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Research report

Obesity, eating behavior and physical activity during COVID-19 lockdown: A study of UK adults

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ABSTRACT

Eating, physical activity and other weight-related lifestyle behaviors may have been impacted by the COVID-19 crisis and people with obesity may be disproportionately affected. We examined weight-related behaviors and weight management barriers among UK adults during the COVID-19 social lockdown. During April–May of the 2020 COVID-19 social lockdown, UK adults (N = 2002) completed an online survey including measures relating to physical activity, diet quality, overeating and how mental/physical health had been affected by lockdown. Participants also reported on perceived changes in weight-related behaviors and whether they had experienced barriers to weight management, compared to before the lockdown. A large number of participants reported negative changes in eating and physical activity behavior (e.g. 56% reported snacking more frequently) and experiencing barriers to weight management (e.g. problems with motivation and control around food) compared to before lockdown. These trends were particularly pronounced among participants with higher BMI. During lockdown, higher BMI was associated with lower levels of physical activity and diet quality, and a greater reported frequency of overeating. Reporting a decline in mental health because of the COVID-19 crisis was not associated with higher BMI, but was predictive of greater overeating and lower physical activity in lockdown. The COVID-19 crisis may have had a disproportionately large and negative influence on weight-related behaviors among adults with higher BMI.

1. Introduction

The worldwide COVID-19 pandemic has already caused a considerable public health burden. During March–April 2020 there were more than 30,000 deaths attributable to coronavirus in the UK alone (National Records of Scotland, 2020; Office of National Statistics, 2020). On the 23rd March, the UK government introduced formal social lockdown measures to restrict the spread of the virus. The COVID-19 crisis and social lockdown measures to limit virus transmission are likely to have had considerable social consequences beyond the direct death toll attributable to COVID-19 (Brooks et al., 2020; Shevlin et al., 2020). For example, the percentage of UK adults experiencing a significant mental health problem is estimated to have risen by approximately 50% based on nationally representative data collected before and during COVID-19 lockdown (Daly, Sutin, & Robinson, 2020).

The impact that the COVID-19 crisis has had on weight-related behaviors, including healthy eating and physical activity is unclear, but

may be substantial (Pearl, 2020). During the pandemic, supply chain disruption and panic buying may have limited access to fresh foods, increasing reliance on unhealthier foods with longer shelf lives (Tan et al., 2020). In the UK, access to weight management and bariatric surgery services has also been impacted by the virus as many outpatient clinics and elective operations were postponed due to National Health Service (NHS) England guidance to maximise critical care and respiratory support capacity for COVID-19 patients (NHS, 2020). Likewise, people may have been reluctant to exercise in public because of concerns about potential infection.

A study of 41 children and adolescents with obesity in Italy found that compared to data collected in 2019, three weeks into social lockdown participants reported less time exercising and increased consumption of ‘unhealthy’ junk foods (Pietrobelli et al., 2020). In a UK study, adults with obesity were more likely to report that they believed that a limited number of behaviors typically protective against weight gain (e.g. physical activity) had declined compared to before lockdown

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(Robinson, Gillespie, & Jones, 2020), although neither of these studies included validated or widely used measures of physical activity, diet quality or overeating collected during social lockdown. Moreover, the importance of studying weight-related behaviors and understanding barriers to weight management during the COVID-19 crisis is highlighted by higher BMI being associated with an increased risk of hospitalisation and death from coronavirus (Garg et al., 2020; Klang et al., 2020).

The aim of the present study was to examine perceived changes (before vs. during social lockdown) to a range of weight-related behaviors in a large sample of UK adults during social lockdown, as well as to examine whether there have been common barriers to weight management because of the COVID-19 crisis. In addition, we examined physical activity levels, diet quality and problematic overeating during lockdown in order to investigate factors associated with and potentially contributing to reduced levels of physical activity and less healthy eating during the COVID-19 crisis. Because people living with obesity may be disproportionately affected by lockdown measures (e.g. due to risk-based shielding measures and reduced access to weight management services) (Bhutani & Cooper, 2020), a focus of the present work was to examine the extent to which higher BMI is associated with weight management-related barriers and behaviours during COVID-19 lockdown. In line with (Robinson et al., 2020), we predicted that higher BMI may be associated with negative changes in weight-related behaviors and experiencing more barriers to weight management due to the COVID-19 crisis.

