





ORIGINAL ARTICLE

Epidemiology/Genetics

Changes in body weight, health behaviors, and mental health in adults with obesity during the COVID-19 pandemic

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Abstract

Objective: The aim of this study was to examine the relationships between body weight changes, health behaviors, and mental health in adults with obesity during the second year of the COVID-19 pandemic.

Methods: Between March 1, 2021, and November 30, 2021, adults from three obesity practices completed an online survey. The primary outcomes were $\geq 5\%$ of body weight change since March 2020 and associated health behaviors and mental health factors.

Results: The sample ($n = 404$) was 82.6% female (mean age 52.5 years, mean BMI 43.3 kg/m²). Mean weight change was + 4.3%. Weight gain $\geq 5\%$ was reported by 30% of the sample, whereas 19% reported $\geq 5\%$ body weight loss. The degree of both weight gain and weight loss correlated positively with baseline BMI. Eighty percent of the sample reported difficulties with body weight regulation. Those who gained $\geq 5\%$ versus those who lost $\geq 5\%$ body weight were more likely to report higher levels of stress, anxiety, and depression; less sleep and exercise; less healthy eating and home-cooked meals; and more takeout foods, comfort foods, fast foods, overeating, and binge eating.

Conclusions: Weight gain in adults with obesity during the COVID-19 pandemic is associated with higher baseline BMI, deteriorations in mental health, maladaptive eating behaviors, and less physical activity and sleep. Further research is needed to identify effective interventions for healthier minds, behaviors, and body weight as the pandemic continues.

INTRODUCTION

The COVID-19 pandemic, caused by SARS-CoV-2, is entering its third year as the world endures the omicron variant surge. It has been well documented that people with obesity and related comorbidities, such as type 2 diabetes mellitus, are at greater risk for severe illness, hospitalization, and mortality from COVID-19 compared with individuals with a healthy weight [1–3]. This is alarming as the prevalence of

obesity in US adults is greater than 40%, and there is growing evidence for weight gain during the pandemic that is primarily affecting people with obesity [4].

Our group was among the first in the literature to document the impact of COVID-19-related lockdown orders on health behaviors and mental health in people with obesity [5]. Beyond perceived difficulties with weight loss and maladaptive eating behaviors, more than 70% of respondents noted increased stress, anxiety, and depression [5]. Additional studies have shown that increases in anxiety and depression are more pronounced in people with obesity compared

with those with a healthy BMI during the pandemic [6, 7]. The significant relationship between these new mental health pressures, dysfunctional health behaviors, and substance abuse was reported during a subsequent wave of the pandemic [8]. Researchers have found similar increases in maladaptive eating behaviors, decreases in physical activity, and worsening mental health in earlier waves of the pandemic, which were all associated with weight gain [9, 10]. Factors related to the pandemic have also been associated with attenuated weight loss from lifestyle interventions and metabolic and bariatric surgery (MBS) [11, 12].

Thus, it is crucial to understand the impact of the prolonged COVID-19 pandemic on health behaviors, mental health, and body weight in people with obesity. It is unclear whether the negative impacts on health documented early in the pandemic will diminish or intensify with the protracted duration of the pandemic. This data can inform health care providers on approaches to assess and manage the consequences of the pandemic to avoid further weight gain and morbidity in this at-risk population. We hypothesized that the COVID-19 pandemic has had a negative and durable impact on weight, which is largely driven by mental health and health behaviors.

METHODS

Design

The present study utilizes a cross-sectional design from a sample of convenience.

Population

All included participants were ≥ 18 years of age with BMI ≥ 30 . All participants were patients of one of the following (1) the University of Texas Southwestern Medical Center's Weight Wellness Program or (2) Bariatric Surgery Program or (3) a community bariatric surgery partner practice in Dallas, Texas and were seen for obesity treatment in the prior 2 years. Exclusion criteria were (1) current BMI < 30 and/or (2) not signing the informed consent to participate.

Procedures

An online, nonanonymous survey was implemented from March 1, 2021, through November 30, 2021. The University of Texas Health System Institutional Review Board approved the study. Patients were invited via email to participate in a 15-minute survey about the COVID-19 pandemic's impact on health and lifestyle behaviors in people with obesity. Participants signed an online consent and authorized contact for future studies. Data were collected and managed using a Research Electronic Data Capture (REDCap) web-based application hosted at the University of Texas Southwestern Medical Center [13].

Study Importance

What is already known?

- Studies early in the COVID-19 pandemic reported that lockdown measures were contributing to increases in body weight, stress, mental health issues, and maladaptive health behaviors. As we enter the third calendar year of the pandemic, it is unknown whether the pandemic is having a sustained impact on these factors in people with obesity.

What does this study add?

- We report the association between weight gain and high levels of self-reported stress, anxiety, depression, and maladaptive eating behaviors, as well as less sleep and physical activity, in adults with obesity during the prolonged COVID-19 pandemic. Almost 30% of the sample gained $\geq 5\%$ weight, and those with more severe obesity gained more weight.

How might these results change the direction of research or the focus of clinical practice?

- As the pandemic continues, people with obesity need to be evaluated for stress, anxiety, and depression to provide appropriate support and interventions. Our data can inform clinicians on which health behaviors to assess and patient groups that may be at greater risk for weight gain. This study highlights areas for future research on the impact of stress and the pandemic on people with obesity.

