; CFI = 1.000; TLI = 0.999; RMSEA = 0.008 (90% CI 0.000–0.086); SRMR = 0.003). This model revealed a non-significant indirect ($p = 0.666$) and total effect ($p = 0.916$) of suspension of in-person classes and change in habitation on beer consumption. However, there was a significant increase in Beer consumption among those who did not experience a change in habitation ($\beta = 0.104$, $p < 0.001$) compared to those who did experience a habitation change (Table 7).

Global fit indices for the model with wine consumption as an outcome variable suggest a good model fit (chi-square = 575.320, $p = 0.000$; CFI = 1.000; TLI = 1.019; RMSEA = 0.000 (90% CI 0.000–0.034); SRMR = 0.000). There was a significant total effect of a suspension of in-person classes on wine consumption (Table 8, Fig. S2) when controlling for sex and race/ethnicity, driven by the significant reduction in wine consumption among participants who did not experience a suspension of in person classes (direct effect) (total effect, $p = 0.035$; direct effect, p −0.033). However, there was no significant indirect effect (mediation and moderation effect) of the suspension of in-person classes on wine consumption ($p = 0.727$).

With hard liquor consumption as an outcome variable, global fit indices suggested a good model fit (chi-square = 0.072, $p = 0.789$; CFI = 1.000; TLI = 1.029; RMSEA = 0.000 (90% CI 0.000–0.055); SRMR = 0.001). Students who did not experience a suspension of in person classes self-reported consuming less Hard Liquor (total effect, $p = 0.005$; direct effect, $p = 0.005$), driven by the significant increase in consumption among those who did *not* experience a living change ($p = 0.010$) (Table 9, Fig. S3).

Table 2 Self-reported daily fluid intake by race/ethnicity and sex

	Black/African American		American Indian		Asian		White/Caucasian		Native Hawaiian or Pacific Islander	Other		Hispanic or Latino or Spanish v		Overall	
	Female (N = 137)	Male (N = 31)	Female (N = 20)	Male (N = 6)	Female (N = 35)	Male (N = 18)	Female (N = 544)	Male (N = 175)	Female (N = 1)	Female (N = 25)	Male (N = 7)	Female (N = 82)	Male (N = 16)	Female (N = 766)	Male (N = 241)
Total Fluid (mL)															
Mean (SD)	2000 (1040)	2330 (1640)	1790 (1020)	3370 (2120)	1810 (833)	1730 (790)	1840 (955)	2220 (1770)	1530 (NA)	1580 (908)	2170 (795)	1840 (955)	2220 (1770)	1920 (960)	2400 (1270)
Median [Min, Max]	1850 [467, 7100]	1800 [532, 7140]	1520 [526, 4330]	2690 [1750, 7540]	1820 [390, 3790]	1700 [532, 3620]	1690 [272, 5750]	1460 [544, 6600]	1530 [1530, 1530]	1320 [272, 4470]	2310 [1080, 3220]	1690 [272, 5750]	1460 [544, 6600]	1770 [118, 7980]	2170 [532, 7540]
Water (mL)															
Mean (SD)	1010 (550)	1050 (561)	793 (576)	942 (694)	1010 (448)	1060 (493)	936 (568)	736 (504)	1060 (NA)	880 (567)	936 (532)	936 (568)	736 (504)	963 (549)	1010 (519)
Median [Min, Max]	1060 [0, 1860]	1060 [189, 1860]	710 [94.6, 1770]	1060 [142, 1770]	1060 [331, 1860]	1060 [94.6, 1860]	828 [0, 1860]	665 [142, 1860]	1060 [1060, 1060]	946 [124, 1860]	710 [166, 1770]	828 [0, 1860]	665 [142, 1860]	946 [0, 1860]	1060 [47.3, 1860]
Beer (mL)															
Mean (SD)	23.7 (82.3)	37.5 (99.9)	49.7 (78.7)	291 (418)	16.6 (37.9)	5.59 (13.8)	47.8 (168)	236 (307)	142 (NA)	14.7 (39.4)	79.4 (98.7)	47.8 (168)	236 (307)	39.6 (95.2)	116 (260)
Median [Min, Max]	0 [0, 591]	0 [0, 473]	0 [0, 248]	124 [0, 1060]	0 [0, 142]	0 [0, 47.3]	0 [0, 1240]	237 [0, 1180]	142 [142, 142]	0 [0, 189]	23.7 [0, 248]	0 [0, 1240]	237 [0, 1180]	0 [0, 1240]	0 [0, 1860]
Missing							16 (19.5%)	3 (18.8%)				16 (19.5%)	3 (18.8%)		
Wine (mL)															
Mean (SD)	46.0 (127)	24.5 (72.8)	42.5 (58.9)	240 (403)	15.9 (35.4)	18.9 (51.3)	36.6 (79.2)	39.8 (97.7)	59.2 (NA)	28.6 (52.1)	27.2 (39.1)	36.6 (79.2)	39.8 (97.7)	41.4 (100)	34.4 (101)
Median [Min, Max]	0 [0, 1180]	0 [0, 355]	0 [0, 189]	62.1 [0, 946]	0 [0, 142]	0 [0, 189]	0 [0, 473]	0 [0, 331]	59.2 [59.2, 59.2]	0 [0, 189]	17.7 [0, 94.6]	0 [0, 473]	0 [0, 331]	0 [0, 1180]	0 [0, 946]
Missing	16 (11.7%)	3 (9.7%)	4 (20.0%)	1 (16.7%)	9 (25.7%)	2 (11.1%)	13 (15.9%)	5 (31.2%)	0 (0%)	6 (24.0%)	2 (28.6%)	13 (15.9%)	5 (31.2%)	114 (14.9%)	35 (14.5%)
Hard Liquor (mL)															
Mean (SD)	23.3 (78.1)	30.1 (69.8)	21.7 (49.7)	126 (286)	12.8 (44.7)	12.8 (30.5)	11.5 (34.9)	131 (357)	0 (NA)	8.28 (29.6)	23.7 (45.4)	11.5 (34.9)	131 (357)	16.4 (51.9)	34.9 (108)

Table 2 (continued)

	Black/African American		American Indian		Asian		White/Caucasian		Native Hawaiian or Pacific Islander	Other		Hispanic or Latino or Spanish v		Overall	
	Female (N = 137)	Male (N = 31)	Female (N = 20)	Male (N = 6)	Female (N = 35)	Male (N = 18)	Female (N = 544)	Male (N = 175)	Female (N = 1)	Female (N = 25)	Male (N = 7)	Female (N = 82)	Male (N = 16)	Female (N = 766)	Male (N = 241)
Median [Min, Max]	0 [0, 710]	0 [0, 248]	0 [0, 189]	11.8 [0, 710]	0 [0, 237]	0 [0, 94.6]	0 [0, 177]	8.87 [0, 1240]	0 [0, 0]	0 [0, 142]	0 [0, 124]	0 [0, 177]	8.87 [0, 1240]	0 [0, 710]	0 [0, 1240]
Missing							18 (22.0%)	4 (25.0%)				18 (22.0%)	4 (25.0%)		
Coffee (mL)															
Mean (SD)	124 (252)	55.5 (175)	139 (229)	447 (717)	151 (217)	125 (226)	158 (195)	203 (247)	166 (NA)	115 (149)	279 (311)	158 (195)	203 (247)	179 (272)	278 (409)
Median [Min, Max]	17.7 [0, 1770]	0 [0, 946]	17.7 [0, 710]	172 [0, 1860]	47.3 [0, 946]	23.7 [0, 710]	94.6 [0, 946]	94.6 [0, 710]	166 [166, 166]	23.7 [0, 532]	237 [0, 710]	94.6 [0, 946]	94.6 [0, 710]	71.0 [0, 1770]	94.6 [0, 1860]
Missing							11 (13.4%)	3 (18.8%)				11 (13.4%)	3 (18.8%)		
Energy Drinks (mL)															
Mean (SD)	26.5 (119)	118 (255)	3.55 (10.9)	29.6 (39.4)	7.44 (29.1)	29.9 (111)	34.1 (93.2)	183 (314)	0 (NA)	50.6 (124)	65.9 (86.4)	34.1 (93.2)	183 (314)	29.3 (100)	86.2 (213)
Median [Min, Max]	0 [0, 1060]	0 [0, 1240]	0 [0, 35.5]	11.8 [0, 94.6]	0 [0, 166]	0 [0, 473]	0 [0, 473]	41.4 [0, 1180]	0 [0, 0]	0 [0, 473]	35.5 [0, 237]	0 [0, 473]	41.4 [0, 1180]	0 [0, 1240]	0 [0, 1860]
Missing							18 (22.0%)	2 (12.5%)				18 (22.0%)	2 (12.5%)		
Milk (mL)															
Mean (SD)	66.1 (178)	109 (256)	143 (208)	280 (232)	108 (155)	69.7 (90.4)	80.1 (152)	97.8 (100)	0 (NA)	96.5 (235)	35.5 (54.2)	80.1 (152)	97.8 (100)	71.9 (161)	141 (278)
Median [Min, Max]	0 [0, 1770]	23.7 [0, 1420]	0 [0, 710]	243 [0, 710]	23.7 [0, 532]	11.8 [0, 237]	23.7 [0, 1180]	94.6 [0, 331]	0 [0, 0]	17.7 [0, 1180]	0 [0, 142]	23.7 [0, 1180]	94.6 [0, 331]	0 [0, 1770]	23.7 [0, 1860]
Missing							2 (2.4%)	3 (18.8%)				2 (2.4%)	3 (18.8%)		
Low Fat Milk (mL)															
Mean (SD)	24.2 (96.2)	20.8 (36.1)	16.6 (36.1)	15.8 (38.6)	72.7 (132)	33.8 (77.1)	0 [0, 1060]	0 [0, 710]	35.5 (NA)	9.23 (26.3)	55.8 (100)	26.5 (57.4)	113 (339)	29.9 (87.3)	36.9 (116)