2. Method

2.1. Sample

Eligibility criteria were: aged 18 years or above, fluent in English, current UK resident. Participants were recruited from an online panel provider (Prolific Researcher Peer, Brandimarte, Samat, & Acquisti, 2017) and through online advertisement (e.g. social media) targeted at weight management groups and mailing lists. We recruited paid participants through Prolific Researcher (£1.25) and stratified recruitment by gender (50-50). We also stratified recruitment in Prolific to be roughly equivalent to UK obesity prevalence (Health Survey for England resources, 2018) based on self-reported BMI (~30% \geq 30 kg/m²), in order to be able to compare participants with obesity to participants with 'normal' weight (based on BMI). Participants recruited through online advertisement were incentivised by being given the option of entry into a prize draw (£250). All data were collected during 28th April-22nd May 2020. Social lockdown in the UK commenced 23rd March and during the period of data collection, social lockdown restrictions remained in place and included school closures, non-essential travel, meeting members of other households and closure of all non-essential businesses. The study was approved by the University of Liverpool Research Ethics Committee. See <https://osf.io/h7mrn/> for the pre-registered protocol and analysis plan. Because analyses were exploratory we did not conduct a formal power analysis, although we aimed to recruit a minimum of 1000 participants from Prolific and to advertise via social media for up to 4 weeks.

2.2. Measures

All study questionnaire measures are available in full at <https://osf.io/h7mrn/>. For detailed scoring information of all questionnaire data, see online supplementary materials. After providing consent, participants completed demographic measures (see Table 1), including self-reported weight and height. Participants also reported on whether they would normally be accessing weight management services and whether they had ever been diagnosed with a psychiatric condition (e.g. depression). Next participants completed items on whether they had been formally diagnosed or suspected they previously/currently had

Table 1
Sample characteristics.

	M (SD)/N (%)
Age (years)	34.74 (12.3)
Gender (female) ^a	1236 (61.7%)
Degree level education (yes)	1311 (65.5%)
Household income (£)	47, 558 (56,123)
Ethnicity (white)	1796 (89.7%)
Previous psychiatric condition diagnosis	649 (32.4%)
At risk medical group for COVID	486 (24.3%)
Diagnosed or suspected COVID diagnosis	331 (16.5%)
BMI (kg/m ²)	27.8 (7.2)
BMI < 18.5 kg/m ²	62 (3.1%)
BMI 18.5–24.9 kg/m ²	794 (39.7%)
BMI 25–29.9 kg/m ²	508 (25.4%)
BMI 30–34.9 kg/m ²	337 (16.8%)
BMI 35 kg/m ² and above	301 (15.0%)
Normally accessing weight management	235 (11.7%)
IPAQ (metabolic equivalent minutes)	2443 (2316)
WHO well-being percentage score	47.5 (20.7)
WHO cut off for 'low well-being' (<13)	1058 (52.8%)

^a Prefer not to say or non-binary gender (n = 10).

COVID-19 and indicated if they had any of 10 medical conditions (e.g. diabetes, weakened immune system, BMI \geq 40 kg/m²) identified by the UK NHS (NHS, 2020) as 'high risk' for COVID-19. In a randomized order, participants next completed the questionnaires below. The survey also included attention check questions to identify any participants responding randomly.

2.3. Perceived changes since COVID-19 lockdown

Participants were asked 'Compared to before the COVID-19 lockdown in the UK, I have' and using a 7-point response scale (1 = A lot less frequently, 4 = The same amount, 7 = A lot more frequently) responded to 11 items on behaviors related to weight management (e.g. 'snacked', 'exercised'), followed by 19 items on the extent to which participants had experienced barriers/facilitators to healthy eating and physical activity (e.g. 'Been motivated to eat healthily', 'Had time to exercise') compared to before lockdown (7 point Likert response scale, Strongly Disagree to Strongly Agree). Participants also completed 10 items on mental/physical health and interpersonal experiences compared to before lockdown (e.g. 'Felt lonely', 'Had conflict/arguments with others') using a 7-point scale (1 = A lot less frequently, 7 = A lot more frequently).

