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Snacking and anxiety during the coronavirus disease (COVID-19) pandemic: A prospective cohort study

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ABSTRACT

Anxiety and snacking increased during the initial coronavirus disease 2019 (COVID-19) lockdowns, but it remains unknown whether this change in snacking persisted and if it related to anxiety levels. We used prospective data to examine changes in snacking frequency from t1 (eased restrictions in England in May–June 2020) to t2 (national lockdown in December 2020–March 2021), the association of anxiety (assessed by the Generalised Anxiety Disorder-7 questionnaire at t1) with the snacking change, and the mediating and moderating effects of disinhibition and flexible restraint (assessed by the Three Factor Eating Questionnaire in 2016–17). Analyses including 2128 adults (mean age 28.4 y) residing in England from the Avon Longitudinal Study of Parents and Children showed that snacking frequency increased over time (mean change 1.23 (95% CI 0.81, 1.65) snacks/wk). Linear regressions of snacking adjusted for sociodemographic covariates showed that having clinical levels of generalised anxiety at t1, versus not, was associated with 1.22 (95% CI 0.07, 2.37) more snacks/wk at t2. Disinhibition partially mediated the association between Generalised Anxiety Disorder and snacking ($\beta_{\text{indirect}} =$ 0.15, 95% CI 0.01, 0.32), while there was no evidence that flexible restraint moderated the association ($\beta = 0.05$, 95% CI -0.57, 0.66). Our longitudinal findings highlight a detrimental anxiety-snacking association partly operating via disinhibition, suggesting future research could target mitigating anxiety and disinhibited eating behaviours to benefit diet-related outcomes following the pandemic.

1. Introduction

The coronavirus disease 2019 (COVID-19) was declared a global pandemic on 11 March 2020 (World Health Organisation, 2020), which led to repeated lockdown measures implemented to curb infection (Wang et al., 2020). England experienced three periods of national lockdowns, in March–May 2020, November–December 2020, and January–March 2021, when the public was instructed to stay at home apart from to do essential activities (Institute for Government, 2022). The sudden disruption to normal routines precipitated declines in mental health (Santabárbara et al., 2021) and changes to eating behaviours (Bakaloudi et al., 2022; Mignogna et al., 2022), including increased frequency of snacking, defined as the number of times food is consumed between meals (Hess et al., 2016). A meta-analysis of 43 studies documented a tripling of anxiety rates, including a rise in General Anxiety Disorder (GAD) (Santabárbara et al., 2021), which is a long-term condition characterised by constant worrying and restlessness (NHS, 2018). Additionally, a systematic review of 17 studies found that in the majority of studies, participants perceived that their snack consumption had increased rather than decreased since before the

Abbreviations: ALSPAC, Avon Longitudinal Parents and Children Study; COVID-19, coronavirus disease 2019; GAD, Generalised Anxiety Disorder; GAD-7, Generalised Anxiety Disorder-7 questionnaire; SES, socioeconomic status; SMFQ, Short Mood and Feelings Questionnaire; SPSS, Statistical Package for the Social Sciences; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; TFEQ, Three Factor Eating Questionnaire.

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pandemic (Mignogna et al., 2022). However, many studies were cross-sectional and relied on participants retrospectively reporting their perceived change in snacking (yes/no) instead of their intake at multiple timepoints. Under the assumption that energy from snacks adds to, rather than displaces, meal energy (Chapelot, 2011), increased snacking could induce a positive energy balance and be an important modifiable risk factor for weight gain and diet-related non-communicable disease (GBD 2017 Diet Collaborators, 2019; Larsen & Heitmann, 2019; Wei et al., 2021).