Table 2 (continued)

	Black/African American		American Indian		Asian		White/Caucasian		Native Hawaiian or Pacific Islander	Other		Hispanic or Latino or Spanish v		Overall	
	Female (N = 137)	Male (N = 31)	Female (N = 20)	Male (N = 6)	Female (N = 35)	Male (N = 18)	Female (N = 544)	Male (N = 175)	Female (N = 1)	Female (N = 25)	Male (N = 7)	Female (N = 82)	Male (N = 16)	Female (N = 766)	Male (N = 241)
Median [Min, Max]	0 [0, 946]	0 [0, 94.6]	0 [0, 124]	0 [0, 94.6]	0 [0, 473]	0 [0, 237]	43.8 (131)	40.6 (72.5)	35.5 [35.5, 35.5]	0 [0, 94.6]	0 [0, 248]	0 [0, 237]	0 [0, 1180]	0 [0, 1060]	0 [0, 1180]
Missing												9 (11.0%)	4 (25.0%)		
Nut Milk (mL)															
Mean (SD)	61.0 (159)	34.9 (63.5)	54.7 (79.6)	56.2 (98.1)	89.4 (221)	0.986 (4.18)	0 [0, 1420]	0 [0, 473]	0 (NA)	53.5 (109)	67.6 (94.1)	75.4 (132)	70.1 (160)	47.9 (119)	33.3 (85.2)
Median [Min, Max]	0 [0, 1180]	0 [0, 248]	11.8 [0, 237]	8.87 [0, 248]	0 [0, 1180]	0 [0, 17.7]			0 [0, 0]	0 [0, 473]	0 [0, 237]	0 [0, 710]	0 [0, 591]	0 [0, 1180]	0 [0, 710]
Missing												10 (12.2%)	2 (12.5%)		
Fruit Juice (mL)															
Mean (SD)	210 (355)	227 (417)	91.7 (219)	84.8 (133)	55.3 (89.6)	69.0 (167)	37.6 (150)	41.6 (109)	23.7 (NA)	109 (207)	66.8 (83.0)	108 (226)	69.3 (96.6)	77.6 (204)	69.4 (179)
Median [Min, Max]	94.6 [0, 1860]	47.3 [0, 1420]	0 [0, 946]	17.7 [0, 331]	0 [0, 355]	11.8 [0, 710]	0 [0, 1770]	0 [0, 710]	23.7 [23.7, 23.7]	0 [0, 710]	17.7 [0, 189]	17.7 [0, 1420]	11.8 [0, 331]	0 [0, 1860]	0 [0, 1420]
Missing												3 (3.7%)	2 (12.5%)		
Sweetened Juice Beverages (mL)															
Mean (SD)	109 (262)	177 (356)	31.9 (81.4)	79.9 (164)	39.4 (106)	57.8 (118)	101 (221)	165 (306)	0 (NA)	57.5 (147)	62.5 (70.6)	80.7 (250)	65.1 (105)	51.1 (174)	62.5 (169)
Median [Min, Max]	17.7 [0, 1860]	23.7 [0, 1420]	0 [0, 355]	20.7 [0, 414]	0 [0, 532]	0 [0, 473]	0 [0, 1860]	35.5 [0, 1770]	0 [0, 0]	0 [0, 710]	59.2 [0, 189]	0 [0, 1770]	23.7 [0, 355]	0 [0, 1860]	0 [0, 1420]
Missing												8 (9.8%)	4 (25.0%)		
Soft Drinks (mL)															

Table 2 (continued)

	Black/African American		American Indian		Asian		White/Caucasian		Native Hawaiian or Pacific Islander	Other		Hispanic or Latino or Spanish v		Overall	
	Female (N = 137)	Male (N = 31)	Female (N = 20)	Male (N = 6)	Female (N = 35)	Male (N = 18)	Female (N = 544)	Male (N = 175)	Female (N = 1)	Female (N = 25)	Male (N = 7)	Female (N = 82)	Male (N = 16)	Female (N = 766)	Male (N = 241)
Mean (SD)	77.2 (222)	90.4 (234)	102 (133)	302 (401)	14.5 (33.4)	79.9 (121)	81.1 (242)	64.6 (191)	35.5 (NA)	36.0 (82.6)	55.8 (122)	80.0 (201)	217 (372)	90.1 (212)	148 (285)
Median [Min, Max]	0 [0, 1860]	0 [0, 946]	41.4 [0, 473]	142 [0, 1060]	0 [0, 94.6]	29.6 [0, 473]	0 [0, 1860]	0 [0, 1420]	35.5 [35.5, 35.5]	0 [0, 355]	0 [0, 331]	0 [0, 1180]	53.2 [0, 1180]	0 [0, 1860]	23.7 [0, 1770]
Missing												10 (12.2%)	2 (12.5%)		
Diet Drinks (mL)															
Mean (SD)	32.3 (125)	132 (453)	23.7 (80.9)	246 (424)	28.4 (100)	44.7 (117)	1.62 (5.93)	2.22 (7.03)	0 (NA)	16.6 (56.1)	123 (175)	77.2 (314)	101 (153)	65.9 (214)	77.9 (243)
Median [Min, Max]	0 [0, 946]	0 [0, 1860]	0 [0, 355]	29.6 [0, 1060]	0 [0, 473]	0 [0, 473]	0 [0, 63.0]	0 [0, 60.0]	0 [0, 0]	0 [0, 248]	35.5 [0, 473]	0 [0, 1860]	8.87 [0, 473]	0 [0, 1860]	0 [0, 1860]
Missing							102 (18.8%)	27 (15.4%)				15 (18.3%)	4 (25.0%)		
Sweet Tea (mL)	2.22 (6.73)	2.30 (7.53)	1.53 (2.59)	3.06 (6.51)	1.19 (3.27)	0.686 (2.12)			NA (NA)	0.981 (2.74)	1.52 (2.78)			1.69 (5.83)	2.16 (6.76)
Mean (SD)	0 [0, 63.0]	0 [0, 40.0]	0 [0, 8.00]	0 [0, 14.7]	0 [0, 16.0]	0 [0, 8.00]			NA [NA, NA]	0 [0, 11.2]	0 [0, 6.40]	1.17 (5.35)	2.20 (3.87)	0 [0, 63.0]	0 [0, 60.0]
Median [Min, Max]	17 (12.4%)	2 (6.5%)	0 (0%)	1 (16.7%)	8 (22.9%)	4 (22.2%)			1 (100%)	4 (16.0%)	2 (28.6%)	0 [0, 42.0]	0 [0, 11.2]	132 (17.2%)	38 (15.8%)
Missing												15 (18.3%)	4 (25.0%)		