2.4. Physical activity, diet quality, overeating and well-being during lockdown

Participants completed the International Physical Activity Questionnaire (IPAQ), reporting on amount of vigorous (e.g. aerobics) and moderate activity (e.g. bicycling), walking and sitting during the previous 7 days (Sjostrom et al., 2005) and we calculated total number of metabolic equivalent (MET) minutes. Participants completed a UK-based short 13 item food frequency questionnaire (SFFQ) in which consumption frequencies of 'healthy' and 'unhealthy' key food groups (e.g. fruit, vegetables, wholegrains, sugary drinks, processed meat) during the last week are measured (Green et al., 2016). To characterise overeating, participants completed the 8-item Appetitive Drive subscale of the Addiction-Like Eating Behavior Scale (Ruddock, Christiansen, Halford, & Hardman, 2017), reporting on the last week (e.g. 'I binged when eating', 5 item response scale of 'Never' to 'Always'). Participants also completed the 5 item WHO (Topp et al., 2015) well-being scale (e.g. 'I have felt cheerful and in good spirits') reporting on feelings experienced during the last week using a 6-point response format ('All of the time' to 'At no time').

2.5. Main planned analyses

To examine whether participant demographics were associated with perceived changes in weight management relevant behaviors compared to before lockdown, we scored each behavior (see Table 2) from 1 to 7 based on response options (higher scores indicating worsening of weight management behavior), reverse scoring the following items: eaten a healthy and balanced diet, dieted/fasted, used weight control products, exercised, been physically active and got a good night's sleep) and summed scores across the 11 weight management-related items (to provide an overall pattern of change). We used linear regression to predict changes in weight management-related behavior, with the following demographic predictor variables: gender, age, ethnicity (white vs. not), education level (degree vs. not), household income, previous diagnosis of psychiatric condition (yes vs. no), accessing weight management support prior to lockdown (yes vs. no), formal or suspected diagnosis of COVID-19 (yes vs. no), BMI category (<18.5, 18.5–24.9 [reference category], 25–29.9, 30–34.9 and ≥ 35 kg/m²), high risk health condition (yes vs. no). Significance was set at p < .05.

We next examined whether participant characteristics and mental/physical health and interpersonal consequences of COVID-19 were associated with measures of physical activity, diet quality, and over-eating during lockdown. We used the 'felt lonely, depressed, anxious, felt like harming myself, had suicidal thoughts' perceived change items to create an overall composite score of negative mental health consequences of COVID-19 lockdown. To create a summary measure of negative interpersonal consequences of COVID-19 lockdown we totalled score on 'had conflict/arguments with others, been verbally or physically abused by others, felt socially connected to others (reverse scored)'. We also used the 'experienced (more) physical health symptoms' as a measure of physical health consequences of COVID-19. We used hierarchical regression analysis and in the first step of each model we entered COVID-19 lockdown negative mental health consequences, negative interpersonal consequences and physical health consequences, alongside participant characteristics and BMI (continuous). In a second step of each model we included interaction terms between BMI and each of the COVID-19 consequences variables to examine whether the effects of these predictor variables on outcomes varied by BMI. We treated BMI as a continuous variable in analyses to minimize the number of interaction terms included in models and maximise statistical power. Significance was set at p < .01 to account for the relatively large number of variables and models.

3. Results

3.1. Sample

A total of 2364 participants were recruited into the study, 1260 from Prolific and 1104 recruitment via social media. Removal of 23 participants who were not eligible (e.g. not UK adults), 58 participants who failed attention checks, 271 participants who did not complete the

survey, 8 participants who provided implausible weight/height data and 2 participants with implausible physical activity data (see online supplementary materials), resulted in a final sample size of N = 2002. Sample characteristics are reported in Table 1. BMI was largely representation of the UK population (32% of the sample were classed as having obesity).