Experimental and observational evidence supports a detrimental effect of elements of psychological stress, e.g., anxiety, on snacking behaviour (Buckland & Kemps, 2021; Coulthard et al., 2021; Sadler et al., 2021), possibly explained by stress depleting cognitive resources needed for self-control, thereby impairing appetite regulation and misconceiving negative feelings as hunger, as posited by psychosomatic theory (Kaplan & Kaplan, 1957; Torres & Nowson, 2007). This process of losing control over eating can be presented in certain eating behaviour/appetitive traits, including emotional and external eating (the loss of control over eating in response to emotions and when surrounded by palatable foods), which may be encapsulated within a broader trait of disinhibition (Vainik et al., 2019). While previous work has linked generalised anxiety to disinhibited tendencies (Hussenoeder et al., 2021), no study has yet examined the mediating role of disinhibition on anxiety and snack intake, as has been done with emotional and external eating on other stress-related variables (rumination and depression) (Kornacka et al., 2021; Paans et al., 2019). Furthermore, cognitive restraint (the persistent intention to 'diet'/restrict food intake to manage weight) can modify one's risk for a higher BMI (Konttinen et al., 2018), and can be split into rigid restraint which produces an impulsive 'all-or-nothing' approach to dieting, and flexible restraint, representing a more regulated and sustainable response (Moussally et al., 2015; Westenhoefer et al., 2013). While such cognitive flexibility has been suggested to protect against stress-induced eating (Sadler et al., 2021), it has not yet been related to anxiety. Given the pronounced increase in anxiety across the population in England over the COVID-19 period (Kwong et al., 2020), understanding the impact of anxiety on snacking habits and the interplay with eating behaviour traits could inform tailored interventions to prevent future weight gain.

2. Methods

2.1. Aim

Using a longitudinal design, our primary aim was to investigate the change in snacking frequency from a period of eased restrictions (May–July 2020) to the third lockdown in England (December 2020–March 2021). Our secondary aims were to investigate whether anxiety prospectively associated with the change in snacking, and the potential mediating and moderating effects of disinhibition and flexible restraint. We hypothesised that anxiety would be associated with higher change in snacking frequency, and that the anxiety-snacking association would be mediated by disinhibition and moderated by flexible restraint.

2.2. Participants

Data came from the Avon Longitudinal Study of Parents and Children (ALSPAC), a three-generational population-based study that examines various health-related behaviours and outcomes throughout the life course (Boyd et al., 2013). Pregnant woman in the Avon area expected to deliver between 1 April 1991 and 31 December 1992 were eligible to take part, and 14,541 women were recruited opportunistically through 'expression of interest' cards in community and antenatal settings (Boyd et al., 2013). This yielded 13,988 offspring, and an additional 913 children were recruited before they turned 18, to form the original sample of 14,901 (Boyd et al., 2013; Fraser et al., 2013; Northstone et al., 2019). This sub-sample are now young adults and were analysed in the current study.

2.3. Data collection

Demographic and health data were collected over time since study enrolment. Please note that the study website contains details of all the data that is available through a fully searchable data dictionary and variable search tool (http://www.bristol.ac.uk/alspac/researchers/our-data/). Our main study data were taken from the 2016-17 questionnaire and two COVID-related questionnaires administered during a period of eased restrictions (26 May–5 July 2020; time-point 1) and the third lockdown (1 December 2020–19 March 2021; time-point 2) (Smith et al., 2021; Wellcome, 2021), shown on Fig. 1. Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time. Approval for the current analysis was obtained by the University of Bristol Exercise Nutrition and Health Sciences Ethics Committee (Ethics Approval Number: 047-21).

Study data were collected and managed using the Research Electronic Data Capture (REDCap) tool hosted at the University of Bristol (Harris et al., 2009). REDCap is a secure, web-based software platform designed to support online data capture for research studies.

Snacking frequency was ascertained by a single item ('in the last month, how often have you usually eaten a snack?'), where 'snack' was self-defined. Nine response options were given (6+ per day, 4–5 times per day, 2–3 times per day, once a day, 5–6 times per week, 2–4 times per week, once a week, 1–3 times per month, never/<once per month) and the midpoints were used to derive average snacks per week, comparable with previous studies (Olea-López & Johnson, 2016; Larson et al., 2016; Supplementary Table 1).

Anxiety was measured by the Generalised Anxiety Disorder-7 questionnaire (GAD-7) (Spitzer et al., 2006). Participants reported how often over the past two weeks they were bothered by seven statements (e.g., 'feeling nervous, anxious or on edge') on a four-point scale ('not at all', 'several days', 'more than half the days', 'nearly every day'). Scores ranged from 0 to 21 and higher scores indicated higher anxiety. Anxiety was treated continuously and categorically using the clinical threshold score of ≥10 (Kroenke et al., 2007), herein referred to as 'anxiety severity' and 'GAD', respectively.

