British Journal of Nutrition (2022), 127, 298–317 doi:10.1017/S0007114521000921

Systematic review of the effects of pandemic confinements on body weight and their determinants

Moien AB Khan[1,2]*, Preetha Menon[3], Romona Govender[1], Amal MB Abu Samra[1], Kholoud K Allaham[1], Javaid Nauman[3,4,5], Linda Östlundh[6], Halla Mustafa[1], Jane E.M. Smith[7] and Juma M AlKaabi[8]

[1]*Nutrition Studies Research Group, Department of Family Medicine, College of Medicine and Health Sciences, United Arab Emirates University, Al-Ain, United Arab Emirates*
[2]*Primary Care, NHS North West London, London TW3 3EB, UK*
[3]*Institute of Public Health, College of Medicine and Health Sciences, United Arab Emirates University, Al-Ain, United Arab Emirates*
[4]*Department of Circulation and Medical Imaging, Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Trondheim, Norway*
[5]*Healthy Living for Pandemic Event Protection (HL – PIVOT) Network, Chicago, IL, USA*
[6]*National Medical Library, College of Medicine and Health Sciences, United Arab Emirates University, Al-Ain, United Arab Emirates*
[7]*Bodreinallt Surgery, NHS Wales, Conwy, LL32 8AT, UK*
[8]*Department of Internal Medicine, College of Medicine and Health Sciences, United Arab Emirates University, Al-Ain, United Arab Emirates*

(Submitted 16 September 2020 – Final revision received 3 March 2021 – Accepted 7 March 2021 – First published online 12 March 2021)

Abstract

Pandemics and subsequent lifestyle restrictions such as 'lockdowns' may have unintended consequences, including alterations in body weight. This systematic review assesses the impact of pandemic confinement on body weight and identifies contributory factors. A comprehensive literature search was performed in seven electronic databases and in grey sources from their inception until 1 July 2020 with an update in PubMed and Scopus on 1 February 2021. In total, 2361 unique records were retrieved, of which forty-one studies were identified eligible: one case–control study, fourteen cohort and twenty-six cross-sectional studies (469, 362 total participants). The participants ranged in age from 6 to 86 years. The proportion of female participants ranged from 37 % to 100 %. Pandemic confinements were associated with weight gain in 7·2–72·4 % of participants and weight loss in 11·1–32·0 % of participants. Weight gain ranged from 0·6 (SD 1·3) to 3·0 (SD 2·4) kg, and weight loss ranged from 2·0 (SD 1·4) to 2·9 (SD 1·5) kg. Weight gain occurred predominantly in participants who were already overweight or obese. Associated factors included increased consumption of unhealthy food with changes in physical activity and altered sleep patterns. Weight loss during the pandemic was observed in individuals with previous low weight, and those who ate less and were more physically active before lockdown. Maintaining a stable weight was more difficult in populations with reduced income, particularly in individuals with lower educational attainment. The findings of this systematic review highlight the short-term effects of pandemic confinements.

Key words: **Quarantine: Lockdown: Body weight: Obesity: Weight determinants: Pandemic**

Devastating physical morbidity and mortality outcomes due to coronavirus disease 2019 (COVID-19) have been mitigated by[1,2] social distancing and quarantine measures[3], with significant direct and indirect health implications. Although lockdown has reduced the 'R number', physical well-being may have suffered from increased levels of stress, anxiety and mental health issues[4–6]. Moderate weight gain in people with a normal BMI has an adverse effect on metabolism, which increases the risk of diabetes, CVD[7] or long-term ill-health[8]. Lockdown may precipitate weight gain similar to that seen during the 6-week summer holidays because of increased inactive time spent at home and snacking on energy-dense foods[9–11]. Rundle and

Abbreviation: COVID-19, coronavirus disease 2019.

* **Corresponding author:** Dr Moien AB Khan, email moien.khan@uaeu.ac.ae

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colleagues argued that the extent and haste of the restrictions have exaggerated these observations[12] leading to rapid weight gain. This presents particular issues with the gained weight being more difficult to shed[13]. Moreover, physical and social isolation is a recognised risk factor for obesity[14], with weight due to overconsumption, particularly when large "emergency" food stores are present[15]. Reduced physical activity has further exacerbated the weight gain.