3.2. Perceived changes since COVID-19 lockdown

Participants' perception of changes in weight-related behaviors and barriers to healthy eating and physical activity are reported in Tables 2 and 3. For perceived changes in mental/physical health and interpersonal outcomes, see Table 4.

Table 3
Weight management barriers and facilitators ('compared to before the COVID-19 lockdown in the UK, I have').

	Disagree Response ^a	Agree Response ^a	Unsure
Eaten more because of my feelings	986 (49%)	847 (42%)	169 (8%)
Eaten less because of my feelings	1282 (64%)	520 (26%)	200 (10%)
Felt in control of my eating	718 (36%)	1076 (54%)	208 (10%)
Been able to access healthy food	362 (18%)	1547 (77%)	93 (5%)
Been able to access physical space to exercise	529 (26%)	1409 (70%)	64 (3%)
Been able to afford healthy food	325 (16%)	1577 (79%)	100 (5%)
Been able to plan healthy meals	358 (18%)	1546 (77%)	98 (5%)
Known how to eat healthily in the current circumstances	213 (11%)	1661 (83%)	128 (6%)
Known how to stay active in the current circumstances	268 (13%)	1641 (82%)	93 (5%)
Had time to eat healthily	181 (9%)	1753 (88%)	68 (3%)
Had time to exercise	253 (13%)	1698 (85%)	51 (3%)
Had unhealthy food in the house	303 (15%)	1654 (83%)	45 (2%)
Been motivated to eat healthily	773 (39%)	1091 (55%)	138 (7%)
Been motivated to exercise	765 (38%)	1145 (57%)	92 (5%)
Fallen back into unhealthy eating habits	897 (45%)	985 (49%)	120 (6%)
Fallen back into habits of exercising less	965 (48%)	944 (47%)	93 (5%)
Been able to access weight management support (e.g. weight loss group) ^b	100 (43%)	113 (48%)	22 (9%)
Been supported by others to eat healthily	901 (45%)	852 (43%)	249 (12%)
Been supported by others to be physically active	730 (37%)	1080 (54%)	192 (10%)

^a Strongly disagree/agree, disagree/agree, disagree/agree somewhat collapsed.

^b Data reported only for participants reporting use of weight management support prior to lockdown (n = 235).

Table 2
Weight management behaviors ('compared to before the COVID-19 lockdown in the UK, I have').

	A lot less	Less	A little less	The same amount	A little More	More	A lot more
Eaten a healthy and balanced diet	121 (6%)	236 (12%)	331 (17%)	620 (31%)	347 (17%)	233 (12%)	114 (6%)
Eaten large meals or snacks	67 (3%)	166 (8%)	205 (10%)	687 (34%)	512 (26%)	289 (14%)	76 (4%)
Snacked	101 (5%)	160 (8%)	191 (10%)	434 (22%)	537 (27%)	415 (21%)	164 (8%)
Dieted/fasted	234 (12%)	238 (12%)	181 (9%)	964 (48%)	165 (8%)	118 (6%)	102 (5%)
Skipped meals	218 (11%)	227 (11%)	184 (9%)	897 (45%)	242 (12%)	148 (7%)	86 (4%)
Used weight control products (e.g. meal replacements)	165 (8%)	67 (3%)	32 (2%)	1674 (84%)	27 (1%)	22 (1%)	15 (1%)
Exercised	216 (11%)	276 (14%)	308 (15%)	309 (15%)	392 (20%)	307 (15%)	194 (10%)
Been physically active (e.g. gardening)	200 (10%)	231 (12%)	232 (12%)	410 (21%)	482 (24%)	318 (16%)	129 (6%)
Spent time sitting down	10 (1%)	41 (2%)	93 (5%)	393 (20%)	398 (20%)	558 (28%)	509 (25%)
Drank alcohol	279 (14%)	154 (8%)	122 (6%)	744 (37%)	332 (17%)	234 (12%)	137 (7%)
Got a good night's sleep	148 (7%)	279 (14%)	379 (19%)	607 (30%)	258 (13%)	216 (11%)	115 (6%)

Table 4
Mental/physical health and interpersonal outcomes ('Compared to before the COVID-19 lockdown in the UK, I have').