Eating behaviour traits (disinhibition and cognitive restraint) were assessed between 2016 and 2017 using a modified version of the 51-item Three Factor Eating Questionnaire (TFEQ; Fig. 1) (Stunkard & Messick, 1985). Questions were asked in a dichotomous (true/false) or four-point format to measure how true a statement was or frequent a certain behaviour, with higher scores indicating greater disinhibition or cognitive restraint. Sixteen items measured disinhibition (e.g., 'when I am anxious, I find myself eating'), thus scores ranged from 0 to 16. Fourteen items measured overall cognitive restraint (scores ranged from 0 to 14), including seven for flexible restraint (e.g., 'when I have eaten my quota of calories, I am usually good about not eating more'). The TFEQ has exhibited good test-retest reliability over 12 months (Bond et al., 2001), such that these traits can be considered stable over time (Boswell et al., 2018). We examined the overall cognitive restraint variable to enable comparability to past studies, as well as the individual flexible restraint construct to provide a more nuanced understanding of the impact of restraint (Westenhoefer et al., 1999), and scores were treated continuously in the main analyses.

BMI (kg/m^2) was directly assessed by a clinician between 2015 and 2017 and was analysed continuously.

Sex, ethnicity, and socioeconomic status (SES) were identified from hospital records and self-report questionnaires at study enrolment. For parsimony, binary variables were derived for females/males, White/non-White, and mother's education level (<A-level/≥A-level) was used for SES (Kwong et al., 2020).

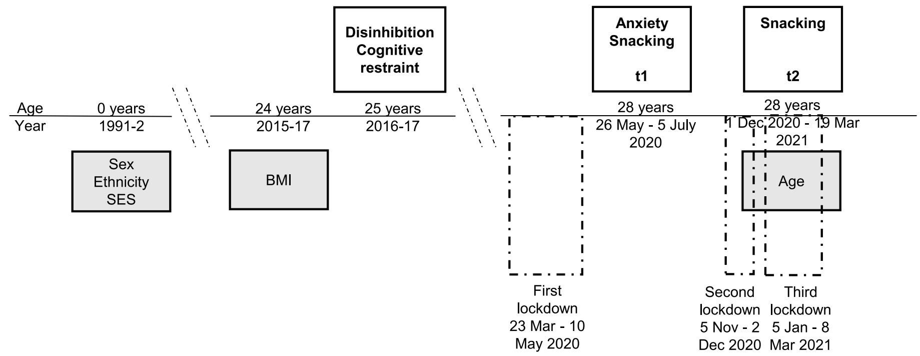

Fig. 1. Timeline of measurements for the variables of interest from the Avon Longitudinal Study of Parents and Children. SES = socioeconomic status.

Age (mo) was recorded at t2 and used as a continuous variable.

2.4. Statistical analyses

Analyses were performed in SPSS version 27 (SPSS Inc. Chicago). Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (STROBE) (Supplementary Table 2) (von Elm et al., 2007). The hypotheses and analysis plan were specified before the data were accessed.

Descriptive statistics (n (%) or mean ± SD) were reported for the key variables: snacking frequency at t1 and t2, snacking frequency change, anxiety severity, GAD, age, sex, ethnicity, SES, BMI, disinhibition, cognitive restraint, and flexible restraint. The scores for snacking at t1 and t2 were also split by GAD categories (GAD/non-GAD), to understand the variability in snacking scores according to the presence of clinical anxiety levels at t1.

We modelled change in snacking between the two time points via a linear model with snacking at t2 as the dependent variable, adjusted for baseline snacking at t1. Model 1 included anxiety and snacking at t1 to assess whether anxiety in the model had an impact on snacking at t2 independent of habitual snacking. Model 2 included the potential confounders of age, sex, ethnicity, SES, BMI, and overall cognitive restraint, as the general construct of restraint has been identified as a more relevant confounder than the sub-constructs of flexible and rigid restraint (Kwong et al., 2020; Magklis et al., 2019; Warne et al., 2021). Regression coefficients reported are unstandardised and residuals were inspected visually to check model assumptions.