The COVID-19 outbreak adversely affected food supply and demand on a global scale[16]. For some, lockdown gave more time to cook and overconsume, while those who were financially disadvantaged suffered from malnutrition and weight loss because of inflated food prices and food insecurity[17,18].

Recent research has linked obesity to an increased risk of contracting severe infections of COVID-19, thereby increasing the risk for extended hospitalisation and increased mortality[19]. Importantly, therapeutic interventions and prophylactic treatments are more difficult and less effective in this group[20–25], with resultant poorer outcomes. Thus, weight gain secondary to pandemic confinement has an increased significance.

As the pandemic unfolds, researchers all over the globe try to better understand the prevalence, factors involved and impact of weight change in order to guide prevention strategies that will address this major public health crisis. These efforts have led to the identification of multiple determinants including biological, psychological and sociological processes that influence body weight during the pandemic. In this report, the interplay between these factors has been extrapolated from a systematic review of the current literature. Through an analysis of these observations, future public health interventions can be determined.

Materials and methods

Methods and analysis

This review has been informed by the Cochrane Handbook for Systematic Reviews of Interventions[26] and is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses[27]. The review protocol is registered in the PROSPERO International Register of Systematic Reviews (Registration number CRD42020193440). This systematic review did not need approval from the ethics committee or required informed consent from the study populations as the data were retrieved from open-source databases and internet searches.

Search strategy

A medical librarian (L.Ö.) performed a comprehensive literature search in the electronic databases PubMed Embase, Scopus, PsycInfo, Cochrane, CINAHL and Web of Science in June and July of 2020. Search terms related to 'pandemics' AND 'body weight' AND 'confinement' were systematically developed with the help of PubMed and PubMed's MeSH and reviewed and discussed with a subject specialist (M.A.B.K.). The search string developed in PubMed was later adapted and applied to all databases. A combination of the search fields of 'Title', 'Abstract' and MeSH/Thesaurus (when available) was used to ensure the best possible search precision and results. No filters or limitations were applied to ensure the inclusion of pre-indexed materials. All databases were searched from their inception until July 2020. Selected sources of grey literature and the preprint archive medRxiv were additionally included in the literature search. A search update in PubMed and Scopus was conducted on 1 February 2021. No additional relevant studies were located after hand screening the results from the updated search.

A search log with database specifications, detailed search strings, results and notes for all sources included in the search is available in online Supplementary Appendix 1.

Inclusion and exclusion criteria

All study designs relevant to human pandemic confinements and their effects on body weight were included (Table 1). All age groups were included, and there were no language restrictions.

This review was extended to articles published from the time of inception until 1 July 2020 and from an update in PubMed and Scopus on 1 February 2021. The primary outcome was to determine the effects of pandemic confinements on body weight. The secondary research outcome was to identify factors affecting body weight during pandemic confinements.

We excluded animal studies and studies investigating the effect of obesity or overweight on various outcomes during the pandemic. We also excluded studies that only narrated the effects of obesity or overweight as a risk factor worsening pandemic-related disease. Studies on diseases, such as HIV, measles and mumps, were also excluded.

Screening and selection

All references identified in the databases and grey searches (n 5070) were uploaded to the systematic review tool Covidence (Veritas Health Innovation, 2020) for automatic deduplication and blinded screening (Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram (Fig. 1)). Two reviewers (H.M. and M.A.B.K.) independently screened the references at both the title/abstract (n 2361) and full-text level (n 78). A third reviewer (P.M.) resolved any conflicts. The grey references and preprints were screened and deduplicated manually by M.A.B.K. and L.Ö. Finally, the reference lists of the included papers were hand screened. Those full-text articles that did not meet the inclusion criterion were excluded (n 27) (Fig. 1). One study investigating weight gain exclusively in pregnant women was excluded[28] as it was impossible to distinguish physiological from pandemic-related weight gain in this group.