Measures

Participants were queried on factors that included demographics and what changes had occurred to their body weight, lifestyle factors, and physical and mental health from the beginning of the pandemic (March 2020) to the present (March 2021 to November 2021). The primary dependent variable of interest was body weight change $\geq 5\%$, and primary independent variables were health behaviors and psychological factors, such as anxiety and depression. Covariates included age, gender, education, and BMI.

Demographics

Demographic questions were based on the validated instrument the Behavioral Risk Factor Surveillance System (BRFSS), which is a US-based national public health survey [14] that has shown high reliability [15] and validity [16]. The BRFSS collects state data about health-

related risk behaviors and chronic health conditions [17]. It is the largest continuously conducted health survey system in the world [17]. Respondents are asked their gender, race/ethnicity, age, marital status, education level, and household income information. Age is reported in years and both height and weight without shoes are recorded. Sex is conceptualized within the core BRFSS as a biological variable and is determined by self-report [18]. The survey assesses changes in employment, including job loss, changes in work hours, essential worker designation, and work-from-home status.

Body weight

Participants were categorized according to self-reported changes in body weight during the pandemic as those who lost $\geq 5\%$ of their body weight (weight-loss group), maintained weight $\pm 4.9\%$ (weight-stability group), or gained $\geq 5\%$ of their body weight (weight-gain group) since March 2020.

Weight change

Participants reported their weight at the beginning of the pandemic (March 2020), their current body weight, and their highest and their lowest weights during the pandemic. Weight gain was defined as an increase $\geq 5\%$ of body weight, weight loss was defined as losing $\geq 5\%$ of body weight, and weight stability as maintaining a weight between these ranges ($\pm 4.9\%$). A body weight change of 5% was selected as previous research has shown that this degree of weight loss is sufficient to achieve clinically meaningful, positive health outcomes [19–21]. Percent body weight change was calculated as follows:

$$(\text{Current Weight} - \text{Weight in March 2020}) \times \frac{100}{\text{Weight in March 2020}}$$

COVID-19

COVID-19–related questions focused on history of testing, difficulty getting tested, and COVID-19 vaccination status.

Mental health, health behaviors, and food access

Mental health, health behaviors, and food access were assessed through questions adapted from standardized questionnaires. Specifically, disordered eating questions were guided by individual items from the Eating Disorder Examination Questionnaire Short [13], including (1) Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)? and (2) Have you had a strong desire to lose weight? Stress, anxiety, depression, sleep, and healthy eating were assessed via questions that asked respondents to compare their lifestyle and health behaviors before the COVID-19 pandemic with their

current behaviors. These questions included the following: (1) Do you eat more home-cooked meals?; (2) Do you eat more healthy meals?; (3) Do you eat more takeout or delivered food?; (4) Do you eat more comfort foods?; (5) Are you more likely to go out to buy (fast) food to get out of the house?; and (5) Has your level of stress, anxiety, and depression changed? Answers were on a Likert scale as follows: significantly less, slightly yes, unchanged, slightly more, significantly more, not applicable. For the analysis, significantly/slightly less and more were collapsed and compared with each other and those who answered no change.

Statistical analyses

Descriptive analysis was performed for baseline characteristics including age, sex (male or female), BMI categories (30–34.9, 35–39.9, and $\geq 40 \text{ kg/m}^2$), race/ethnicity (non-Hispanic white [NHW], non-Hispanic black [NHB], Hispanic, and other), education (some high school, high school graduate, some college or technical school, and college graduate), annual household income ($< \$25,000$, $\$25,000$ – $\$49,999$, $\$50,000$ – $\$74,999$, and $\geq \$75,000$), and COVID-19 factors (e.g., vaccine uptake). Median imputation was performed for patients missing weight information.

Pearson χ^2 and Fisher exact tests were used to compare changes in weight-related behaviors and psychological factors, such as difficulty with weight management, exercise, sleep, stress, anxiety, depression, and eating behaviors. Pairwise comparisons were also conducted to examine the between-group differences including (1) the weight-loss group versus the weight-gain group, (2) the weight-loss group versus the weight-stability group, and (3) the weight-gain group versus the weight-stability group. Univariate logistic regression models were built to calculate the odds ratios for weight gain versus no weight gain (the combination of the weight-loss and weight-stability group), using weight-related behaviors and psychological factors of interest as independent variables. Separate adjusted logistic regression models were built to examine the association between weight gain (Y/N) and each health behavior and mental health predictor (independent variable) while adjusting for age (continuous variable), gender (binary variable [male or female]), race/ethnicity (categorical variable [NHW, NHB, Hispanic, and other]), and education level (categorical variable [some high school, high school graduate, some college or technical school, and college graduate]). All statistical analyses were performed using SAS v9.4 (SAS Institute, Inc.) and a two-sided p value < 0.05 was considered significant.

Power analysis

A post hoc power analysis was conducted via the PROC POWER procedure in SAS v9.4. Weight gain (yes/no) was entered as the primary outcome with a binomial distribution, and depression or anxiety was entered as the covariates with an ordinal distribution. The results showed ample power (> 0.99) in the logistic regression models.