Linear regression models (adjusted as described above) assessed whether the association between anxiety and snacking frequency was mediated by disinhibition or moderated by flexible restraint, only when a main effect was observed between anxiety severity/GAD and snacking. Using Hayes' SPSS PROCESS macro (version 3.5) (Hayes, 2017), bias-corrected 95% CIs for all effect (unstandardised beta) coefficients were estimated using bootstrapping with 5000 samples (Bollen & Stine, 1990).

Evidence of mediation was denoted by the pathway 'a x b' in Fig. 4, which is the product of pathway 'a' (the coefficient of the association between the independent variable; anxiety or GAD, and the mediator; disinhibition) and 'b' (the coefficient of the association between the mediator and the dependent variable; snacking). This is seen as the 'indirect effect' through which anxiety affects snacking via disinhibition. If the evidence for a direct effect (c') of anxiety on snacking was removed after the mediator was added into the model, this indicated full mediation, whereas if it remained, this indicated partial mediation (Baron & Kenny, 1986). Moderation was explored via interaction terms between anxiety and flexible restraint and GAD and flexible restraint. Anxiety and flexible restraint were mean-centred prior to creating interaction terms to aid with interpretability (Haldar, Jackard, Turrisi, & Wan, 1990; Montoya, 2019). The simple slopes procedure was used to present the moderation effect graphically, to show how the anxiety-snacking association differed between three categories of flexible restraint (low: mean -1SD, medium: mean, high: mean +1SD) (Aiken et al., 1991).

2.5. Missing data and sensitivity analyses

We excluded participants who did not have snacking data at both time-points or complete data on key demographic variables (age, sex, ethnicity, and SES). For the regression analyses, we analysed a subsample of those with complete data on anxiety (n = 2086) and those with complete data on all study variables (snacking, demographic variables, anxiety, disinhibition, cognitive restraint, and BMI) (n = 1418). This approach maximised the sample size for describing the snacking frequency change (Schafer & Graham, 2002). To explore the pattern of missingness, we compared the characteristics of the larger sample (n = 2086) and the restricted sample (n = 1418).

3. Results

3.1. Descriptive characteristics

Our analyses included a maximum of 2128 adults (70.1% female, 98.4% White British) with a mean ± SD age of 28.4 ± 0.54 y and a mean ± SD anxiety score of 6.0 ± 5.18. See Table 1 for descriptive statistics. We found 22.5% of the participants were categorised as having probable GAD (GAD-7 score ≥10). Mean disinhibition and cognitive restraint were 6.03 ± 3.36 (ranging between 0 and 15) and 4.87 ± 3.25 (ranging between 0 and 14), respectively.

3.2. The change in snacking frequency

Our regression analysis sample comprised 1418 individuals with complete data for all variables of interest (Supplementary Fig. 1). Compared to the sample with data on anxiety, snacking, and demographic variables (n = 2086), the restricted sample with complete data on all covariates (n = 1418) had a slightly lower anxiety score (5.73 versus 5.97) and a higher snacking change score (1.50 versus 1.24 snacks/wk) (Supplementary Table 3).

Mean snacking frequency increased from 13.1 ± 8.09 to 14.3 ± 9.75 snacks/wk from t1 to t2, equating to an average increase of 1.23 ± 9.82 snacks/wk (Table 1). Fig. 2 shows the distribution of snacking frequency at t1 and t2 for the total sample. Differences by GAD were observed. People with clinical levels of anxiety (GAD) increased their snacking frequency by 1.57 snacks/wk over time, from 13.7 ± 8.85 to 15.3 ± 10.4, while those without GAD increased by 1.14 snacks/wk, from 12.9 ± 7.86 to 14.0 ± 9.55 (Table 1).

Fig. 3 shows that people with GAD at t1 were more likely to increase their snacking (34.7%) compared to those without GAD (31.4%). See Supplementary Fig. 2 for a more detailed description of the distribution of snacking for the total sample, and those with and without GAD.

Table 1
Descriptives of the study variables. GAD = Generalised Anxiety Disorder; SES = socioeconomic status.