Data extraction

The study characteristics including the authors, year of publication, country of origin, study design, research instruments used, validity of survey questionnaire, proportion of female participants, age range and mean age of participants, mean BMI of participants and mean weight of participants were extracted by one reviewer (M.A.B.K.). The other reviewers (P.M., R.G. and A.M.B.A.S.) extracted and reviewed the data independently. Determinants that had an impact on body weight were extracted and reviewed (primarily by M.A.B.K. and secondarily by P.M., R.G. and A.M.B.A.S.).

Table 1. Inclusion and exclusion criteria

	Inclusion	Exclusion
Population	Human studies on pandemic confinement	Animal studies Studies investigating the effect of obesity or overweight on various outcomes during the pandemics Diseases such as HIV, measles and mumps
Effect	Studies describing the impact of quarantine on body weight Studies showing the impact of quarantine on the overweight/obese population	Studies showing obesity or overweight as a risk factor for the pandemic
Outcome	Effect on body weight. Weight change (%), BMI change (kg/m^2) Demographic, behavioural, social, physical, psychological, lifestyle and environmental behaviours during confinement that have effect body weight Studies showing measures taken to manage weight changes during confinement	
Study	Designs: all study designs. Language: all languages. Year: publication year inception – 1 February 2021	

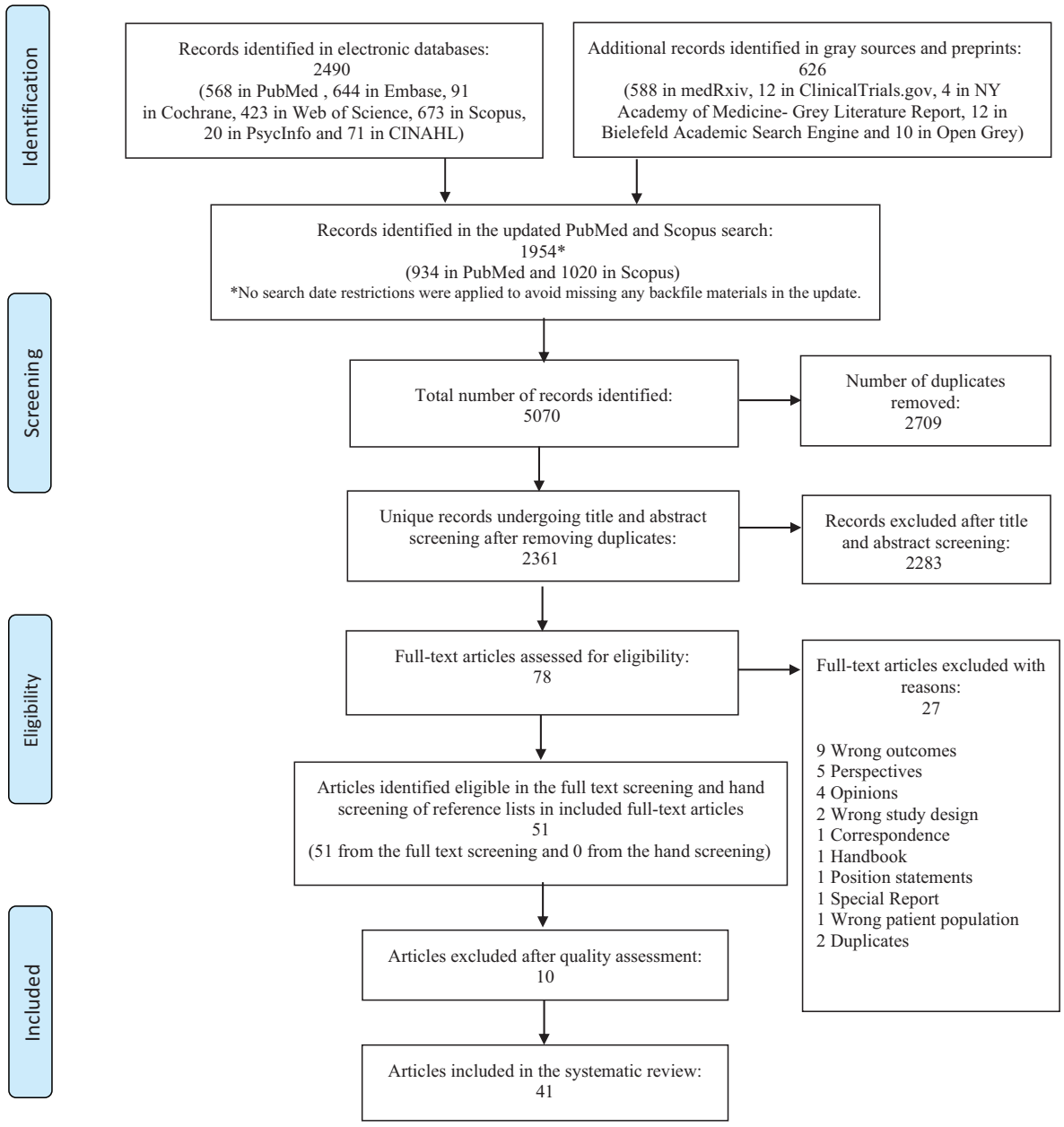

Fig. 1. PRISMA flow chart showing the screening process.

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Quality assessment (n 51)

Two reviewers (M.A.B.K. and P.M.) independently performed a quality assessment of the fifty-one studies identified as eligible in the screening (online Supplementary Appendix 2). We applied a validated Newcastle–Ottawa Quality Assessment Scale to assess the quality of the studies that were included in the review[29–31]. Quality scores obtained via the Newcastle–Ottawa scale for cross-sectional, cohort studies and case–control studies were used to assess selection, comparison and outcomes. Score disagreements were resolved through a discussion between M.A.B.K. and P.M., and a final consensual rating was assigned to each study. Studies six or more stars were considered high quality and were included in the review. Studies with fewer than six stars were excluded (online Supplementary Appendix 2).

Results (*n* 41)

Categorisation of determinants