TABLE 1 Patient descriptive and weight characteristics

Variable	Total (n = 404)
Male, n (%)	66 (17.4)
Age (y), mean (SD)	52.5 (12.9)
Race, n (%)	
Non-Hispanic White	185 (49.7)
Non-Hispanic Black	96 (25.8)
Hispanic	70 (18.8)
Other	21 (5.7)
Education, n (%)	
Some high school	3 (0.8)
High school graduate	33 (8.7)
Some college or technical school	124 (32.7)
College graduate	219 (57.8)
Employment status	
Employed for wages	216 (57.1)
Self-employed	15 (4.0)
Retired	86 (22.8)
Unemployed/other	61 (16.1)
Annual household income, n (%)	
<\$25,000	41 (10.7)
\$25,000–49,999	76 (20.1)
\$50,000–74,999	77 (20.4)
≥\$75,000	184 (48.7)
Financial difficulties, n (%)	128 (40.0)
Work from home, n (%)	116 (28.7)
Completely	86 (74.1)
3–4 d/wk	15 (12.9)
1–2 d/wk	15 (12.9)
Insurance, n (%)	
Private insurance	243 (64.9)
Government	109 (29.1)
Other	22 (5.9)
COVID-19 vaccine, n (%)	282 (69.8)
Received first dose only	7 (2.5)
Received two doses	275 (97.5)
Current BMI, mean (SD)	43.3 (7.7)
30–34.9, n (%)	24 (5.9)
35–39.9, n (%)	87 (21.5)
≥40, n (%)	293 (72.5)
Difficulties with weight management, n (%)	265 (79.8)
Absolute weight change since pandemic (lb), mean (SD)	+4.2 (38.6)
Percent weight change since pandemic (%), mean (SD) ^a	+4.3 (26.0)
Weight change since pandemic by % group	
≤ –10%, ^a n (%)	35 (8.7)
–9.99% to –4.99%, ^a n (%)	44 (10.9)
–5% to 4.99%, ^a n (%)	207 (51.2)

(Continues)

TABLE 1 (Continued)

Variable	Total (n = 404)
+5% to 9.99%, ^a n (%)	59 (14.6)
≥ +10%, ^a n (%)	59 (14.6)

^aTotal body weight change was computed by (Current Weight – Weight in March 2020) × 100/Weight in March 2020.

Sensitivity analysis

To explore the potential impact of missing data, we compared the demographics of complete cases with those with missing information on health behaviors or psychological factors. The results imply there was no difference between missing and nonmissing groups at the α level of 5% (Supporting Information Table S1).

RESULTS

A total of 404 patients were enrolled in the COVID-19 and Obesity Phase III study from March 1, 2021, to November 30, 2021. The analyzed sample was 82.6% female, mean age was 52.5 years, and 49.7% identified as NHW, 25.8% NHB, 18.8% Hispanic, and 5.7% as “other” (e.g., multiracial, Asian). The majority (57.8%) were college graduates. Almost half of the sample (48.7%) had an annual household income > \$75,000, although almost 40% of the sample reported having financial difficulties. Approximately 60% reported being employed, with 4.0% of those being self-employed. More than one quarter (28.7%) of the sample were working from home/remotely. Most of the sample (69.8%) were vaccinated against COVID-19, and almost all (97.5%) had received the recommended vaccination course at the time of the survey. The mean BMI for our study sample was 43.3 kg/m² (SD 7.7), and 72.5% of participants had BMI ≥ 40 kg/m². Approximately 80% reported difficulties with weight management. Almost 30% of the sample reported gaining ≥ 5% of their body weight during the pandemic with 19% reporting ≥ 5% weight loss (Table 1). The average weight change during this period of the pandemic was + 4.3% with wide variability in weight changes as demonstrated in Figure 1.

When comparing those who gained ≥ 5% versus those with stable weight (± 4.9%) versus those who lost ≥ 5% body weight by various factors, results showed no differences with respect to age, gender, or race/ethnicity. The self-reported reasons for difficulty with weight management included stress (84.9%), anxiety (71.7%), boredom (62.3%), depression (56.2%), lack of sleep (46.4%), increased hunger (38.1%), closed gyms (36.6%), working from home (33.6%), lack of healthy food options (23.8%), finances (21.1%), taking care of children/family (20.4%), longer work hours (19.2%), lack of time (19.2%), and COVID-19 infection (9.2%).

In those who gained ≥ 5% body weight, weight gain was positively correlated with BMI ($r = 0.2948$, $p = 0.0014$) as demonstrated in Figure 2A. Meaning that the higher the BMI, the greater