	N	Mean ± SD or *n* (%)
Age, y	2128	28.4 ± 0.54
Sex, *n* (% female)	2128	1492 (70.1)
Ethnicity, *n* (% White)	2128	2094 (98.4)
SES, *n* (% ≥ A level)	2128	1074 (50.5)
Anxiety severity t1[a]	2086	6.0 ± 5.18
GAD t1, *n* (% GAD)[b]	2086	479 (22.5)
Disinhibition[c]	1778	6.03 ± 3.36
Cognitive restraint[c]	1778	4.87 ± 3.25
Flexible restraint[c]	1778	2.24 ± 1.76
BMI, kg/m^2	1636	24.8 ± 5.18
	N	**Mean ± SD**
Snacking frequency t1[d]		
Full sample	2128	13.1 ± 8.09
GAD[b]	479	13.7 ± 8.85
No GAD[f]	1607	12.9 ± 7.86
Snacking frequency t2[d]		
Full sample	2128	14.3 ± 9.75
GAD[b]	479	15.3 ± 10.4
No GAD[f]	1607	14.0 ± 9.55
Snacking frequency change[e]		
Full sample	2128	1.23 ± 9.82
GAD[b]	479	1.57 ± 10.5
No GAD[f]	1607	1.14 ± 9.65

[a] Measured with the Generalised Anxiety Disorder-7 questionnaire (range 0–21).
[b] Measured with the Generalised Anxiety Disorder-7 questionnaire (score ≥10).
[c] Measured with the Three Factor Eating Questionnaire (disinhibition range 0–16 and cognitive restraint range 0–14).
[d] Measured in snacks/wk during a period of eased restrictions (t1) and the third lockdown (t2).
[e] Measured by snacks/wk at t2 − snacks/wk at t1.
[f] Measured with the Generalised Anxiety Disorder-7 questionnaire (score <10).

3.3. The association between anxiety and the change in snacking frequency

There was no evidence of a linear association across the full range of anxiety severity scores at t1 and snacking at t2 (Table 2), in either model 1a, run in the sample with just anxiety and snacking ($n = 2096$), model 1b, run in the sample with complete data on all covariates ($n = 1418$), or model 2, covariate adjusted model 1b. In the larger sample ($n = 2096$) there was no evidence of association between GAD and snacking at t2 (Table 2, model 1a). In the restricted sample ($n = 1418$), there was evidence of association, which was robust after the inclusion of covariates. Participants with GAD at t1 ate 1.22 (95% CI 0.07, 2.37) more snacks/wk at t2 than participants without GAD (Table 2, model 2).

3.4. The mediating effect of disinhibition

For the association between GAD and snacking, a mediation analysis showed evidence of mediation by disinhibition ($\beta_{\text{indirect}} = 0.15$, 95% CI 0.01, 0.32, Fig. 4). As the direct effect of GAD on snacking remained after the addition of disinhibition as a mediator (β (c') = 1.22, 95% CI 0.07, 2.37, Fig. 4), disinhibition was identified as a partial mediator for GAD and snacking.

3.5. The moderating effect of flexible restraint

There was no evidence that flexible restraint moderated the anxiety-snacking association, as shown by the interaction effects between flexible restraint and anxiety on snacking in Supplementary Table 4 (β = 0.05, 95% CI -0.57, 0.66). This is supported by Supplementary Fig. 3 which shows no difference in the relationship between anxiety severity or GAD and snacking at different levels of flexible restraint.

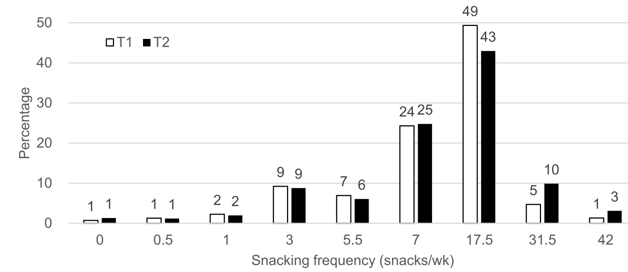

Fig. 2. Bar chart of the proportion of participants reporting different snacking frequencies at t1 (period of eased restrictions in England from May to June 2020) and t2 (period of national lockdown in England from December 2020 to March 2021).