Ten studies met the inclusion criteria covering pandemic confinements and their effects. These were then further subdivided into the following five main categories:

a. Demographic determinants
b. The impact of pandemic confinements on body weight
c. Dietary changes and other lifestyle behaviour changes during the confinement
d. Behaviour changes observed in obese participants
e. Determinants of obesity during pandemic confinements.

Our search yielded 5070 records of which 2361 unique studies remained after deduplication. After applying the inclusion and exclusion criteria in the title and abstract screening, seventy-eight articles were eligible for full-text screening (Fig. 1). We excluded ten studies based on a quality assessment of the results, and twenty-seven studies were excluded based on reasons presented in the Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram (Fig. 1). The range of observations covered dietary choices[13,20–25,32–35,35–46], lifestyle changes in children[23,35,47–50], physical activity levels[32–34,36,37–40,42,45,46,48,51,52–59], psychosocial factors[21,22,25,37,43,44,50,51,54,55,57,60,61], socio-economic factors[22,36,47,51,53,60] and sleeping patterns[25,45,50,62].

Demographic determinants (study and sample characteristics) (n 41)

Table 2 describes the characteristics of each of the forty-one included studies. All of the studies were published in 2020 and 2021. Two studies were from preprints and were included after assessing their qualities individually[21,51].

The included studies had the following countries of origin: Brazil[58], China[39,56], Croatia[50,63], France[46,51,55], Jordan[57], India[47,54], Iraq[60], Italy[20,22,23,34,35,44,44,52], Korea[49], Lithuania[38], Netherlands[59], Poland[24,41,50], Spain[43,45,62], Turkey[42,48,64,65], United Arab Emirates[32], UK[53] and the USA[25,37,40,66]. Furthermore, multi-regional studies conducted intercontinentally[21], among eighteen countries in the Middle East and North Africa region[33], and Paraguay and Italian-based multinational researches[61] are included in our analysis.

Altogether, the studies enrolled 469 362 participants. The participants ranged in age from 6 to 86 years, and the mean ages for the individuals studied ranged from 9·9 to 74·3 years. The proportion of female participants ranged from 37 % to 100 %. The number of participants in the included studies ranged from 41 to 381 564. All studies included both male and female participants except one study[36]. The duration of confinement for the selected studies for this systematic review ranged between 1 and 24 weeks.