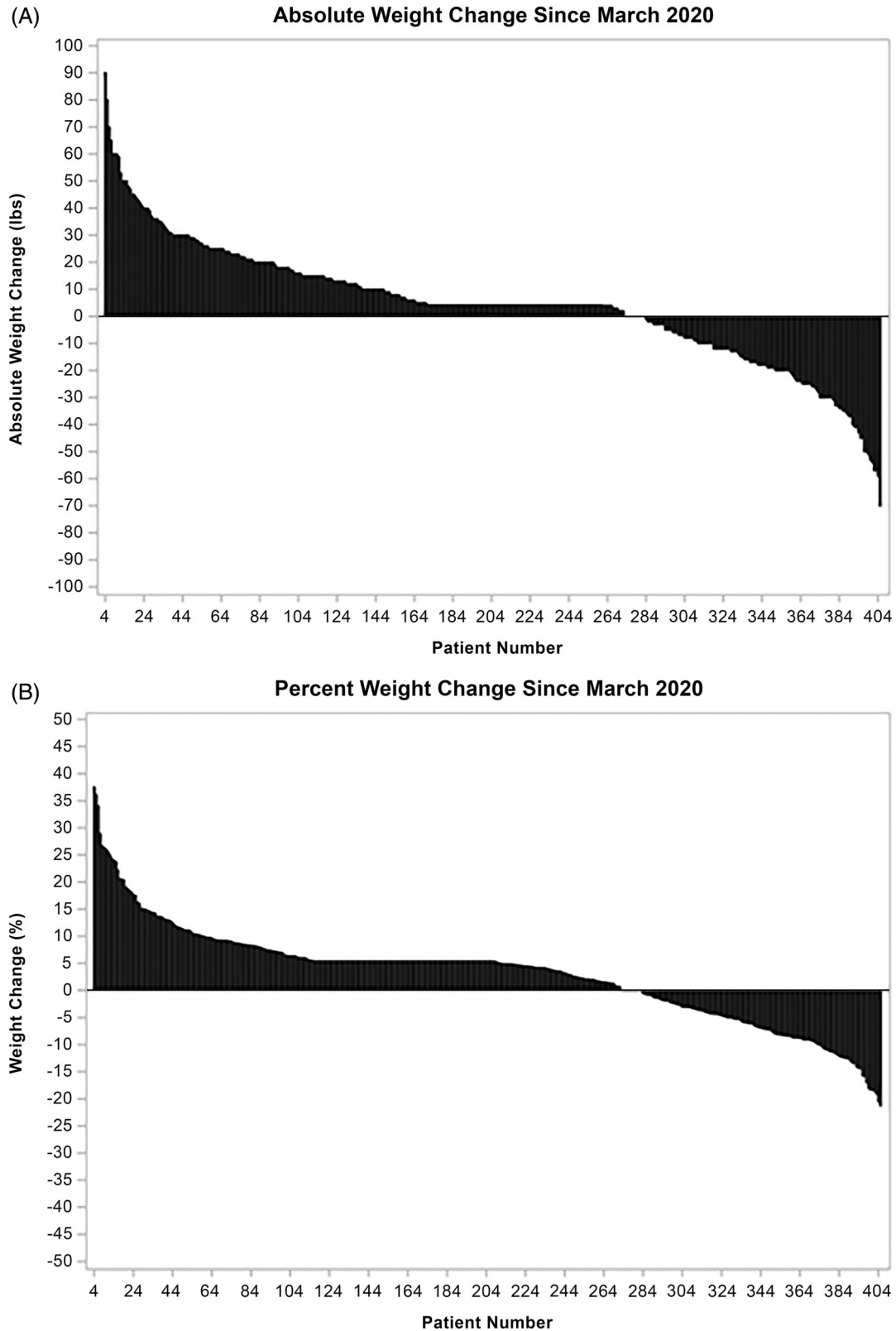


FIGURE 1 Waterfall plot of absolute and percent weight change during COVID-19 pandemic. Each bar represents one patient

weight gain during the evaluated period. On the contrary, Figure 2B showed a significant negative correlation between absolute weight loss and BMI in the weight-loss group ($r = -0.2522$,

$p = 0.0279$). The figure displays absolute weight loss on a negative scale, signifying that higher baseline BMI was associated with greater weight loss.