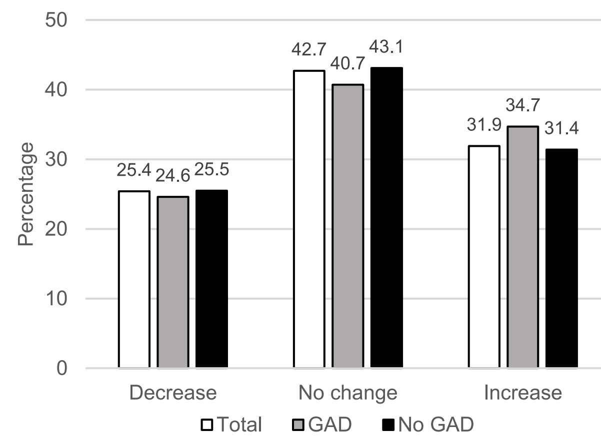

Fig. 3. Bar chart showing the proportion of participants reporting decreases, no change and increases in snacking from t1 (period of eased restrictions in England from May to June 2020) to t2 (period of national lockdown from December 2020 to March 2021). GAD = Generalised Anxiety Disorder.

4. Discussion

To the authors' knowledge, this is the first study to investigate a change in snacking frequency associated with the third lockdown in England, and the association of anxiety and measured (rather than perceived) changes in snacking. We provide new evidence for a more pronounced effect of GAD than less severe levels of anxiety, and a mediating effect of disinhibition.

Our sample reported an increase in 1.2 snacks/wk from 13.1 (t1; period of eased restrictions) to 14.3 (t2; the third lockdown), which equated to an increase of 0.17 snacks/day from 1.87 to 2.04 snacks. Similarly, a study of 3500 adults in Germany documented an increase of 0.56 snacks/day from 1.5 (pre-pandemic) to 2.1 (the first lockdown) (Mata et al., 2021), which seems to align with our results as our baseline measure was taken following the initial lockdown, when it is possible that snacking had already increased. However, comparability was limited as Mata et al. only measured snacks high in fat, salt and sugar whereas our measure did not specify food type and therefore definitional variation could also explain the smaller overall change (Hess et al., 2016). Another study of 201,301 UK adults found a small decrease of 0.1 snacks/day from 1.6 (pre-pandemic) to 1.5 (period of eased restrictions in July–August 2020) (Mazidi et al., 2021), which suggested a less adverse pattern. However, their results were likely affected by memory

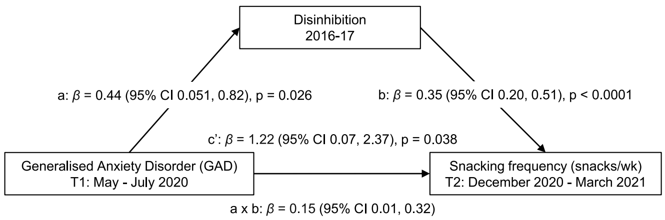

Fig. 4. Model testing disinhibition mediating the association between Generalised Anxiety Disorder (GAD) and snacking ($n = 1418$).
Mediations are from linear regression models using unstandardised coefficients, adjusted for age, sex, ethnicity, socioeconomic status, BMI and cognitive restraint. c' pathways represent the direct effect of GAD on snacking when the mediator (disinhibition) is in the model, the product of a and b (a x b) pathway represents the indirect effect where GAD is associated with snacking indirectly through disinhibition.

Table 2
Associations of anxiety severity and GAD with weekly snacking frequency (snacks/wk) at t2. GAD = Generalised Anxiety Disorder.