	A lot less	Less	A little less	Same amount	A little more	More	A lot more
Felt lonely	96 (5%)	111 (6%)	96 (5%)	642 (32%)	519 (26%)	353 (18%)	185 (9%)
Felt depressed	94 (5%)	112 (6%)	108 (5%)	756 (38%)	522 (26%)	273 (14%)	137 (7%)
Felt anxious	86 (4%)	76 (4%)	139 (7%)	543 (27%)	539 (27%)	400 (20%)	219 (11%)
Felt like harming myself	86 (4%)	39 (2%)	36 (2%)	1724 (86%)	62 (3%)	32 (2%)	23 (1%)
Had suicidal thoughts	121 (6%)	55 (3%)	31 (2%)	1638 (82%)	91 (5%)	33 (2%)	33 (2%)
Experienced physical health symptoms	193 (10%)	98 (5%)	112 (6%)	1137 (57%)	305 (15%)	119 (6%)	38 (2%)
Had conflict/arguments with others	166 (8%)	131 (7%)	163 (8%)	807 (40%)	500 (25%)	178 (9%)	57 (3%)
Been verbally or physically abused by others	220 (11%)	62 (3%)	44 (2%)	1564 (78%)	75 (4%)	25 (1%)	12 (1%)
Felt bad about my weight	48 (2%)	59 (3%)	99 (5%)	810 (41%)	440 (22%)	323 (16%)	223 (11%)
Felt socially connected to others	315 (16%)	436 (22%)	456 (23%)	449 (22%)	244 (12%)	81 (4%)	21 (1%)

3.3. Predictors of perceived weight management behavior change

See Table 5 for full results. Significant independent predictors of less favourable weight management behavior change since lockdown were being of lower education level, being white, having been diagnosed with a psychiatric condition, having class II obesity and above (BMI ≥35 kg/m²), having a high-risk medical condition and having had a case of suspected/diagnosed COVID. Being in the overweight BMI category (p = .055) and class 1 obesity (BMI 30–34.9 kg/m², p = .070) were both non-significantly associated with less favourable weight management-related behaviors since lockdown. None of the other variables were significant. We also repeated the analysis examining perceived changes in eating behavior and physical activity items only and results were similar (i.e. class II obesity and above was associated with less favourable perceived change to eating and physical activity). See Table 5.

3.4. Diet quality during lockdown

Being male, younger, lower in education, white and having a higher BMI were all (independently) significantly associated with lower diet quality during lockdown (ps < .01). See Table 6.

Table 5
Predictors of less favourable changes in weight-related behaviors (perceived change).

	Perceived decrease in weight protective behaviors (all) ^a	Perceived decline in healthier eating behaviors ^b	Perceived decrease in physical activity behaviors ^c
	Adjusted R ² = .048	Adjusted R ² = .037	Adjusted R ² = .026
Age	β = -.022, p = .361	β = .011, p = .643	β = -.069, p = .004*
Gender (female)	β = .038, p = .093	β = .026, p = .245	β = .004, p = .865
Degree level education (yes)	β = -.069, p = .003*	β = -.082, p < .001*	β = -.026, p = .259
Household income (£)	β = -.018, p = .416	β = .008, p = .728	β = -.050, p = .024*
Ethnicity (not white)	β = -.045, p = .043*	β = -.045, p = .042*	β = .000, p = .998
Previous psychiatric diagnosis (yes)	β = .095, p < .001*	β = .031, p = .179	β = .086, p < .001*
At risk medical group for COVID (yes)	β = .049, p = .043*	β = .022, p = .375	β = .077, p = .002*
Diagnosed/suspected COVID (yes)	β = .050, p = .025*	β = .051, p = .020*	β = .025, p = .254
Normally accessing weight management (yes)	β = .037, p = .111	β = .087, p < .001*	β = -.012, p = .621
BMI < 18.5 kg/m ²	β = .018, p = .414	β = -.018, p = .438	β = .024, p = .286
BMI 25–29.9 kg/m ²	β = .047, p = .055	β = .033, p = .181	β = .017, p = .490
BMI 30–34.9 kg/m ²	β = .047, p = .070	β = .038, p = .133	β = .027, p = .309
BMI ≥ 35 kg/m ²	β = .114, p < .001*	β = .080, p = .003*	β = .078, p = .004*

For BMI categories, BMI 18.5–24.9 is the reference category.