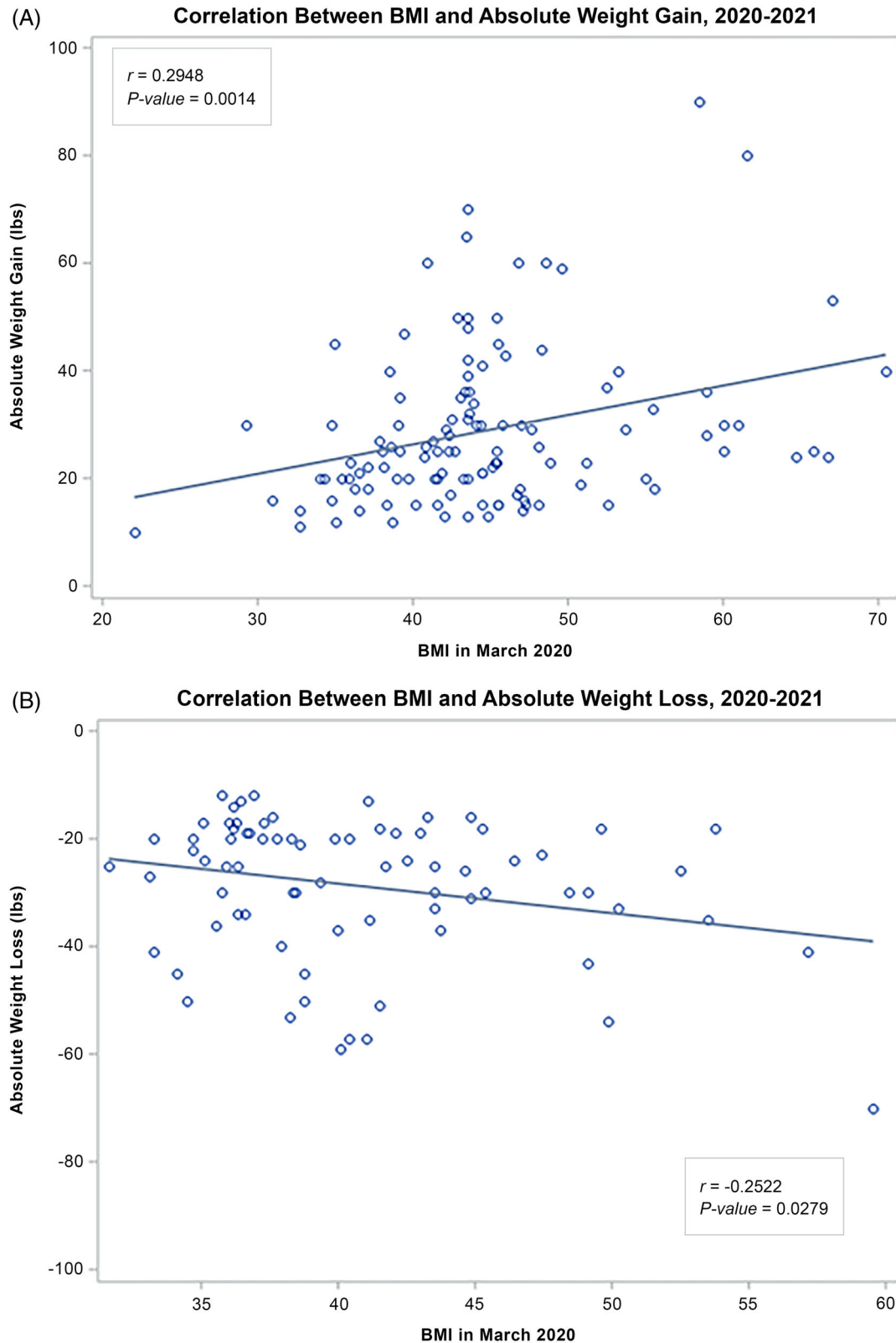


FIGURE 2 (A) Relationship between BMI and absolute weight gain in people who gained $\geq 5\%$ body weight. (B) Relationship between BMI and absolute weight loss in people who lost $\geq 5\%$ body weight [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

Furthermore, when comparing those who gained $\geq 5\%$ versus those who lost $\geq 5\%$ body weight, we noticed that more than double of the participants from the weight-gain group reported difficulties

with weight management (95.7% vs. 42.9%, $p < 0.001$) In addition, the weight-gain group reported more stress (91.5% vs. 66.7%, $p < 0.001$), anxiety (85.1% vs. 70.1%, $p = 0.018$), and depression (75.7% vs. 47.1%,

TABLE 2 Change in health behaviors and mental health by body weight change groups

	Body weight change groups, N (%)				p value ^f
	Total	Weight loss ≥ 5% (n = 79)	Weight stability (n = 207)	Weight gain ≥ 5% (n = 118)	
Age					
Mean (SD), y	52.6 (12.9)	51.4 (11.7)	53.1 (13.4)	52.2 (12.9)	0.580
Gender					
Male	66 (17.4)	17 (22.1)	27 (14.6)	22 (18.8)	0.140
Female	313 (82.6)	60 (77.9)	158 (85.4)	95 (81.2)	
Race					
NHW	185 (49.7)	31 (41.3)	89 (49.7)	65 (55.1)	0.166
NHB	96 (25.8)	22 (29.3)	49 (27.4)	25 (21.2)	
Hispanic	70 (18.8)	15 (20.0)	36 (20.1)	19 (16.1)	
Other	21 (5.7)	7 (9.3)	5 (2.8)	9 (7.6)	
Weight-loss goal^a					
Easier to achieve	32 (9.7)	24 (31.2)*,**	7 (5.1)**,**	1 (0.9)*,**	<0.001
Not affected	47 (14.2)	20 (26.0)*,**	23 (16.8)**,**	4 (3.4)*,**	
Harder to achieve	252 (76.1)	33 (42.9)*,**	107 (78.1)**,**	112 (95.7)*,**	
Stress^b					
Less	27 (8.2)	15 (19.2)*,**	9 (6.8)**	3 (2.6)*	<0.001
Unchanged	30 (9.1)	11 (14.1)*,**	12 (9.0)**	7 (6.0)*	
More	271 (82.6)	52 (66.7)*,**	112 (84.2)**	107 (91.5)*	
Anxiety^c					
Less	19 (5.9)	10 (13.0)*	7 (5.3)	2 (1.8)*	0.018
Unchanged	50 (15.5)	13 (16.9)*	22 (16.8)	15 (13.2)*	
More	253 (78.6)	54 (70.1)*	102 (77.9)	97 (85.1)*	
Depression^a					
Less	18 (6.0)	5 (7.1)*	13 (10.7)**	0 (0)*,**	<0.001
Unchanged	99 (33.1)	32 (45.7)*	41 (33.6)**	26 (24.3)*,**	
More	182 (60.9)	33 (47.1)*	68 (55.7)**	81 (75.7)*,**	
Sleep^b					
Less	146 (44.7)	23 (30.3)**	70 (51.9)**	53 (45.7)	0.018
Unchanged	81 (24.8)	25 (32.9)**	33 (24.4)**	23 (19.8)	
More	100 (30.6)	28 (36.8)**	32 (23.7)**	40 (34.5)	
Healthy eating^a					
Less	131 (39.9)	19 (24.1)*,**	53 (39.9)**	59 (50.9)*	<0.001
Unchanged	62 (18.7)	5 (6.3)*,**	35 (26.3)**	22 (18.9)*,	
More	135 (41.2)	55 (69.6)*,**	45 (33.8)**	35 (30.2)*	
Eat more home-cooked meals					
Yes	206 (51.0)	59 (74.7)*,**	87 (42.0)**	60 (50.9)*	<0.001
No	198 (49.0)	20 (25.3)*,**	120 (58.0)**	58 (49.2)*	
Eat more takeout/delivered food					
Yes	137 (33.9)	14 (17.7)*	53 (25.6)**	70 (59.3)*,**	<0.001
No	267 (66.1)	65 (82.3)*	154 (74.4)**	48 (40.7)*,**	
Comfort food^b					
Less	54 (16.4)	33 (42.3)*,**	16 (11.9)**,**	5 (4.3)*,**	<0.001
Unchanged	63 (19.2)	19 (24.4)*,**	32 (23.7)**,**	12 (10.3)*,**	
More	212 (64.4)	26 (33.3)*,**	87 (44.4)**,**	99 (85.3)*,**	