Impact of confinement on body weight

In our study, 7·2–72·4 % of all participants including both adults and children experienced an increase in body weight during the confinement periods[20,22,24,25,32,34–36,38–40,42–51,54,56–61,63–67](Fig. 2). The mean weight gain ranged from 0·6 (SD 1·3) to 3·0 (SD 2·4) kg. There was a higher weight gain among participants who self-reported stress[25,44,54,55,57,60,61], anxiety and depression[22,51,57,60,61]. Weight loss was observed in 11·1–32·0 % of participants[20,24,32,34,36,39,50,51,54,59,64,67]. The mean experienced weight loss ranged from 2·0 (SD 1·4) to 2·9 (SD 1·5) kg.

Dietary and other lifestyle behaviour changes during confinement

Table 3 describes dietary and behavioural changes that were caused by pandemic-related confinements. Most studies reported an increase in food intake associated with increased snacking[20,22,24,25,32,33,35,36,38,40,42,43,50,51,54,67] and all these studies documenting perceived weight gain[20,22,24,25,32,33,35,36,38,40,42,43,50,51,54,67].

Appetite was modified either negatively or positively and was associated with employment change, suspension or working from home[20,51,52,57] or due to suspension of school attendance[23,47–49].

The initiating factors were as follows: response to smell and sight of food[24,25], boredom, binge eating and food cravings[24,25,40,42,44,54,66], snacking post dinner[25,32,33,38] and visual stimulation through social media[32]. A significant correlation was observed between snacking, the consumption of high density processed food and a higher BMI[20,22,24,38]. Increased energy intake by 10–49·4 % was observed among study participants[20,22,24,25,32–38,40,42–44,51,54,66], particularly those with an increased consumption of high density processed foods[20,22,23,34–36,38,40,42,43,50,67], female sex[20,34,38,42,51,63] or with a higher BMI[20,22–24,36,38,43,44,48,63]. There was an increase in the number of meals eaten per day[23,35,36,44,67] and participants ate more than usual[34,38,42,54]. The proportion of respondents engaged in cooking increased from 40 % to 62 % in our study sample[24,32,38,51]. Likewise, consumption of homemade recipes increased[22,23,32,33,38,51] and eating homemade desserts increased compared with pre-lockdown[20,22,23,32,34,38,67].

Less than one-third of the surveyed participants consumed fresh fruits and vegetables on a daily basis, while a similar number consumed sweets and desserts every day[20,21,24,32,36,38,39,51].

Table 2. Characteristics of included studies
(Mean values and standard deviations)