*significant based on planned analysis strategy (p < .05).

N = 1992 (10 participants data excluded from model based on non-binary gender).

^a Perceived changes in 'eaten a healthy and balanced diet' (reversed), 'eaten large meals or snacks', 'snacked', 'dieted/fastened' (reversed), 'skipped meals', 'used weight control products' (reversed), 'exercised' (reversed), 'been physically active' (reversed), 'spent time sitting down', 'drank alcohol' and 'got a good night's sleep' (reversed) totalled.

^b Perceived changes in 'eaten a healthy and balanced diet' (reversed), 'eaten large meals or snacks', 'snacked', 'dieted/fastened' (reversed) totalled.

^c Perceived changes in 'exercised', 'been physically active', 'spent time sitting down' (reversed) totalled.^a Perceived changes in 'eaten a healthy and balanced diet' (reversed), 'eaten large meals or snacks', 'snacked', 'dieted/fastened' (reversed), 'skipped meals', 'used weight control products' (reversed), 'exercised' (reversed), 'been physically active' (reversed), 'spent time sitting down', 'drank alcohol' and 'got a good night's sleep' (reversed) totalled.

3.5. Overeating during lockdown

Being younger, female, lower in education, having a previous psychiatric diagnosis, having had suspected/confirmed COVID-19, higher BMI and experiencing negative mental health since lockdown were (independently) significantly associated with increased overeating during lockdown. See Table 6.

3.6. Physical activity during lockdown

Lower income, being non-white, having a high-risk medical condition, higher BMI, experiencing negative mental health and increased physical health symptoms since lockdown were all (independently) significantly associated with lower physical activity levels during lockdown. None of the COVID-19 lockdown consequence variables significantly interacted with BMI in any of the models. See Table 6.

3.7. Further analyses: Principal components analysis (PCA) of perceived weight management barriers and perceived mental health change

We conducted PCA on the COVID-19 wt management barrier questionnaire items to identify clusters of weight management barriers.

Table 6
Predictors of physical activity, diet quality and overeating in lockdown.

Step 1	Physical activity (MET minutes)	Diet quality (total score on FFQ)	Overeating (Appetitive drive subscale)
	Adjusted R ² = .066	Adjusted R ² = .092	Adjusted R ² = .156
Age	$\beta = .049, p = .037$	$\beta = .212, p < .001^*$	$\beta = -.084, p < .001^*$
Gender (female)	$\beta = -.039, p = .082$	$\beta = .150, p < .001^*$	$\beta = .058, p = .006^*$
Degree level education (yes)	$\beta = -.024, p = .278$	$\beta = .091, p < .001$	$\beta = -.075, p < .001^*$
Household income (£)	$\beta = .072, p = .001^*$	$\beta = .012, p = .567$	$\beta = -.010, p = .628$
Ethnicity (not white)	$\beta = -.073, p = .001^*$	$\beta = .075, p = .001^*$	$\beta = -.013, p = .548$
Previous psychiatric diagnosis (yes)	$\beta = -.049, p = .030$	$\beta = -.013, p = .544$	$\beta = .067, p = .002^*$
At risk medical group for COVID (yes)	$\beta = -.066, p = .007^*$	$\beta = -.019, p = .423$	$\beta = -.009, p = .695$
Diagnosed/suspected COVID (yes)	$\beta = .039, p = .078$	$\beta = -.016, p = .467$	$\beta = .059, p = .004^*$
BMI	$\beta = -.132, p < .001^*$	$\beta = -.167, p < .001^*$	$\beta = .361, p < .001^*$
COVID mental health decline (perceived)	$\beta = -.083, p = .001^*$	$\beta = -.036, p = .151$	$\beta = .075, p = .002^*$
COVID interpersonal decline (perceived)	$\beta = .011, p = .670$	$\beta = -.046, p = .058$	$\beta = .032, p = .169$
COVID physical health decline (perceived)	$\beta = -.106, p < .001^*$	$\beta = -.054, p = .022$	$\beta = .013, p = .627$
Step 2	Adjusted R ² = .065	Adjusted R ² = .092	Adjusted R ² = .155
BMI*COVID mental health decline	$\beta = -.027, p = .273$	$\beta = -.002, p = .926$	$\beta = .023, p = .340$
BMI* COVID interpersonal decline	$\beta = -.003, p = .896$	$\beta = -.033, p = .183$	$\beta = -.008, p = .746$
BMI* COVID physical health decline	$\beta = .022, p = .355$	$\beta = .023, p = .326$	$\beta = .007, p = .760$