(Continues)

TABLE 2 (Continued)

	Body weight change groups, N (%)				p value ^f
	Total	Weight loss ≥ 5% (n = 79)	Weight stability (n = 207)	Weight gain ≥ 5% (n = 118)	
Fast food ^d					
Less	117 (36.0)	47 (61.0)*,**	47 (61.0)**,**	23 (19.8)*,**	<0.001
Unchanged	69 (21.2)	16 (20.8)*,**	33 (25.0)**,**	20 (17.2)*,**	
More	139 (42.8)	14 (18.2)*,**	52 (39.4)**,**	73 (62.9)*,**	
Overeating ^c					
Less	78 (24.4)	44 (58.7)*,**	23 (17.6)**,**	11 (9.7)*,**	<0.001
Unchanged	60 (18.8)	15 (20.0)*,**	33 (25.2)**,**	12 (10.5)*,**	
More	182 (56.9)	16 (21.3)*,**	75 (57.3)**,**	91 (79.8)*,**	
Binge eating ^e					
Less	65 (23.8)	38 (56.7)*,**	16 (14.7)**,**	11 (11.3)*,**	<0.001
Unchanged	82 (30.0)	15 (22.4)*,**	45 (41.2)**,**	22 (22.7)*,**	
More	126 (46.2)	14 (20.9)*,**	48 (44.0)**,**	64 (66.0)*,**	
Exercise time ^c					
Decreased	170 (51.1)	29 (36.7)*,**	72 (52.9)**	69 (58.5)*	<0.001
Unchanged	40 (12.0)	9 (11.4)*,**	19 (14.0)**	12 (10.2)*	
Increased	59 (17.7)	33 (41.8)*,**	19 (14.0)**	7 (5.9)*	
Do not exercise	64 (19.2)	8 (10.1)*,**	26 (19.1)**	30 (25.4)*	

*p < 0.05 for weight loss vs. weight gain. **p < 0.05 for weight loss vs. weight stability. ***p < 0.05 for weight gain vs. weight stability.

^aN_{missing} = 73.

^bN_{missing} = 72.

^cN_{missing} = 71.

^dN_{missing} = 74.

^eN_{missing} = 77.

^fANOVA for continuous variables and χ^2 test or Fisher exact test for categorical variables.

p < 0.001), alongside less sleep (45.7% vs. 30.3%, p = 0.018). The weight-gain group was also associated with less healthy lifestyle behaviors such as less healthy eating (50.9% vs. 39.9%, p < 0.001), less home-cooked meals (50.9% vs. 24.2%, p < 0.001), more take-out/delivered food (59.3% vs. 17.7%, p < 0.001), more comfort foods (85.3% vs. 33.3%, p < 0.001), more fast foods (62.9% vs. 18.2%, p < 0.001), overeating (79.8% vs. 21.3%, p < 0.001), binge eating (66.0% vs. 20.9%, p < 0.001), and decreased exercise time (58.5% vs. 36.7%, p < 0.001). Specific comparisons with the weight-stability group can be found in Table 2.

Fully adjusted logistic regression models showed that those who gained ≥ 5% versus those who lost ≥ 5% body weight were 9.5 times more likely to report difficulty with weight management (adjusted odds ratio [aOR] 9.52 95% CI: 3.21-28.23, p < 0.001). They were also more than two times as likely to report depression-related symptoms (aOR 2.23, 95% CI: 1.27-3.94, p < 0.006) and almost four times as likely to report consuming takeout meals (aOR 3.87, 95% CI: 2.41-6.23, p < 0.001) and higher comfort foods consumption (aOR 4.12, 95% CI: 42.01-8.42, p < 0.001), as well as three times more likely to report an increment in fast-food eating (aOR 2.74, 95% CI: 1.44-5.20, p = 0.002), overeating (aOR 3.43, 95% CI: 1.61-7.3, p = 0.001), and binge eating (aOR 3.10, 95% CI: 1.64-5.87, p < 0.001) (Table 3).

DISCUSSION

The COVID-19 pandemic continues to disrupt everyday life with successive surges in cases from new variants and social restrictions. These unpredictable and seemingly prolonged changes to routines, work situations, and prior liberties have contributed to a negative impact on health behaviors and mental wellbeing for people with obesity, which are also affecting body weight. Indeed, as we enter the third year of the pandemic, results here show that people with obesity continue to face mental health and health behavior challenges, especially those who have gained weight. These results have important implications for health care professionals who care for people with obesity. The impact of the pandemic on body weight is not limited to the initial lockdown period in the first half of 2020. These data provide evidence of a sustained negative effect beyond 2 years.