Table 3 Level of self-reported physical activity by race/ethnicity and sex

	Insufficiently active ($N=113$)	Moderately active ($N=133$)	Active ($N=768$)	Overall ($N=1014$)
Sex				
Female	90 (79.6%)	105 (78.9%)	571 (74.3%)	766 (75.5%)
Male	22 (19.5%)	25 (18.8%)	194 (25.3%)	241 (23.8%)
Prefer not to answer	1 (0.9%)	2 (1.5%)	3 (0.4%)	6 (0.6%)
Missing	0 (0%)	1 (0.8%)	0 (0%)	1 (0.1%)
Race/Ethnicity				
Not Hispanic or Latino or Spanish Origin	96 (85.0%)	120 (90.2%)	691 (90.0%)	907 (89.4%)
American Indian	2 (1.8%)	4 (3.0%)	20 (2.6%)	26 (2.6%)
Asian	9 (8.0%)	8 (6.0%)	37 (4.8%)	54 (5.3%)
Black/African American	30 (26.5%)	26 (19.5%)	112 (14.6%)	168 (16.6%)
Other	6 (5.3%)	5 (3.8%)	21 (2.7%)	32 (3.2%)
White or Caucasian	65 (57.5%)	86 (64.7%)	573 (74.6%)	724 (71.4%)
Native Hawaiian	0 (0%)	0 (0%)	1 (0.1%)	1 (0.1%)
Missing	1 (0.9%)	4 (3.0%)	4 (0.5%)	9 (0.9%)
Hispanic or Latino or Spanish Origin	15 (13.3%)	12 (9.0%)	71 (9.2%)	98 (9.7%)
Missing	2 (1.8%)	1 (0.8%)	6 (0.8%)	9 (0.9%)

By contrast, the model showed no significant total effect ($p=0.116$), indirect effect ($p=0.747$), or direct effect ($p=0.116$) of a suspension of in person classes on plain Water consumption, when controlling for sex, race/ethnicity, and academic standing (Table 10, Fig. S4). Global fit indices for this model suggested a good fit (chi-square = −0.746, $p=0.746$; CFI = 1.000; TLI = 1.002; RMSEA = 0.000 (90% CI 0.000–0.059); SRMR = 0.001). The moderated mediation model for self-reported physical activity classification produced a good global fit (chi-square = 0.025, $p=0.873$; CFI = 1.000; TLI = 1.053; RMSEA = 0.000 (90% CI 0.000–0.044); SRMR = 0.000) (Table 11), there was no significant indirect effect ($p=0.934$), direct effect ($p=0.129$) or total effect ($p=0.131$) of a suspension of in person classes on activity level. However, non-White participants reported lower activity levels ($p<0.001$), when controlling for a suspension of in person classes, habitation, sex, and academic classification. Females also reported lower physical activity levels ($p=0.032$), independent of habitation, race/ethnicity, or a suspension of in person classes.

To explore whether the effects of change in habitation on total fluid intake were influenced by indirectly by changes in exercise habits, a moderated mediation model was conducted with the suspension of in-person classes as a predictor of Total Fluid intake, moderated by Physical Activity level (where '0' = "Sedentary", '1' = "moderately active", '2' = "active"), mediated by change in habitation ('0' = "No living change", '1' = "Living change"), and covaried by Sex, Race/Ethnicity (Table 12, Fig. S5). Global fit indices for this model suggested a good fit (chi-square = 0.002, $p=0.961$; CFI = 1.000; TLI = 1.001; RMSEA = 0.000 (90% CI = 0.000–0.000); SRMR = 0.000). This model produced a significant indirect effect of a suspension of in-person classes on total fluid intake, when passing through a change in habitation, when controlling for sex, race/ethnicity, and physical activity level (std. $\beta=0.011$, $p=0.006$). However, the total effect (including the direct effect of suspension of in-person classes on total fluid intake) was not significant ($p=0.271$), suggesting these effects were primarily due to a change in habitation, where a change in living situation led to increased total fluid intake (std. $\beta=0.10$, $p<0.001$). Greater physical activity classification was associated with increased fluid consumption (std. $\beta=0.091$, $p=0.003$), when controlling for sex and race/ethnicity.

Discussion

This cross-sectional study sought to characterize fluid intake and physical activity habits of a diverse sample of college students during the initial response (Spring 2020 academic semester) to the COVID-19 pandemic. Furthermore, we explored the impact of disruptions in normal living on fluid intake and physical activity behaviors. To our knowledge, this is the first study that has focused specifically on fluid intake and physical activity behaviors in this population and how mid-academic semester changes in living situations in response to college/university-driven policies to combat the spread of COVID-19 impacted these health-related behaviors. Given the evidence supporting

Table 4 Self-reported fluid intake predicted by sex, race/ethnicity, academic classification, and habitation. Sex coded as 0 = "Male", 1 = "Female"

	Dependent variable:															
	Total Fluid (mL)	Water (mL)	Beer (mL)	Wine (mL)	Hard Liquor (mL)	Coffee (mL)	Energy Drinks (mL)	Milk (mL)	Low Fat Milk (mL)	Nut Milk (mL)	Fruit Juice (mL)	Sweetened Juice Beverages (mL)	Soft Drinks (mL)	Diet Soft Drinks (mL)	Sweet Tea (mL)	Other (mL)
Sex	−326.019*** (68.180)	−1.124 (44.795)	−11.523*** (2.211)	2.523 (1.838)	−3.549*** (0.745)	−35.028* (15.229)	−0.128*** (0.017)	−27.330*** (5.645)	0.003 (0.003)	2.350* (1.034)	−3.841 (2.495)	−2.667* (1.123)	−24.553*** (5.970)	−0.004 (0.009)	−0.005 (0.005)	0.0001 (0.0002)
Race/Ethnicity																
African American	67.417 (79.850)	92.116 (52.462)	−10.260*** (2.589)	1.281 (2.125)	−0.973 (0.873)	−72.349*** (17.835)	−0.007 (0.019)	−5.596 (6.611)	−0.002 (0.003)	2.664* (1.211)	61.859*** (2.922)	10.020*** (1.315)	−17.296* (6.992)	−0.022* (0.010)	0.008 (0.006)	−0.00003 (0.0002)
Asian	−188.830 (127.551)	93.897 (83.802)	−11.346** (4.136)	−3.368 (3.564)	−2.022 (1.395)	−53.599 (28.489)	−0.068* (0.031)	7.810 (10.561)	0.009 (0.006)	−0.823 (1.934)	6.320 (4.668)	2.667 (2.100)	−30.694** (11.169)	−0.026 (0.016)	−0.007 (0.009)	0.00003 (0.0003)
American Indian	−27.268 (175.966)	−156.867 (115.611)	5.272 (5.705)	10.766* (4.845)	1.292 (1.924)	−24.415 (39.303)	−0.034 (0.043)	70.432*** (14.570)	−0.003 (0.008)	7.168** (2.668)	6.667 (6.439)	3.640 (2.898)	31.872* (15.409)	−0.001 (0.022)	0.026* (0.012)	0.013*** (0.0005)
Native Hawaiian	−370.999 (880.280)	89.468 (578.352)	119.289*** (28.542)	39.122 (21.844)	−5.796 (9.624)	−18.886 (196.617)	−0.037 (0.213)	−27.786 (72.886)	35.473*** (0.038)	−6.433 (13.346)	14.320 (32.212)	−2.662 (14.496)	−7.647 (77.085)	−0.054 (0.111)	−0.022 (0.062)	−0.0005 (0.002)
Other Race	−240.203 (180.338)	−8.227 (118.484)	−4.119 (5.847)	1.960 (5.089)	−0.469 (1.972)	5.674 (40.280)	0.009 (0.044)	−15.729 (14.932)	−0.005 (0.008)	1.362 (2.734)	3.868 (6.599)	5.612 (2.970)	−31.349* (15.792)	0.017 (0.023)	0.007 (0.013)	0.0002 (0.0005)
Hispanic/Latino/Spanish Origin	9.314 (108.256)	−28.738 (71.125)	−0.500 (3.510)	0.982 (2.933)	−1.697 (1.184)	−28.353 (24.180)	0.015 (0.026)	15.746 (8.964)	0.002 (0.005)	3.780* (1.641)	8.013* (3.961)	0.075 (1.783)	−7.137 (9.480)	−0.028* (0.014)	−0.017* (0.008)	−0.0001 (0.0003)
Academic Classification	50.783 (27.482)	38.403* (18.056)	2.837** (0.891)	1.912** (0.734)	0.200 (0.300)	20.247*** (6.138)	−0.013* (0.007)	−2.073 (2.276)	−0.001 (0.001)	0.152 (0.417)	−2.008* (1.006)	−2.175*** (0.453)	−7.091** (2.407)	0.005 (0.003)	−0.005* (0.002)	0.00000 (0.0001)
Habitation																
Living off Campus	199.662* (81.531)	85.790 (53.567)	5.877* (2.644)	9.164*** (2.193)	2.995*** (0.891)	30.279 (18.211)	0.034 (0.020)	−5.631 (6.751)	0.008* (0.004)	1.057 (1.236)	1.908 (2.984)	1.208 (1.343)	4.314 (7.140)	−0.002 (0.010)	−0.002 (0.006)	0.0001 (0.0002)
Living with spouse/partner	288.597** (98.965)	31.915 (65.021)	3.359 (3.209)	5.952* (2.651)	1.852 (1.082)	76.232*** (22.105)	0.008 (0.024)	−17.612* (8.194)	0.005 (0.004)	0.802 (1.500)	−0.184 (3.621)	−0.227 (1.630)	−0.782 (8.666)	0.019 (0.012)	−0.003 (0.007)	0.0004 (0.0003)
Living with parent/guardian	135.440 (89.491)	89.886 (58.796)	−0.894 (2.902)	0.467 (2.398)	−0.226 (0.978)	−4.971 (19.988)	0.049* (0.022)	5.814 (7.410)	0.005 (0.004)	−1.370 (1.357)	5.358 (3.275)	0.914 (1.474)	12.911 (7.837)	0.005 (0.011)	−0.003 (0.006)	−0.0002 (0.0002)
Other living arrangements	−120.392 (254.216)	−179.918 (167.022)	−8.099 (8.243)	−1.319 (6.834)	−2.627 (2.779)	61.022 (56.781)	−0.047 (0.062)	16.866 (21.049)	0.004 (0.011)	−1.547 (3.854)	1.771 (9.303)	−4.001 (4.186)	55.669* (22.261)	0.022 (0.032)	−0.021 (0.018)	−0.0005 (0.001)
Total Exercise	3.122*** (0.722)	2.422*** (0.475)	−0.006 (0.023)	−0.016 (0.019)	0.009 (0.008)	0.232 (0.161)	0.001*** (0.0002)	0.202*** (0.060)	0.00005 (0.00003)	0.025* (0.011)	−0.007 (0.026)	−0.011 (0.012)	−0.196** (0.063)	0.00003 (0.0001)	−0.0001* (0.0001)	0.00001** (0.00000)
Constant	1,745.315*** (108.357)	678.799*** (71.191)	17.106*** (3.513)	1.090 (2.990)	5.334*** (1.185)	102.697*** (24.202)	0.161*** (0.026)	64.182*** (8.972)	0.009* (0.005)	1.827 (1.643)	19.478*** (3.965)	13.085*** (1.784)	96.456*** (9.489)	0.039** (0.014)	0.051*** (0.008)	0.0002 (0.0003)