S. no	First author, year, country	Number of participants	Study design	Instrument used	Local setting/target population	Survey questions type	Proportion of female participants (%)	Age of participants range (years)	Mean age of participants (SD)		Mean BMI/Centile of participants		Mean weight (kg) of participants	
1	Adıbelli, *et al*., 2020, Turkey[48].	597	Cross-sectional study	Online survey	Children aged 7–13 years and their parents	Validated	55·8	7–13 (child) 26–57 (parent)	9·87± 1·99 (children) 37·63 ± 5·83 (parents)		NR		NR	
2	Ahmed, *et al*., 2020, Iraq[60].	765	Prospective cross-sectional case series study	Face-to-face interview	Patients visiting bariatric clinic	Validated	39·4	< 20–> 70	NR		NR		73	
3	Athanasiadis, *et al*., 2020, USA[40].	208	Cross-sectional	Online survey	Postoperative bariatric patients	Validated	86	NR	48·9	11·2	NR		92·1	23·6
4	Błaszczyk-Bebenek, *et al*., 2020, Poland[41].	312	Observational retrospective	Self-administered web-based questionnaire	Healthy adults	Validated	64·1	NR	41·12	13·05	24·98	4·33	73·47	16·65
5	Chagué *et al*., 2020, France[46].	124	Cross-sectional survey	Phone interviews	Congestive heart failure patients	New	39·5	NR	71·0	14·0	28·2	5·4		
6	Chopra, *et al*., 2020, India[54].	995	Cross-sectional study	Online survey	Adults ≥ 18 years	Validated	41·5	≤30 > 30	33·33	14·5	24·8 ± 4·7 kg/m^2		NR	
7	Cransac-Miet, *et al*., 2021, France[55].	195	Cross-sectional population-based study	Phone interview	Patients with chronic coronary syndromes	New	39	NR	65·5	11·1	NR		NR	
8	Deschasaux-Tanguy *et al*., 2020, France[51].	37 252	Cross-sectional survey	Self-administered web-based questionnaire	NutriNet-Santé cohort	Validated	52·3	18–80+	52·1	16·6	NR		NR	
9	Di Santo, *et al*., 2020, Italy[34].	126	Cross-sectional observational study	Telephone interview	Mild cognitive impairment patients	Validated	81	60–87	74·29	6·51	NR		NR	
10	Di Renzo *et al*., 2020, Italy[20].	3533	Cross-sectional survey	Self-administered web-based questionnaire	General public	Validated	75·1	12–86	± 13·53		27·66	4·10	66·87	13·16
11	Dogaš, *et al*., 2021, Croatia[63].	3027	Cross-sectional study	Online questionnaire	General public	Validated	70·1	NR	40	30–50	74·03	16·03	24·64	4·22
12	Dondi, *et al*., 2021, Italy[35].	5811	Cross-sectional study	Online survey	Italian resident parents of children ≤ 18 years	Validated	91·7	≤ 30–> 50	NR		NR		NR	
13	Dragun, *et al*., 2020, Split, Croatia[50].	531	Cross-sectional study	Online survey	Students	Validated	63·8	17–24 (median)	18·0	6·0	21·4	3·3	NR	
14	Drywień, *et al*., 2020, Poland[36].	1769	Cross-sectional study	Online survey	Polish women	Validated	100	≥ 18	NR		NR		NR	
15	Dihogo Gama de Matos, *et al*., 2020, Brazil[58].	426	Cross-sectional study	Self-administered web-based questionnaire	General public	Validated	49·1	7–80	Multiple range from children to elderly		Multiple stratified per age		Multiple weight stratified per age	
16	Gentile, *et al*., 2020, Vasto- Italy and Paraguay[61].	110	Observational study	Phone-based clinical follow-up and survey	Psychiatric outpatients	Validated	54·5	NR	38·6	14·1	NR		NR	
17	Giustino *et al*., 2020, Italy[52].	802	Cross-sectional study	Self-administered web-based questionnaire	Physically active participants	Validated	51	NR	32·27	12·81	23·44	3·33	67·13	13·41
18	He, *et al*., 2020, China[39].	339	Cross-sectional study	Online survey	Adults ≥ 18 years	New	52·3	NR	Males:36·4 (11·9) Females: 37·6 (12·4)		NR		Female: 51·1 ± 4·1 Male: 65·6 ± 5·8	

Table 2. (*Continued*)