Our group was among the first in the literature to document the impact of the COVID-19 pandemic on health behaviors, mental health, and substance use in a diverse population with obesity [5, 8]. These data are impactful given the high prevalence of obesity and the potential for circumstances of the COVID-19 pandemic to negatively influence the health, behaviors, and body weight of people living with obesity [5, 8, 22]. Notably, our data show that there is a positive

TABLE 3 Crude and adjusted odds ratio for weight gain ≥ 5% vs. weight change < 5% by health behaviors and mental health status

Variable	Crude odds (95% CI) ^a	p value ^a	Adjusted odds (95% CI) ^b	p value ^b
Weight-loss goal				
Easier to achieve	0.35 (0.04-3.26)	0.354	0.37 (0.04-3.60)	0.393
Not affected	1.0 (ref)	—	1.0 (ref)	—
Harder to achieve	8.60 (3.0-24.68)	<0.001	9.52 (3.21-28.23)	<0.001
Exercise time				
Decreased	1.59 (0.76-3.35)	0.218	1.81 (0.84-3.92)	0.132
Unchanged	1.0 (ref)	—	1.0 (ref)	—
Increased	0.31 (0.11-0.89)	0.029	0.35 (0.12-1.01)	0.053
Do not exercise	2.06 (0.89-4.75)	0.090	4.04 (0.94-17.42)	0.073
Sleep				
Less	1.44 (0.80-2.59)	0.228	1.54 (0.82-2.87)	0.178
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	1.68 (0.90-3.15)	0.105	1.89 (0.98-3.66)	0.059
Stress				
Less	0.41 (0.10-1.78)	0.631	0.44 (0.10-1.97)	0.948
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	2.14 (0.89-5.17)	0.089	2.29 (0.91-5.75)	0.079
Anxiety				
Less	0.28 (0.05-1.34)	0.110	0.24 (0.05-1.22)	0.085
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	2.36 (0.97-5.75)	0.266	1.35 (0.67-2.72)	0.395
Depression				
Less	— ^c	0.965	— ^c	0.884
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	2.25 (1.32-3.84)	0.003	2.23 (1.27-3.94)	0.006
More home-cooked meals				
Yes	0.99 (0.65-1.52)	0.971	0.86 (0.54-1.36)	0.509
No	1.0 (ref)	—	1.0 (ref)	—
More takeout/delivery food				
Yes	4.77 (3.02-7.54)	<0.001	3.87 (2.41-6.23)	<0.001
No	1.0 (ref)	—	1.0 (ref)	—
Comfort food				
Less	0.43 (0.14-1.32)	0.142	0.44 (0.14-1.38)	0.159
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	3.72 (1.88-7.38)	<0.001	4.12 (2.01-8.42)	<0.001
Fast food				
Less	0.60 (0.30-1.20)	0.147	0.65 (0.32-1.33)	0.018
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	2.71 (1.46-5.03)	0.002	2.74 (1.44-5.20)	0.002
Healthy eating				
Less	1.49 (0.80-2.78)	0.210	1.67 (0.87-3.22)	0.124
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	0.64 (0.33-1.21)	0.171	0.66 (0.34-1.29)	0.227
Overeating				
Less	0.66 (0.27-1.61)	0.359	0.44 (0.16-1.23)	0.118
Unchanged	1.0 (ref)	—	1.0 (ref)	—

(Continues)

TABLE 3 (Continued)

Variable	Crude odds (95% CI) ^a	p value ^a	Adjusted odds (95% CI) ^b	p value ^b
More	4.0 (1.99-8.02)	<0.001	3.43 (1.61-7.30)	0.001
Binge eating				
Less	0.56 (0.25-1.25)	0.156	0.59 (0.25-1.40)	0.229
Unchanged	1.0 (ref)	—	1.0 (ref)	—
More	2.82 (1.54-5.13)	<0.001	3.10 (1.64-5.87)	<0.001

Note: Bolding indicates statistically significant ($p < 0.05$).

^aCrude logistic regression for each health behavior and mental health predictor.

^bSeparate models for each health behavior and mental health predictor adjusting for age, gender, race/ethnicity, and education level.

^cNot enough sample size to compute odds ratios.

correlation between baseline BMI and weight gain during the COVID-19 pandemic. This is alarming as rates of severe obesity were increasing prior to the pandemic [4].

It is notable that 80% of participants reported difficulty with weight management during the pandemic, whereas 29% reported $\geq 5\%$ weight gain, and 19.4% reported $\geq 5\%$ weight loss. These data are in line with other studies that have reported weight gain during the pandemic in the US population [23]. According to one study, 48% of American adults gained weight, compared with 18% who lost weight during the pandemic [23]. The more pronounced weight gain observed in the study is likely caused by different cutting points for weight gain, weight stability, and weight loss. Unlike our study, which used a $\pm 4.9\%$ weight change as stability, the aforementioned study considered weight stability if the participants reported that their body weight was unchanged. Therefore, direct comparisons with our results are not possible but indicated that in the general population, including those with BMI < 30 , more people have gained weight than lost [23, 24]. The majority of those who found weight loss more challenging attributed this difficulty to higher stress, anxiety, depression, and boredom.

Participants who gained $\geq 5\%$ body weight were more likely to report significantly higher stress, anxiety, and depression, as well as less sleep. Prior studies have described the relationship between weight gain and higher stress [25], depression [24], and anxiety [6] during this pandemic. Particularly, studies evaluating the mental health status of adults during the pandemic found a 9-fold increase in anxiety levels compared with before the pandemic [6]. Furthermore, this effect was greater in those with obesity [6]. Considering that our participants with obesity reported anxiety as one of the main reasons for difficulty with weight management, it is reasonable to assume that some of the difficulty in weight regulation during the pandemic can be partially explained by psychological factors such as a greater burden of anxiety.