Table 4 (continued)

	Dependent variable:															
	Total Fluid (mL)	Water (mL)	Beer (mL)	Wine (mL)	Hard Liquor (mL)	Coffee (mL)	Energy Drinks (mL)	Milk (mL)	Low Fat Milk (mL)	Nut Milk (mL)	Fruit Juice (mL)	Sweetened Juice Beverages (mL)	Soft Drinks (mL)	Diet Soft Drinks (mL)	Sweet Tea (mL)	Other (mL)
Observations	972	972	972	827	972	972	972	972	972	972	972	972	972	972	972	972
Residual Std. Error	882.251 (df = 958)	625.964 (df = 958)	25.168 (df = 958)	20.472 (df = 813)	8.250 (df = 958)	195.806 (df = 958)	0.179 (df = 958)	66.622 (df = 958)	0.037 (df = 958)	10.723 (df = 958)	23.142 (df = 958)	11.451 (df = 958)	72.704 (df = 958)	0.110 (df = 958)	0.061 (df = 958)	0.004 (df = 958)

Race variables with 0 = "White/Caucasian" as baseline

Habitation with 0 = "On Campus" as baseline

Note: $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Table 5 Self-reported physical activity predicted by sex, race/ethnicity, academic classification, and habitation

	Dependent variable	
	Moderately active	Active
Sex	0.071 (0.340)	-0.340 (0.263)
Race/ethnicity		
Black/African American	−0.461 (0.325)	-0.908^{***} (0.253)
Asian	−0.416 (0.523)	-0.837^{*} (0.405)
American Indian	0.321 (0.889)	0.017 (0.761)
Native Hawaiian	-5.687^{***} (0.000)	9.633^{***} (0.00000)
Other race	−0.245 (0.660)	−0.707 (0.521)
Academic classification	0.061 (0.128)	−0.013 (0.101)
Habitation		
Living off Campus	0.759^{*} (0.380)	0.932^{**} (0.308)
Living with spouse/partner	−0.222 (0.445)	0.100 (0.336)
Living with parent/guardian	−0.066 (0.403)	0.239 (0.302)
Other living arrangements	0.492 (0.967)	-0.116 (0.836)
Constant	−0.132 (0.459)	2.116^{***} (0.354)
Akaike Inf. Crit	1,415.428	1,415.428

Sex coded as 0 = "Male", 1 = "Female". Race variables with 0 = "White/Caucasian" as baseline. Living arrangement variables with 0 = "On Campus" as baseline

Note: $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

the health benefits associated with physical activity and maintaining an appropriate level of hydration through adequate water intake, understanding the impact of a global pandemic on these health-related behaviors in a college population that may be developing their independent health behaviors is vital for the development of evidence driven policy. The ensuing discussion compares the findings of our study to existing literature with a specific focus on fluid intake, physical activity, and alcohol consumption.

Total fluid intake

Overall, fluid intake among the college students (females, 1920 ± 960 mL; males, 2400 ± 1270 mL) in this study approximated the adequate intake recommendations established by the European Food Safety Authority (EFSA, 2.0 L/d and 2.5 L/d for females and males, respectively) [54]; however, only 39.6% of females and 38.6% of males in our study self-reported meeting or exceeding these recommendations. Furthermore, when comparing self-reported fluid intake to the adequate intake recommendations by the Institutes of Medicine (IOM, 2.7 L/d and 3.7 L/d for females and males, respectively) [55], only 16.3% of females and 13.3% of males in the current study met this threshold. Previous data depict the prevalence of underhydration among population-based data; however, these data support that females are more likely to consume adequate volumes of

Table 6 Moderated mediation model results with total fluid consumption as outcome variable. Race/ethnicity coded as "White" = 0, "Non-white" = 1. Sex coded as "Male" = 0. "Female" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Total fluid–habitation	207.82	66.12	3.14	0.00	76.92	336.28	0.10
Total fluid–suspension of in person classes	−329.30	243.86	−1.35	0.18	−835.99	122.97	−0.03
Total fluid–sex	−435.23	78.95	−5.51	0.00	−595.46	−288.75	−0.19
Total fluid–race/ethnicity	−32.60	77.88	−0.42	0.68	−182.41	120.31	−0.01
Habitation–suspension of in person classes	0.07	0.30	0.24	0.81	−0.14	0.93	0.02
Habitation–academic classification	0.16	0.01	14.44	0.00	0.14	0.18	0.39
Habitation–suspension of in person classes: academic classification	0.08	0.10	0.86	0.39	−0.18	0.19	0.05
Habitation–sex	−0.08	0.03	−2.64	0.01	−0.14	−0.02	−0.08
Habitation–race/ethnicity	−0.07	0.03	−2.08	0.04	−0.13	−0.00	−0.06
Indirect1: = (a1 + a3)*b1	32.48	47.33	0.69	0.49	0.07	197.34	0.01
Total: = c1 + (a1*a3)*b1	−328.04	245.08	−1.34	0.18	−833.53	128.41	−0.03

Table 7 Moderated mediation model results with Beer consumption as outcome variable. Race/ethnicity coded as "White" = 0, "Non-white" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Beer –habitation	35.90	11.27	3.18	0.00	15.78	60.34	0.10
Beer–suspension of in person classes	−5.96	56.76	−0.11	0.92	−77.47	145.44	−0.00
Beer–sex	−70.89	16.92	−4.19	0.00	−108.52	−41.49	−0.20
Beer–race/ethnicity	−33.09	10.49	−3.15	0.00	−53.16	−12.01	−0.09
Beer–academic classification	5.51	4.96	1.11	0.27	-4.78	14.65	0.04
Habitation –suspension of in person classes	−0.01	0.31	−0.02	0.98	−0.20	0.88	−0.00
Habitation –academic classification	0.15	0.01	12.11	0.00	0.13	0.17	0.37
Habitation –suspension of in person classes: academic classification	0.11	0.10	1.09	0.27	−0.16	0.21	0.07
Habitation –sex	−0.08	0.03	−2.31	0.02	−0.14	−0.01	−0.07
Indirect1: = (a1 + a3)*b1	3.56	8.25	0.43	0.67	−1.28	31.88	0.01
Total: = c1 + (a1*a3)*b1	−5.99	56.78	−0.11	0.92	−78.25	145.61	−0.00