S. no	First author, year, country	Number of participants	Study design	Instrument used	Local setting/target population	Survey questions type	Proportion of female participants (%)	Age of participants range (years)	Mean age of participants (SD)		Mean BMI/Centile of participants		Mean weight (kg) of participants	
19	Ismail, *et al.*, 2020, MENA Region[3].	2970	Cross-sectional	Online questionnaire	Adults ≥ 18 years	Validated	71·6	18–> 55	NR		NR		NR	
20	Ismail, *et al.*, 2020, UAE[33].	1012	Cross-sectional study	Online survey	Adults ≥ 18 years	Validated	75·9	18– ≥ 36	NR		NR		NR	
21	Jia, *et al.*, 2020, China[56].	10 082	Retrospective study	online questionnaire and	Chinese youth	Validated	72	16–28	19·8	2·3	21·8 kg/m^2		NR	
22	Jimenez, *et al.*, 2021, Spain[43].	603	Cross-sectional study	Online survey	Patients attending obesity clinic	New	27·5	18–≥ 55	NR		34·2	7·0	NR	
23	Kang, *et al.*, 2021, Korea[49].	226	Retrospective cohort study	Retrospective review of medical records	Children followed-up at the growth clinic	Not applicable (anthropometric and laboratory parameters)	57·5	4–18	10·5 (8·7–11·4) IQR		0·2 (1·3) anthropometric *z* scores		0·1 (1·2) anthropometric *z* scores	
24	Karatas, *et al.*, 2020, Istanbul[65].	140	Prospective observational case–control study	Physical and biochemical parameters	Known confirmed type 2 diabetes patients matched with healthy patients in outpatient clinic	None	Non-diabetic: 56·4 Diabetic: 68·2	NR	Non-diabetic: 52·61 ± 4·88 Diabetic: 54·81 ± 10·53		Total mean 31·63 ± 3·57 kg/m^2 Non-diabetic: 31·63 ± 3·57 Diabetic 33·44 ± 6·48		Non-diabetic: 85·56 ± 10·53 Diabetic: 87·83 ± 18·27	
25	Keel PhD, *et al.*, 2020, USA[37].	90	Prospective study	Online surveys	Undergraduate psychology students	Validated	88	NR	19·45 (1·26) years		22·93		63·87	
26	Kriaucioniene, *et al.*, 2020, Lithuania[38].	2447	Cross-sectional study	Self-administered web-based questionnaires	General public	Validated	87·8	> 18–≥ 51	NR		NR		NR	
27	Malkawi, *et al.*, 2020, Jordan[57].	2103	Cross-Sectional Study	Online survey	Mothers living in Jordan who have at least one child between the ages of 4–18 years	Validated	NR	Mother's age range: 20–60 years	36·2 years		NR		NR	
28	Marchitelli, *et al.*, 2020, Italy[44].	110	Cross-sectional	Online survey	Day care patients in hospitals for obesity management	Validated	71	NR	No psychiatric illness: 18–75 years (M = 47·24, SD = 14·3) Psychiatric illness: 18–74 years (M = 46·38, SD = 14·5)		No psychiatric illness: 40·19 kg/m^2 (SD = 6·8, range: 27–60) Psychiatric illness: 39·88 kg/m^2 (SD = 6·8, range: 28–55)		NR	
29	Martínez-de-Quel *et al.*, 2021, Spain[45].	161	Longitudinal observational study	Online survey	Spanish adults	Validated	37	19–65	35·0	11·2	23·7	4	67·3	14·8
30	Mason, *et al.*, 2021, USA[66].	1820	Longitudinal prospective cohort study	Online survey	High schools	Validated	61	NR	19·28		NR		70·3 kg	
31	Mitchell *et al.*, 2020, USA[21].	3 81 564	Observational, retrospective, cohort study	Noom app – mobile behaviour change weight loss programme	App-based food data from a digital behaviour change weight loss programme	App-based validated	83·4	≥ 18	47·76	13·59	NR		85·57	20·4

Table 2. (*Continued*)