*significant based on planned analysis strategy ($p < .01$).

Higher MET scores = more active, higher diet quality scores = better quality of diet, higher overeating scores = more frequent overeating.

N = 1992 (10 participants data excluded from model based on non-binary gender).

There were 3 main clusters relating to *difficulties in accessing healthy food*, *lack of healthy eating motivation and control*, and *lack of social support*. Participants with higher BMI were significantly more likely to report experiencing all three barriers. See online supplementary materials for full results. We adopted the same approach to examine perceived changes in mental health pre vs. during lockdown. Although some demographic factors predicted greater perceived declines in mental health (being female, younger, having an existing psychiatric condition), higher BMI was not associated with perceived changes in mental health.

3.8. Further analyses: Associations of perceived changes in eating and physical activity compared to before lockdown and behavior during lockdown

We explored whether participants reporting decreases/increases in healthy eating, physical activity and overeating were engaging in lower/higher levels of these behaviors (measured during lockdown). See online supplementary materials for full results. Measures of perceived changes in behavior were consistently associated with actual levels of behavior in the expected directions (i.e. participants reporting reduced physical activity compared to before lockdown had lower physical activity levels as assessed by the IPAQ in lockdown vs. participants not reporting perceived reductions).

4. Discussion

In a large sample of UK adults, we examined perceived changes in weight-related behaviors and barriers to healthy eating/physical activity as a result of COVID-19 social lockdown, as well as patterns of physical activity, diet quality and overeating during social lockdown.

For the 11 weight-related behaviors participants reported on there was considerable variability in perceived change in frequency since lockdown. For example, although 56% of the sample reported snacking more frequently, 23% reported reduced snacking frequency. Likewise, although 40% of participants reported having exercised less frequently during lockdown, 45% reported increased frequency of exercising. Perceived declines in the frequency of weight-gain protective behaviors were more likely to occur in some participant sub-groups than others (e.g. lower education, members of a high-risk medical condition group). Participants of higher BMI ($\geq 35 \text{ kg/m}^2$) reported the least favourable changes in weight-related behaviors. It was also common for

participants to report experiencing barriers to physical activity and healthy eating during lockdown (e.g. 82% reported an increase in the amount of unhealthy food in the home) and participants with higher BMI were particularly likely to report that compared to before COVID-19 lockdown, they were experiencing increased difficulties in accessing healthy food, lacking motivation and control around food and a lack of social support.

In line with previous research examining BMI and weight-related behaviors prior to the COVID-19 crisis, participants with a higher BMI reported a lower quality of diet, lower physical activity levels and increased overeating, relative to lower BMI (Bensimhon et al., 2006; Vainik et al., 2019; Wolongevicz et al., 2010) during lockdown. In line with other studies examining the mental health burden of COVID-19 (Shevlin et al., 2020; Daly et al., 2020), it was common for participants in the present study to report feeling more lonely, depressed and anxious since lockdown. Higher BMI was not significantly associated with perceived change in mental health, although participants who reported that their mental health had suffered because of lockdown had significantly lower levels of physical activity and more overeating during lockdown.