Sex coded as "Male" = 0. "Female" = 1

Table 8 Moderated mediation model results with wine consumption as outcome variable. Race/ethnicity coded as "White" = 0, "Non-white" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Wine –habitation	11.37	8.15	1.39	0.16	−5.30	26.64	0.06
Wine –suspension of in person classes	−26.56	12.48	−2.13	0.03	−49.43	−0.48	−0.03
Wine –sex	9.01	7.42	1.22	0.22	−6.51	22.67	0.04
Wine –race/ethnicity	7.25	8.84	0.82	0.41	−8.11	27.05	0.03
Wine –academic classification	8.79	3.02	2.91	0.00	3.51	15.27	0.11
Habitation –suspension of in person classes	−0.01	0.31	−0.02	0.98	−0.19	0.89	−0.00
Habitation –academic classification	0.15	0.01	12.16	0.00	0.13	0.18	0.37
Habitation –suspension of in person classes: academic classification	0.11	0.10	1.10	0.27	−0.16	0.21	0.07
Habitation –sex	−0.08	0.03	−2.53	0.01	−0.15	−0.02	−0.08
Indirect1: = (a1 + a3)*b1	1.15	3.30	0.35	0.73	−0.57	14.59	0.00
Total:c1 + (a1*a3)*b1	−26.56	12.58	−2.11	0.03	−49.88	−0.18	−0.03

Sex coded as "Male" = 0. "Female" = 1

Table 9 Moderated mediation model results with hard liquor consumption as outcome variable. Race/ethnicity coded as "White" = 0, "Non-white" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Hard liquor –habitation	14.05	5.44	2.58	0.01	4.30	25.81	0.09
Hard liquor –suspension of in person classes	−23.85	8.45	−2.82	0.00	−39.40	−5.43	−0.04
Hard liquor –sex	−13.89	7.92	−1.75	0.08	−30.95	0.10	−0.08
Hard liquor –race/ethnicity	7.66	6.68	1.15	0.25	−3.93	22.45	0.04
Hard liquor –academic classification	0.35	2.21	0.16	0.87	−4.26	4.41	0.01
Habitation –suspension of in person classes	−0.01	0.31	−0.02	0.98	−0.19	0.90	−0.00
Habitation –academic classification	0.15	0.01	11.94	0.00	0.13	0.18	0.37
Habitation –suspension of in person classes: academic classification	0.11	0.10	1.07	0.28	−0.17	0.21	0.07
Habitation –sex	−0.07	0.03	−2.13	0.03	−0.14	− 0.01	−0.07
Indirect1:(a1 + a3)*b1	1.38	3.40	0.41	0.68	−0.50	13.38	0.01
Total: = c1 + (a1*a3)*b1	−23.87	8.56	−2.79	0.01	−39.60	−4.88	−0.04

Sex coded as "Male" = 0. "Female" = 1

Table 10 Moderated mediation model results with water consumption as outcome variable. Race/ethnicity coded as "White" = 0, "Non-white" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Water –habitation	27.54	38.86	0.71	0.48	−49.02	102.85	0.02
Water –suspension of in person classes	−238.36	151.64	−1.57	0.12	−535.40	60.32	-0.05
Water –sex	−29.14	35.83	−0.81	0.42	−99.68	39.59	−0.02
Water –race/ethnicity	27.36	38.48	0.71	0.48	−47.38	103.49	0.02
Water –academic classification	29.11	15.59	1.87	0.06	−1.77	59.87	0.06
Habitation –suspension of in person classes	0.07	0.30	0.24	0.81	−0.14	0.93	0.02
Habitation –academic classification	0.16	0.01	14.32	0.00	0.14	0.18	0.39
Habitation –suspension of in person classes: academic classification	0.08	0.10	0.86	0.39	−0.18	0.19	0.05
Habitation –sex	−0.08	0.03	−2.64	0.01	−0.14	−0.02	−0.08
Indirect1: = (a1 + a3)*b1	4.30	13.33	0.32	0.75	−8.51	55.33	0.00
Total: = c1 + (a1*a3)*b1	−238.19	151.70	−1.57	0.12	−535.35	60.46	−0.05

Sex coded as "Male" = 0. "Female" = 1

Table 11 Moderated mediation model results with physical activity classification as outcome variable. Race/ethnicity coded as "White" = 0, "Non-white" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Physical activity –habitation	−0.02	0.05	−0.43	0.67	-0.11	0.07	−0.02
Physical activity –suspension of in person classes	0.26	0.17	1.52	0.13	−0.14	0.50	0.04
Physical activity –sex	−0.10	0.05	−2.14	0.03	−0.19	−0.01	−0.07
Physical activity –race/ethnicity	−0.19	0.05	−3.70	0.00	−0.30	−0.09	−0.13
Physical activity –academic classification	0.02	0.02	0.85	0.39	-0.02	0.05	0.03
Habitation –suspension of in person classes	0.07	0.30	0.24	0.81	-0.15	0.92	0.02
Habitation –academic classification	0.16	0.01	14.20	0.00	0.14	0.18	0.39
Habitation –suspension of in person classes: academic classification	0.08	0.10	0.86	0.39	−0.18	0.19	0.05
Habitation –sex	−0.08	0.03	−2.66	0.01	−0.14	−0.02	−0.08
Indirect1: = a1*b1	−0.00	0.02	−0.08	0.93	−0.06	0.02	−0.00
Total: = c1 + a1*b1	0.26	0.17	1.51	0.13	−0.14	0.50	0.04

Sex coded as "Male" = 0. "Female" = 1

Table 12 Moderated mediation model results with total fluid as outcome variable when moderated by physical activity. Race/ethnicity coded as "White" = 0, "Non-white" = 1

Variables	β	SE	z	*p* value	ci.lower	ci.upper	β (std)
Total fluid –habitation	212.69	65.15	3.26	0.00	87.26	341.97	0.10
Total fluid –suspension of in person classes	−366.71	237.70	−1.54	0.12	−853.10	69.46	−0.04
Total fluid –sex	−406.28	78.66	−5.16	0.00	−567.91	−259.97	−0.18
Total fluid –race/ethnicity	−11.51	75.90	−0.15	0.88	−158.02	144.02	−0.00
Total fluid –physical activity	142.10	47.79	2.97	0.00	46.96	233.75	0.09
Habitation –suspension of in person classes	0.48	0.09	5.27	0.00	0.30	0.68	0.11
Habitation –physical activity	−0.01	0.02	−0.28	0.78	−0.05	0.04	−0.01
Habitation –suspension of in person classes: physical activity	−0.06	0.07	−0.99	0.32	−0.21	0.05	−0.04
Habitation –sex	−0.10	0.03	−3.19	0.00	−0.17	−0.04	-0.10

Sex coded as "Male" = 0. "Female" = 1

fluid than males [18, 56]. Our data show an approximately equal percentage of males and females meeting or exceeding daily fluid intake recommendations, albeit greater than 60–85% of participants in our study failed to meet daily fluid intake requirements as established by EFSA and IOM, respectively. While we are unable to determine the reasons for the low prevalence of both males and females in meeting daily fluid intake recommendations among our participants compared to previously published data sets, we speculate that this may be one or combination of: (1) the impact of the societal restrictions (i.e., closure of university campuses, stay-at-home orders, mask requirements, etc.) due to COVID-19 may have influenced fluid intake differently among males and females given the timing (May 2020) of the initial dissemination of the survey, (2) since recruitment of participants was isolated to only those that were currently enrolled in college/university during the Spring 2020 academic semester, access and availability of fluids may have influenced one's ability to meet daily fluid intake recommendations, and (3) differences in our sample compared to previous literature based on race/ethnicity and the known differences in fluid intake behaviors across populations. We also cannot discount the potential influence of our sample's pre-pandemic fluid intake behaviors in that our sample may have been habitually under consuming fluids. However, our previous work disputes the low prevalence of college students meeting fluid intake recommendations [57, 58]. In addition to females exhibiting a lower total fluid intake than males, our study also found that females consumed less total fluid, beer, hard liquor, coffee, energy drinks, milk, and soft drinks than their male counterparts. While the reduced total fluid intake in females compared to males could be explained by differences in body composition and fluid needs between males and females, we are unable to provide a thorough explanation on the reduced intake of the specific beverage types discussed above.