Approximately 60% of those who gained $\geq 5\%$ body weight reported decreases in exercise time, whereas $> 25\%$ reported not exercising at all, which were significantly different to participants who lost weight. These results are consistent with earlier studies during the pandemic, which showed increased sedentary time and lower time and intensity of physical activity [6, 24]. Prior studies have shown a relationship between lower physical activity with depressive

symptoms, higher BMI, and lower self-efficacy in people with depression [26]. Similarly, studies in people with anxiety demonstrate a relationship between low levels of physical activity with poor sleep, unhealthy diet, and social isolation [27]. Studies performed earlier in the pandemic report that declines in mental health were due to the pandemic's predicted lower physical activity during lock-down [28]. Physical activity was likely also impacted by gym closures, masking, working from home, and other changes.

Over 90% of those who gained weight reported increased stress, which was statistically greater than those who lost weight. Psychological stress and sleep deprivation are associated with increased calorie intake and changes in self-care behaviors that make weight loss more difficult [29]. Additionally, depression and anxiety are thought to impact health practices and body weight through a variety of behavioral and neuroendocrine pathways [30, 31].

During the pandemic, many factors have changed the modality and the frequencies with which we purchase, order, prepare, and consume food. Those with $\geq 5\%$ weight gain were significantly more likely to not eat at home and to consume more takeout meals, fast food, and comfort foods. These participants had a greater likelihood of reporting more overeating and binge eating. This is consistent with a previous systematic review evaluating the global impact of COVID-19 on weight and weight-related behaviors in adults, which found weight gain to be associated with a 36% to 60% increase in total food consumption [32]. Knowing this allows health care providers to ask patients about patterns of food preparation and consumption that are high-risk for weight gain during the pandemic or times of increased stress.

These data demonstrate the persistent impact of the COVID-19 pandemic on mental health and health behaviors that were documented by this group during the first and second waves of the outbreak in 2020 [5, 8]. As we navigate through the current wave of the highly transmissible omicron variant of SARS-CoV-2, there have been renewed travel restrictions, work from home directives, and disruptions to daily life, which may exacerbate the deleterious effects on health behaviors, mental health, and body weight documented here [33].

Many experts believe that the COVID-19 pandemic will be with us for some time before becoming endemic [34]. Therefore, we must shift from being reactive to proactive in acknowledging the present

and potential future impact of the pandemic on the health of people with obesity. Health care providers should consider screening for stress, anxiety, depression, and substance-use disorders in addition to providing treatment and other resources as appropriate. Discussions with patients should include health behaviors, including nutrition habits and physical activity, in addition to the importance of sleep and self-care. People with obesity may benefit from additional psychosocial support systems and treatments that could be delivered, as appropriate and desired, via in-person, telehealth, or individual or group formats. Health care providers should not defer interventions until the pandemic is over as it will likely impact us for some time.

Future research needs to identify which factors are contributing to the increased stress and mental health challenges in people with obesity during the pandemic. It may be beneficial to explore influences such as the work-from-home environment, social isolation, and financial pressures. The differences in self-reported eating behaviors, especially overeating and binge eating, in those who gain weight needs further evaluation and classification with respect to disordered eating so that providers can deliver evidence-based interventions. Health systems need to identify people who are most at risk for unhealthy weight changes and behaviors in situations of chronic stress like the pandemic. In addition, we must identify the best ways to engage people to prevent and treat obesity with telehealth and other emerging platforms.

The main limitation of this study is that it uses self-reported body weight, health, and behavior data from a sample of convenience, which may lead to data misreporting and selection bias, respectively. Participants were enrolled primarily from an academic medical center's weight-management program. The majority were college-educated women with an average annual household income of \geq \$75,000, mean age of 52.5 years, and an average BMI within the class 3 obesity range. Accordingly, this study may not be generalizable to a population with a healthy weight or less severe obesity. Our data show that people who are relatively affluent, educated, and already engaged with obesity treatment teams have experienced serious mental health challenges and maladaptive health behaviors during the pandemic, which are associated with weight gain. An additional limitation was not having data on SARS-CoV-2 infection and COVID-19 illness, which may have resulted in residual confounding with some results. More research is needed to determine if those with fewer means, less health care engagement, and different health care access have been more significantly impacted by the COVID-19 pandemic. Findings may inform future policy decisions on public health and mental health services to avoid worsening health, health behaviors, and disparities in at-risk people with obesity. This is important as people with lower socioeconomic status are disproportionately impacted by obesity and COVID-19 [35]. Almost all participants had commercial or federal health insurance coverage, which may cover antiobesity medications or MBS. This is not representative of the average American with obesity, of whom < 2% receive antiobesity medications and < 1% undergo MBS, or those living in countries with different health care access and coverage for obesity therapies [36, 37]. Lastly, because we did not collect information regarding weight changes prior to the pandemic, it

is not possible for us to predict whether the changes in weight observed in our study differed from individual weight trajectories prior to March 2020. Strengths of the study include the presentation of novel data on the impact of the prolonged COVID-19 pandemic on health behaviors, mental health, and body weight in people with obesity that can inform evidence-based, comprehensive health care for this at-risk population.

CONCLUSION

Weight gain in adults with obesity during the COVID-19 pandemic is associated with higher baseline BMI, deteriorations in mental health, maladaptive eating behaviors, less physical activity, and sleep. Further research is needed to identify effective interventions for healthier minds, behaviors, and body weight as the pandemic continues.○

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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