Model	N	Anxiety severity		GAD	
		β[a] (95% CI)	p	β[b] (95% CI)	p
1a[c]	2086	0.06 (−0.01, 0.14)	0.11	0.84 (−0.07, 1.75)	0.07
1b[d]	1418	0.08 (−0.01, 0.18)	0.09	1.31 (0.19, 2.47)	0.02
2[e]	1418	0.06 (−0.04, 0.16)	0.23	1.22 (0.07, 2.37)	0.04

[a] β represents the difference in snacks/wk at t2 for each unit change in anxiety severity (GAD-7) score.
[b] β represents the difference in snacks/wk at t2 for participants with GAD versus those without GAD.
[c] Model 1a (larger sample, $n = 2096$) including anxiety and snacking at t1.
[d] Model 1b (restricted sample with data on all covariates, $n = 1418$) including anxiety and snacking at t1.
[e] Model 2 including confounders (age, sex, ethnicity, socioeconomic status, BMI, disinhibition and cognitive restraint), $n = 1418$.

bias due to asking participants to retrospectively report their intake several months after the first lockdown (Mazidi et al., 2021). Overall, our results provide a unique contribution to the evidence showing pandemic-related changes in snacking and suggest a continuation into the later lockdown periods. Despite the change being relatively small (+1.2 snacks/wk), this could equate to a 200 kcal increase just in snacks over the six-month period, drawing on research showing snacks each contain a mean of 169 kcal (IQR, 121–234) (Magklis et al., 2019). Relatedly, longitudinal data show each additional daily snack consumed can predict an increase in fat mass ($\beta = 0.05$ kg/m^2, 95% CI 0.00, 0.09) and body fat percentage (+0.12%, 95% CI: 0.02, 0.23) (Larsen & Heitmann, 2019), therefore further research could investigate the relevance of the observed increase in snacking for caloric intake and anthropometric outcomes.

We found that individuals with clinical levels of anxiety before the third lockdown experienced a larger increase in snacking going into the lockdown, versus those with lower levels of anxiety, even when accounting for the difference in snacking at baseline. Overall anxiety severity score did not relate to snacking, however, which suggests a possible threshold effect whereby high, but not medium or low, levels of anxiety, drove increased snacking. While we did not add pre-pandemic anxiety into the analysis, we predict that if we did, this may have negated the impact of pandemic anxiety on snacking and indicate that it was not transient changes in anxiety that impacted the changes in snacking, but rather, pre-existing levels of anxiety. This hypothesis would however need to be confirmed with diagnostic data. Previous COVID studies conducted in German and UK populations also found links between higher snacking and anxiety (Coulthard et al., 2021; Mata et al., 2021), although they measured state and health anxiety that reflect acute (short-term, state-like) feelings rather than generalised (trait-like) symptoms (Alberts et al., 2013; Janjetic et al., 2020). A more comparable study among 37,252 French adults in fact found a negative association between generalised anxiety and snacking (Deschasaux-Tanguy et al., 2021), but note that the mean GAD-7 score in their sample was almost half of the current sample's (3.2 versus 6.0), thus the inverse association might reflect a hypophagic (undereating) response inherent to lower severities (Torres & Nowson, 2007), pointing to the proposed 'threshold effect'. While certain ecological momentary assessment studies suggest that temporal changes in affect might have a more pronounced influence on real-time snacking than trait-like factors (Elliston et al., 2017), this was out of the scope of the current study. Furthermore, a previous study found trait-like rumination to predict emotional eating after momentary affect was controlled for (Kornacka et al., 2021), therefore future work could extend this to compare the impacts of generalised anxiety and momentary affect on disinhibition and resultant snacking.

The current study is the first to combine associations of anxiety, eating behaviour traits, and snacking, with earlier work examining anxiety and depression combined or depression only (Byrne et al., 2021). We found the influence of GAD on snacking was partially explained by disinhibited eating behaviour, whereas a previous experimental study among 181 adolescents found responsiveness to food cues (taken to indicate disinhibited eating) mediated the association between a composite score of anxiety and depression on food intake, but this did not extend to snacking (Byrne et al., 2021). However, differences in sample characteristics may explain the contrasting findings, as adults with poorer mental health scores and higher average bodyweight, as in our sample, may be more vulnerable to disinhibited eating than adolescents (Dulloo & Montani, 2015). Moreover, our results were in line with an observational study of 1442 adults that found external eating mediated the association between depression and snacking (Paans et al., 2019), with the mediator explaining more of the effect of depression severity than depression diagnosis. The mediating effect was not seen for emotional eating, however, which the authors explained may be due to different subtypes of depression exerting discordant effects, whereas generalised anxiety may be more homogenous (Paans et al., 2019). While our results indicated that the anxiety-snacking relationship was not modified by flexible restraint, the little variation in restraint scores reducing the statistical power may party explain the negligible result (Anschutz et al., 2008). A recent COVID-19 study among 428 US adults found cognitive flexibility attenuated the effect of stress on increased snacking (Sadler et al., 2021), although their sample being older than our sample is worth noting as the moderating effect of restraint may increase with age (Evers et al., 2018) and they examined perceived stress, which may have a stronger relationship with restraint than anxiety (Janjetic et al., 2020). Notably, both the mediation and moderation effects documented in previous work were specific to salty/savoury snacks not sweet snacks (Paans et al., 2019; Sadler et al., 2021), therefore it could be that such traits exert a more potent effect on foods high in salt that have addictive properties (Garber & Lustig, 2011), a pattern that could not be ascertained through our measure of overall snacking.