Our findings also showed that higher academic standing was associated with greater total fluid consumption, specifically coffee, in agreement with a previous survey of caffeine habits among college students [59]. Furthermore, our data suggest a greater total fluid intake among participants who maintained the same habitation during COVID-19. Upon subsequent analysis, this increased fluid intake may be attributed to greater alcohol intake among those who stayed in their current living situation (see below). Greater physical activity participation predicted increased total fluid consumption, independent of whether participants experienced a change in living situation, suggesting most participants attempt to compensate for increased fluid losses associated with physical activity.

Physical activity

Participants generally met the physical activity guidelines based on their self-reported level of physical activity, with 76% classified as "active" and 13.1% classified as "moderately active". Black/African American, Asian, and Native Hawaiian participants were less likely to report being active compared to Caucasian peers. This is consistent with previous literature identifying lower physical activity among Black/African American female college students [60]. Those who lived off campus tended to report being more "moderately active" and "active" compared to those living on campus, which may be the result of the closure of university recreation facilities during this time. A similar study examining physical activity behaviors pre- and post-pandemic found students who were initially the most active tended to be disproportionately impacted (i.e., decreased physical activity the most in those who were most physical active) by the COVID-19 pandemic in terms of physical activity participation [61]. Perhaps students who lived on campus were accustomed to using their campus recreation

facilities and were less likely to find alternative solutions in the event of such facility closures. Interestingly, one study observed an increase in both physical activity and sedentary time among college students during the pandemic [62]. However, we did not capture sedentary behaviors in the present study. By contrast, some studies have shown a decrease in physical activity behaviors, particularly in countries with stricter confinement guidelines meant to reduce the spread of COVID-19[63]. Other research examining COVID-19 and physical activity has noted substantial changes in resistance training routines with individuals reporting resistance training being less enjoyable despite similar or lower engagement in resistance training routines [64]. Adequate levels of physical activity may promote resilience against COVID-19 symptoms through exercise-induced immunomodulation [65], thus, strategies to maintain activity levels in the event of such disruptions in the future is important both for acute disease prevention, as well as the well-established impact of physical activity on chronic disease risk.

Alcohol consumption

Disruptions imposed by the COVID-19 pandemic (i.e., suspension of classes and changes in habitation) were associated with increased alcohol consumption. In particular, our findings show that beer intake was higher among participants who did not report a change in habitation. However, students of higher academic standing also tended to consume more fluid, which may have impacted these results, since higher academic students were more likely to be of legal age to consume alcohol and typically tend to live in off-campus housing, which may not have required a change of living compared to students who may have lived on campus. In the moderated mediation models, students who experienced a suspension of in-person classes reported consuming more hard liquor and wine and those who did not experience a change in living tended to consume more beer. The joint effects (total effect) of suspension of in-person university classes and a change in living situation predicted lower wine consumption and lower hard liquor consumption in those who did not experience such disruptions. However, these joint effects were not observed for beer consumption.

The transition to online learning, particularly mid-semester as occurred for many during the COVID-19 pandemic, comes with its own set of psychological stressors [66]. It is plausible that changes in the learning environment, combined with anxiety regarding the state of the pandemic, may have contributed to this consumption, which has previously been identified as a growing area of concern for the public even prior to the pandemic [67]. Similarly, Robinson et al. found 36% of UK adults reported consuming either "a little more" (17%), "more" (12%), or "a lot more" (7%), alcohol after lockdown [5]. Another study in Poland found an increase in the frequency of alcohol consumption among adults before and during lockdown [13]. Of note, mean alcohol consumption was relatively modest for both males and females overall (male = 181 ± 379 mL, female = 91.2 ± 171), well below Dietary Guideline recommendations of 2 standard drinks per day for males, and 1 standard drink per day for females [68]. This was expected, given the wide age range of participants, but under-reporting was also a possibility among this population.

The maximum reported alcohol consumption in the present study was 2720 mL for males and 1240 mL for females, well beyond current daily intake recommendations. From our study it is unclear whether individuals near the higher end of the alcohol consumption range drank this much before the start of the COVID-19 pandemic. However, one study [69] examined reported alcohol intake in university students the week before compared to the week after school closure, finding a significant increase in consumption coinciding with symptoms of depression and anxiety. In the same study, those with greater perceived social support tended to consume less alcohol. Unfortunately, our survey did not capture whether participants lived alone, which could then influence alcohol consumption through a reduction in perceived social support for these adverse psychological outcomes. In addition, given the cross-sectional nature of the survey, we cannot say for certain whether the higher total fluid and alcohol intake among those who did not experience a change in habitation was more attributed to this factor or that they are of older academic standing and thus able to purchase alcohol themselves.

Strengths and limitations

There were several strengths of this study. The cross-sectional design of this study allowed us to capture a sample population representative of the racial and ethnic breakdown within the United States. Given the known racial and ethnic differences in both fluid intake [32, 70] and physical activity [71, 72], the representative sample in this study permits improved generalizability of the results. The timing of this study (May 2020) also allowed us to gather fluid intake and physical activity behaviors following the societal restrictions put in place due to COVID-19. Since the initial responses and restrictions to COVID-19 varied across the United States from a timing perspective, ascertaining these behaviors at the conclusion of the Spring 2020 Academic Semester guarantee that the self-reported fluid intake and physical activity behaviors occurred during the implementation of the restrictions.

This study was not without limitations, however. As a cross-sectional survey design, we are not able to fully capture the impact of COVID-19 and associated disruptions on

fluid intake and physical activity behaviors and we cannot be certain that the observed behaviors were present before the COVID-19 pandemic. This study also did not consider the effects mask-wearing may have on fluid intake. Future studies should identify individuals whose workplace or school required/did not require masks throughout the pandemic and whether this influenced fluid consumption. Climate, more importantly, students relocating to geographic locations that were different from their institution of enrollment was not captured. Given that some existing literature [73–75] suggests that ambient temperatures may influence daily fluid intake, students participating in the current study that relocated to geographically different domiciles from their University/College may have altered their fluid intake prior to the investigator's assessment of these behaviors. Participant personal income level, nor household income level, was not assessed in the present study. Individuals with lower personal or household income may have reduced access to certain beverage categories. While personal income of college students may fall within a defined threshold of "low income," household income (i.e., income from their parents/guardians) and the financial support provided directly to the participants may vary considerably. This may be reflective in that 42% of students participating in this study reported that they relocated during the pandemic. Further study should explore fluid intake habits among this population with regard for both individual income levels and any parental support received during this timeframe.

Conclusions

Reported fluid intake among college students during the initial response to the COVID-19 pandemic approximated current daily fluid intake recommendations on average; however, only 40% of participants (both male and female) met or exceeded fluid intake recommendation guidelines established by the European Food Safety Authority. Significant associations between COVID-19-related disruptions and increased alcohol intake are concerning and suggest the need for the development of targeted strategies and programming to attenuate the execution of negative health-related behaviors in emerging adults enrolled in university.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00394-022-03058-9.

Acknowledgements The authors would like to thank all participants who took the time to complete this survey. There are no funding sources to report for supporting this project.

Data availability Data is available upon reasonable request.

Declarations

Conflict of interest None.

Ethical statement This work is the authors own and not that of the United States Olympic & Paralympic Committee, or any of its members or affiliates. WMA has received industry-funded grants from QCK LLC, Statim Technologies LLC, and Techguard LLC. He has also received consulting fees/travel costs from Clif Bar & Company, Gatorade, Samsung, BSX Athletics, and Danone Research Nutricia.