The present research highlights the potential impacts that COVID-19 lockdown has had on a range of weight-related behaviors and barriers among UK adults, as well as identifying groups that may be most in need of support. Social lockdown measures are likely to have wide ranging effects that make weight gain protective behaviors more difficult for many and there have been a number of suggestions that social restrictions to limit the spread of COVID-19 may result in population level weight gain (Pearl, 2020; Bhutani & Cooper, 2020). Our findings tend to support this suggestion and also highlight that adults already of higher BMI may be most at risk of increased weight gain as a result of the COVID-19 crisis. As well as being an established risk factor for all-cause mortality (Bhaskaran et al., 2018), higher BMI is now also thought to be a risk factor for COVID-19 mortality (Klang et al., 2020). As the risk of infection may remain high in many developed countries for some time, prevention efforts to minimize weight gain during the COVID-19 crisis may be warranted.

Across analyses we found that participant characteristics accounted for a relatively small amount of variance in outcome measures. For example, participant characteristics accounted for 5% of variance when examining perceived changes in weight gain protective behaviour and 16% of variance for overeating during lockdown. These findings suggest

that there are likely to be other factors contributing to variability in weight-related behaviours as a result of COVID-19 lockdown. We were unable to measure pre-lockdown engagement in weight gain protective behaviours and other participant characteristics (e.g. personality) and these factors may be important in explaining patterns of weight gain as a result of the COVID-19 crisis.

There are limitations to the present research. The sample had a larger proportion of women and participants with a higher education level than the general population (Health Survey for England resources, 2018). The numbers of participants reporting having ever been diagnosed with a psychiatric condition (33%) or having a high-risk medical condition for COVID-19 (24%) were also relatively high, although the sample did include a wide BMI range and this is a strength. It should also be noted that scores on the WHO well-being measure reported by this sample indicate lower levels of well-being than previous norm values for the UK (Topp et al., 2015), which may reflect the detrimental effects that the COVID-19 crisis is having on well-being. Questionnaire items examining self-reported changes in weight-related behaviors compared to before lockdown measure perceived rather than actual change. Although analyses indicated that these items were associated with validated measurements of current behavior (measured during lockdown) as would be expected (e.g. participants who reported their physical activity had declined since lockdown began were reporting low levels of lockdown physical activity relative to the rest of the sample), their retrospective nature makes them prone to bias. Furthermore, measures of lockdown physical activity, diet quality and overeating are based on self-report, so will be prone to bias. Moreover, the dietary measures included do not provide an overall quantification of energy and nutrient intake, but rather a ‘snapshot’ of some aspects of eating behavior. Due to survey length we were not able to study all potential weight management barriers, so there are likely to be other barriers to weight management that may be important during the COVID-19 crisis. Nonetheless, the measures included provide some indication of potential trends and factors associated with weight-related behaviors in the context of the COVID-19 crisis, highlighting the need to monitor weight-related behaviors as the COVID-19 crisis continues.

5. Conclusions

The present study findings suggest that social lockdown in the UK may have had a disproportionately large influence on weight-related behaviors among adults with higher BMI and there is a need to understand the impact that the COVID-19 crisis may have on population level weight gain.

Ethics approval and consent to participate

Approved by the Health and Life Sciences Research Ethics Committee at the University of Liverpool. Informed consent was obtained from all the participants before they started the study.

Availability of data and materials

The materials and pre-registered analysis is available on the Open Science Framework project page <https://osf.io/h7mrn/>

Funding

N/A.

Authors' contributions

All authors conceived the study design. NM, BM and LM oversaw data collection. ER and NM carried out data analysis. All authors were involved in writing the paper and had final approval of the submitted manuscript.

Declaration of competing interest

ER has previously been the recipient of research funding from Unilever and the American Beverage Association (ABA) for unrelated research. JH has previously been the recipient of research funding from the ABA and the Californian Prune Board for unrelated research. NGM has received funding from the ABA for unrelated research. BRM has received funding to their institution from WW (formerly Weight Watchers International) for unrelated research. CAH has received research funding from the ABA and speaker fees from International Sweeteners Association for unrelated research.

List of abbreviations

BMI body mass index
COVID coronavirus disease

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2020.104853>.

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