4.1. Strengths and limitations

Our study presents novel evidence for a relationship between anxiety and snacking through disinhibition, which could be used to improve practice by designing interventions that target overall disinhibition instead of the constructs of emotional and external eating separately (Vainik et al., 2019). However, it is possible that other confounding factors not included in our analysis contributed to the observed associations. Potential additional explanatory variables could include feelings of boredom or loneliness during the confinements of lockdown (Malaeb et al., 2022), but considering GAD held a stronger effect than anxiety severity, we believe this demonstrates the impact of anxiety over more momentary variables. A second strength is the use of repeated measures of snacking during periods of differing COVID-19 restrictions in

England, while previous research has relied on retrospective recall from before the lockdowns or perceived changes. However, in the absence of a formal validation study, we can only speculate on the nature of error in the questions we used and the impact this may have had on the associations observed.

Our snacking measure is likely to be subject to under-reporting bias, which is common in dietary assessment due to memory or social desirability biases when compared to wearable camera data (Gemming & Ni Mhurchu, 2016). In addition, questions using the word ‘snack’ with no additional cues may elicit food-only or food and beverage eating occasions without beverage-only eating occasions (Leech et al., 2015). Despite this, previous research has shown that recall of intake remains indicative of true intake, reflected in correlations of rs = 0.3–0.6 between questionnaire and biomarker data (Cade et al., 2017), and our estimate of 2 snacks per day is in line with results from another population-based survey using detailed 7-day weighed diet diaries that were recorded in real-time and incorporated day-to-day variation in snacking. Specifically, our estimates were comparable to when snacks were defined as the types of food (median of 2 (IQR 1–3) snacks per day) (Magklis et al., 2019), time of consumption (mean 2 (SD 1) snacks per day), or size of eating occasion (mean 3 (SD 2) (Murakami & Livingstone, 2016). Therefore, possible under-reporting bias may mean the true intake of snacks is likely to be higher than was observed in our study, but results from more detailed dietary assessments indicate our estimates are reasonable. Additionally, generalisability may be hindered due to the sample only involving young adults who were not representative of the national population (e.g., 70% female) (GOV.UK, 2018), and may be disproportionately prone to stress-related eating following periods of restriction (i.e., ‘yo-yo dieting’) than other demographic groups (Dulloo & Montani, 2015).

4.2. Conclusions

To conclude, we observed evidence of increased snacking during the COVID-19 era that may partly be explained by anxiety triggering an underlying tendency towards disinhibited eating. These results are a basis on which to develop interventions for anxious individuals to improve their capacity for emotional regulation and, in turn, reduce the nutrition-related burden of disease following the pandemic. Promising targets could include mindfulness, intuitive eating, physical activity, and food cue exposure therapy (Jacob et al., 2018; Rogers et al., 2017; Smith et al., 2022; van den Akker et al., 2016). Testing in a trial setting could help advance the evidence base and confirm causality between anxiety, disinhibition, and snacking.

Ethics statement

Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time. Approval for the current analysis was obtained by the University of Bristol Exercise Nutrition and Health Sciences Ethics Committee (Ethics Approval Number: 047-21).

Author contributions

ELC, LJ and ECH designed the research; ELC conducted the research and analysed the data; ELC, LJ, ECH and RS wrote the paper; ELC attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. All authors read and approved the manuscript.

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Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2023.106491.

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