References

1. Rodríguez-Pérez C, Molina-Montes E, Verardo V et al (2020) Changes in dietary behaviours during the COVID-19 outbreak confinement in the Spanish COVIDiet study. Nutrients 12:1730. https://doi.org/10.3390/nu12061730
2. Ruiz-Roso MB, de Carvalho PP, Mantilla-Escalante DC et al (2020) Covid-19 confinement and changes of adolescent's dietary trends in Italy, Spain, Chile, Colombia and Brazil. Nutrients 12:1807. https://doi.org/10.3390/nu12061807
3. Scarmozzino F, Visioli F (2020) Covid-19 and the subsequent lockdown modified dietary habits of almost half the population in an Italian sample. Foods 9:675. https://doi.org/10.3390/foods9050675
4. Pietrobelli A, Pecoraro L, Ferruzzi A et al (2020) Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study. Obesity 28:1382–1385. https://doi.org/10.1002/oby.22861
5. Robinson E, Boyland E, Chisholm A et al (2021) Obesity, eating behavior and physical activity during COVID-19 lockdown: a study of UK adults. Appetite 156:104853. https://doi.org/10.1016/j.appet.2020.104853
6. Ingram J, Maciejewski G, Hand CJ (2020) Changes in diet, sleep, and physical activity are associated with differences in negative mood during COVID-19 lockdown. Front Psychol 11:588604. https://doi.org/10.3389/fpsyg.2020.588604
7. Pérez-Rodrigo C, Gianzo Citores M, Hervás Bárbara G et al (2021) Patterns of change in dietary habits and physical activity during lockdown in Spain due to the COVID-19 pandemic. Nutrients. https://doi.org/10.3390/nu13020300
8. Castañeda-Babarro A, Arbillaga-Etxarri A, Gutiérrez-Santamaría B, Coca A (2020) Physical activity change during COVID-19 confinement. Int J Environ Res Public Health. https://doi.org/10.3390/ijerph17186878
9. Martínez-de-Quel Ó, Suárez-Iglesias D, López-Flores M, Pérez CA (2021) Physical activity, dietary habits and sleep quality before and during COVID-19 lockdown: a longitudinal study. Appetite 158:105019. https://doi.org/10.1016/j.appet.2020.105019
10. Cheval B, Sivaramakrishnan H, Maltagliati S et al (2020) Relationships between changes in self-reported physical activity, sedentary behaviour and health during the coronavirus (COVID-19) pandemic in France and Switzerland. J Sports Sci. https://doi.org/10.1080/02640414.2020.1841396
11. Qin F, Song Y, Nassis GP et al (2020) Physical activity, screen time, and emotional well-being during the 2019 novel coronavirus outbreak in China. Int J Environ Res Public Health. https://doi.org/10.3390/ijerph17145170
12. Robinson E, Gillespie S, Jones A (2020) Weight-related lifestyle behaviours and the COVID-19 crisis: An online survey study of UK adults during social lockdown. Obes Sci Pract 6:735–740. https://doi.org/10.1002/osp4.442

13. Błaszczyk-Bębenek E, Jagielski P, Bolesławska I et al (2020) Nutrition Behaviors in polish adults before and during COVID-19 lockdown. Nutrients. https://doi.org/10.3390/nu12103084
14. Brooks SK, Webster RK, Smith LE et al (2020) The psychological impact of quarantine and how to reduce it: rapid review of the evidence. The Lancet 395:912–920. https://doi.org/10.1016/S0140-6736(20)30460-8
15. Leng G, Adan RAH, Belot M et al (2017) The determinants of food choice. Proc Nutr Soc 76:316–327. https://doi.org/10.1017/S002966511600286X
16. Bel-Serrat S, Ojeda-Rodríguez A, Heinen MM et al (2019) Clustering of multiple energy balance-related behaviors in school children and its association with overweight and obesity-WHO European childhood obesity surveillance initiative (COSI 2015–2017). Nutrients. https://doi.org/10.3390/nu11030511
17. Catenacci VA, Ostendorf DM, Pan Z et al (2019) The impact of timing of exercise initiation on weight loss: an 18-month randomized clinical trial. Obes Silver Spring Md. https://doi.org/10.1002/oby.22624
18. Chang T, Ravi N, Plegue MA et al (2016) Inadequate hydration, BMI, and obesity among US adults: NHANES 2009–2012. Ann Fam Med 14:320–324. https://doi.org/10.1370/afm.1951
19. Stookey JD, Kavouras SA, Suh H, Lang F (2020) Underhydration is associated with obesity, chronic diseases, and death within 3 to 6 years in the U.S. population aged 51–70 years. Nutrients 12:905. https://doi.org/10.3390/nu12040905
20. Chudyk A, Petrella RJ (2011) Effects of exercise on cardiovascular risk factors in type 2 diabetes: a meta-analysis. Diabetes Care 34:1228–1237. https://doi.org/10.2337/dc10-1881
21. D'hooge R, Hellinckx T, Van Laethem C, et al (2011) Influence of combined aerobic and resistance training on metabolic control, cardiovascular fitness and quality of life in adolescents with type 1 diabetes: a randomized controlled trial. Clin Rehabil 25:349–359. https://doi.org/10.1177/0269215510386254
22. Daniels D (2016) Angiotensin II (de)sensitization: Fluid intake studies with implications for cardiovascular control. Physiol Behav 162:141–146. https://doi.org/10.1016/j.physbeh.2016.01.020
23. Melander O (2016) Vasopressin, from regulator to disease predictor for diabetes and cardiometabolic risk. Ann Nutr Metab 68(Suppl 2):24–28. https://doi.org/10.1159/000446201
24. Melander O (2017) Vasopressin: novel roles for a new hormone - Emerging therapies in cardiometabolic and renal diseases. J Intern Med 282:281–283. https://doi.org/10.1111/joim.12656
25. Carroll HA, Davis MG, Papadaki A (2015) Higher plain water intake is associated with lower type 2 diabetes risk: a cross-sectional study in humans. Nutr Res 35:865–872. https://doi.org/10.1016/j.nutres.2015.06.015
26. Small M, Bailey-Davis L, Morgan N, Maggs J (2013) Changes in eating and physical activity behaviors across seven semesters of college: living on or off campus matters. Health Educ Behav Off Publ Soc Public Health Educ 40:435–441. https://doi.org/10.1177/1090198112467801
27. Deforche B, Van Dyck D, Deliens T, De Bourdeaudhuij I (2015) Changes in weight, physical activity, sedentary behaviour and dietary intake during the transition to higher education: a prospective study. Int J Behav Nutr Phys Act 12:16. https://doi.org/10.1186/s12966-015-0173-9
28. Brunt A, Rhee Y, Zhong L (2008) Differences in dietary patterns among college students according to body mass index. J Am Coll Health 56:629–634. https://doi.org/10.3200/JACH.56.6.629-634
29. Shin N, Hyun W, Lee H et al (2012) A study on dietary habits, health related lifestyle, blood cadmium and lead levels of college students. Nutr Res Pract 6:340–348. https://doi.org/10.4162/nrp.2012.6.4.340
30. Nelson MC, Lust K, Story M, Ehlinger E (2009) Alcohol use, eating patterns, and weight behaviors in a University population. Am J Health Behav 33:227–237. https://doi.org/10.5993/AJHB.33.3.1
31. Demory-Luce D, Morales M, Nicklas T et al (2004) Changes in food group consumption patterns from childhood to young adulthood: the Bogalusa Heart Study. J Am Diet Assoc 104:1684–1691. https://doi.org/10.1016/j.jada.2004.07.026
32. Adams WM, Hevel DJ, Maher JP, McGuirt JT (2020) Racial and sex differences in 24 hour urinary hydration markers among male and female emerging adults: a pilot study. Nutrients 12:1068. https://doi.org/10.3390/nu12041068
33. Liao Y, Intille SS, Dunton GF (2015) Using ecological momentary assessment to understand where and with whom adults' physical and sedentary activity occur. Int J Behav Med 22:51–61. https://doi.org/10.1007/s12529-014-9400-z
34. Dunton GF, Whalen CK, Jamner LD, Floro JN (2007) Mapping the social and physical contexts of physical activity across adolescence using ecological momentary assessment. Ann Behav Med 34:144–153. https://doi.org/10.1007/BF02872669
35. Higgs S, Ruddock H (2020) Social Influences on Eating. In: Meiselman HL (ed) Handbook of Eating and Drinking: Interdisciplinary Perspectives. Springer International Publishing, Cham, pp 277–291
36. Robinson E, Blissett J, Higgs S (2013) Social influences on eating: implications for nutritional interventions. Nutr Res Rev 26:166–176. https://doi.org/10.1017/S0954422413000127
37. Fragala MS, Kraemer WJ, Denegar CR et al (2011) Neuroendocrine-immune interactions and responses to exercise. Sports Med Auckl NZ 41:621–639. https://doi.org/10.2165/11590430-000000000-00000
38. Freidenreich DJ, Volek JS (2012) Immune responses to resistance exercise. Exerc Immunol Rev 18:8–41
39. Gleeson M, Nieman DC, Pedersen BK (2004) Exercise, nutrition and immune function. J Sports Sci 22:115–125. https://doi.org/10.1080/02640410310001405590
40. Bishop NC, Blannin AK, Walsh NP et al (1999) Nutritional aspects of immunosuppression in athletes. Sports Med Auckl NZ 28:151–176
41. Fortes MB, Diment BC, Di Felice U, Walsh NP (2012) Dehydration decreases saliva antimicrobial proteins important for mucosal immunity. Appl Physiol Nutr Metab Physiol Appliquée Nutr Métabolisme 37:850–859. https://doi.org/10.1139/h2012-054
42. Leandro CG, Ferreira E, Silva WT, Lima-Silva AE (2020) Covid-19 and Exercise-Induced Immunomodulation. NeuroImmunoModulation. https://doi.org/10.1159/000508951
43. Stookey JD, Allu PKR, Chabas D et al (2020) Hypotheses about sub-optimal hydration in the weeks before coronavirus disease (COVID-19) as a risk factor for dying from COVID-19. Med Hypotheses 144:110237. https://doi.org/10.1016/j.mehy.2020.110237
44. Torales J, O'Higgins M, Castaldelli-Maia JM, Ventriglio A (2020) The outbreak of COVID-19 coronavirus and its impact on global mental health. Int J Soc Psychiatry 66:317–320. https://doi.org/10.1177/0020764020915212
45. Pfefferbaum B, North CS (2020) Mental health and the Covid-19 pandemic. N Engl J Med 383:510–512. https://doi.org/10.1056/NEJMp2008017
46. Copeland WE, McGinnis E, Bai Y et al (2021) Impact of COVID-19 pandemic on college student mental health and wellness. J Am Acad Child Adolesc Psychiatry 60:134-141.e2. https://doi.org/10.1016/j.jaac.2020.08.466
47. Fausnacht AG, Myers EA, Hess EL et al (2020) Update of the BEVQ-15, a beverage intake questionnaire for habitual beverage intake for adults: determining comparative validity and

reproducibility. J Hum Nutr Diet Off J Br Diet Assoc. https://doi.org/10.1111/jhn.12749
48. Godin G, Shephard RJ (1985) A simple method to assess exercise behavior in the community. Can J Appl Sport Sci J Can Sci Appl Au Sport 10:141–146
49. Godin G (2011) The Godin-Shephard Leisure-time physical activity questionnaire. Health Fit J Can 4:18–22. https://doi.org/10.14288/hfjc.v4i1.82
50. Amireault S, Godin G (2015) The Godin-Shephard Leisure-time physical activity questionnaire: validity evidence supporting its use for classifying healthy adults into active and insufficiently active categories. Percept Mot Skills 120:604–622. https://doi.org/10.2466/03.27.PMS.120v19x7
51. Garber CE, Blissmer B, Deschenes MR et al (2011) American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 43:1334–1359. https://doi.org/10.1249/MSS.0b013e318213fefb
52. R Core Team (2013) R: A Language and Environment for Statistical Computing
53. Streiner DL (2005) Finding our way: an introduction to path analysis. Can J Psychiatry 50:115–122. https://doi.org/10.1177/070674370505000207
54. Agostoni CV, Bresson JL, Fairweather-tait S et al (2010) Scientific opinion on dietary reference values for water. EFSA J. https://doi.org/10.2903/j.efsa.2010.1459
55. IOM Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. Washington, DC
56. Guelinckx I, Ferreira-Pêgo C, Moreno LA et al (2015) Intake of water and different beverages in adults across 13 countries. Eur J Nutr 54(Suppl 2):45–55. https://doi.org/10.1007/s00394-015-0952-8
57. Sims JNL, Holland JJ, Anderson T, Adams WM (2022) Daily fluid intake behaviors and associated health effects among Australian and United States populations. Front Sports Act Living. https://doi.org/10.3389/fspor.2022.898720
58. Zaplatosch ME, Bechke EE, Goldenstein SJ et al (2022) The influence Of menstrual cycle phase on fluid intake and urinary hydration markers: 1726. Med Sci Sports Exerc 54:419–420. https://doi.org/10.1249/01.mss.0000880340.18876.f2
59. Bertasi RAO, Humeda Y, Bertasi TGO, et al Caffeine intake and mental health in college students. Cureus 13:e14313. https://doi.org/10.7759/cureus.14313
60. McArthur LH, Raedeke TD (2009) Race and sex differences in college student physical activity correlates. Am J Health Behav 33:80–90. https://doi.org/10.5993/ajhb.33.1.8
61. Barkley JE, Lepp A, Glickman E et al (2020) The acute effects of the COVID-19 pandemic on physical activity and sedentary behavior in University students and employees. Int J Exerc Sci 13:1326–1339
62. Romero-Blanco C, Rodríguez-Almagro J, Onieva-Zafra MD et al (2020) Physical activity and sedentary lifestyle in University students: changes during confinement due to the COVID-19 pandemic. Int J Environ Res Public Health 17:E6567. https://doi.org/10.3390/ijerph17186567
63. Castañeda-Babarro A, Arbillaga-Etxarri A, Gutiérrez-Santamaría B, Coca A (2020) Physical activity change during COVID-19 confinement. Int J Environ Res Public Health 17:E6878. https://doi.org/10.3390/ijerph17186878
64. Steele J, Androulakis-Korakakis P, Carlson L et al (2021) The impact of coronavirus (COVID-19) related public-health measures on training behaviours of individuals previously participating in resistance training: a cross-sectional survey study. Sports Med Auckl NZ 51:1561–1580. https://doi.org/10.1007/s40279-021-01438-5
65. Woods JA, Hutchinson NT, Powers SK et al (2020) The COVID-19 pandemic and physical activity. Sports Med Health Sci 2:55–64. https://doi.org/10.1016/j.smhs.2020.05.006
66. Fawaz M, Samaha A (2021) E-learning: depression, anxiety, and stress symptomatology among Lebanese university students during COVID-19 quarantine. Nurs Forum (Auckl) 56:52–57. https://doi.org/10.1111/nuf.12521
67. Sugarman DE, Greenfield SF (2021) Alcohol and COVID-19: How do we respond to this growing public health crisis? J Gen Intern Med 36:214–215. https://doi.org/10.1007/s11606-020-06321-z
68. 2015–2020 Dietary Guidelines | health.gov. https://health.gov/our-work/food-nutrition/2015-2020-dietary-guidelines/guidelines/. Accessed 12 Jul 2020
69. Lechner WV, Laurene KR, Patel S et al (2020) Changes in alcohol use as a function of psychological distress and social support following COVID-19 related University closings. Addict Behav 110:106527. https://doi.org/10.1016/j.addbeh.2020.106527
70. Kenney EL, Long MW, Cradock AL, Gortmaker SL (2015) Prevalence of inadequate hydration among US children and disparities by gender and race/ethnicity: national health and nutrition examination survey, 2009–2012. Am J Public Health 105:e113-118. https://doi.org/10.2105/AJPH.2015.302572
71. Sohn EK, Porch T, Hill S, Thorpe RJ (2017) Geography, race/ethnicity, and physical activity among men in the United States. Am J Mens Health 11:1019–1027. https://doi.org/10.1177/1557988316689498
72. Watson KB, Whitfield G, Chen TJ et al (2021) Trends in aerobic and muscle-strengthening physical activity by race/ethnicity across income levels among US adults, 1998–2018. J Phys Act Health 18:S45–S52. https://doi.org/10.1123/jpah.2021-0260
73. Malisova O, Bountziouka V, Panagiotakos DB et al (2013) Evaluation of seasonality on total water intake, water loss and water balance in the general population in Greece. J Hum Nutr Diet Off J Br Diet Assoc 26(Suppl 1):90–96. https://doi.org/10.1111/jhn.12077
74. Westerterp KR, Plasqui G, Goris AHC (2005) Water loss as a function of energy intake, physical activity and season. Br J Nutr 93:199–203. https://doi.org/10.1079/bjn20041310
75. Heller KE, Sohn W, Burt BA, Eklund SA (1999) Water consumption in the United States in 1994–96 and implications for water fluoridation policy. J Public Health Dent 59:3–11. https://doi.org/10.1111/j.1752-7325.1999.tb03228.x