S. no	First author, year, country	Number of participants	Study design	Instrument used	Local setting/target population	Survey questions type	Proportion of female participants (%)	Age of participants range (years)	Mean age of participants (SD)		Mean BMI/Centile of participants		Mean weight (kg) of participants	
32	Önmez, *et al*., 2020, Turkey[64].	101	Retrospective observational study	Questionnaire	Diabetic patients attending polyclinics	Validated	53·5	18–80	55	13	30·3	5·5	84·7 ± 16·4 kg	
33	Özden, *et al*., 2021, Turkey[42].	1011	Cross-sectional study	Online survey	Nursing students	Validated	60	NR	19·97 ± 3·11 years		NR		NR	
34	Pellegrini *et al*., 2020, Italy[22].	150	Observational retrospective study	Telephone interviews cross-sectional survey	Obese patients in weight loss programme	Validated	76·3	18–75	47·9	16·0	36·6	4·5	92	17
35	Pietrobelli *et al*., 2020, Italy[23].	41	Longitudinal observational study/questionnaire	In-person interview/telephone interviews (parents)	School children	New	46·35.	6–18	13	3·1	30·2 ± 4·1 [a] and BMI % Centile 98·2 ± 1·4		77·4	21·9
36	Rogers *et al*., 2020, UK[53].	5820	Cross-sectional survey	Self-administered web-based questionnaire	General public	Validated	88	20–70+	NR		NR		NR	
37	Romero-Blanco *et al*., 2020, Spain[62].	207	Longitudinal observational study	Self-administered questionnaire	Nursing students	Validated	81·6	17–53	20·6	4·62	NR		NR	
38	Ruissen, *et al*., 2021, Netherlands[59].	435	Observational cohort study	Online questionnaire	Type 1 and Type 2 diabetic patients	Validated	42	≥ 18	Type 1 DM: 50·1 (± 14·9) Type 2 DM: 62·5 (± 11·6)		Type 1 DM: 25·9 (± 4·3) Type 2 DM: 30·2 (± 6·1)		NR	
39	Shah, *et al*., 2020, India[47].	77	Observational study	Follow-up in outpatient clinic	Children with type 1 diabetes	Validated	58·4	5–20	14 ± 4 years		NR		NR	
40	Sidor *et al*., 2020, Poland[24].	1097	Cross-sectional survey	Self-administered web-based questionnaire	General public	New	95·1	18–71	27·7	9·0	21·5 23·5	4·8	66·0	14·5
41	Zachary *et al*., 2020, USA[25].	173	Cross-sectional survey	Self-administered web-based questionnaire	General public	Validated	55·5	≥ 18	28·1	12·5	27·0	7·6	NR	

BMI in children; NR, not reported.

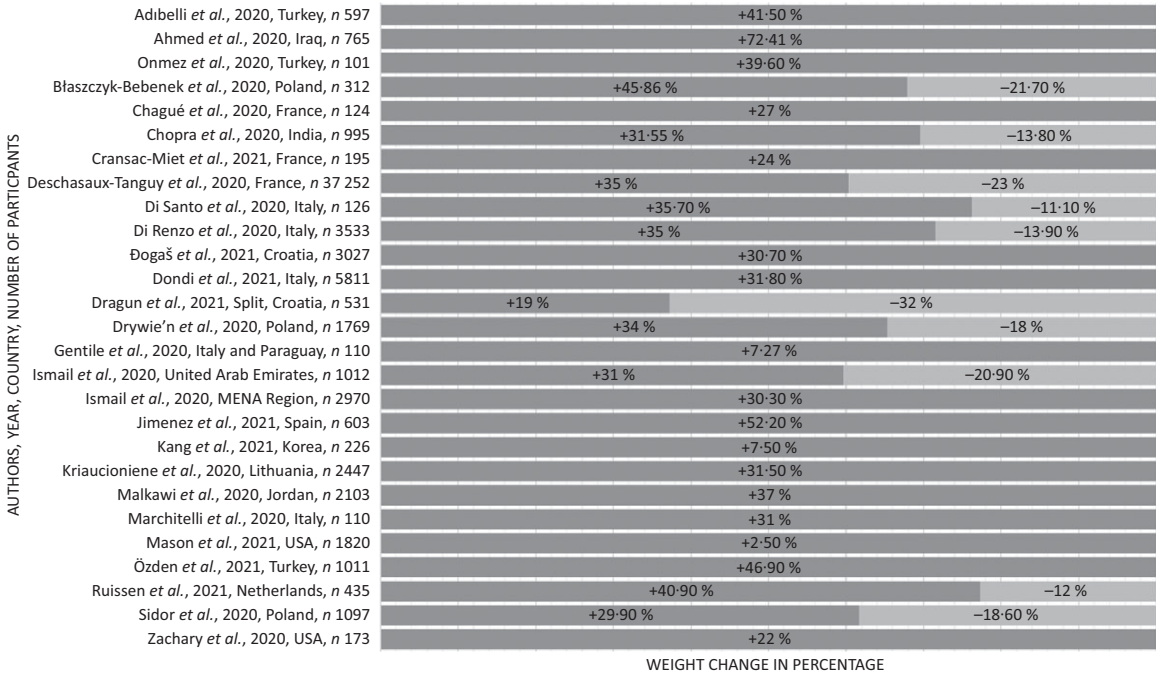

Fig. 2. Body weight changes during pandemic confinements. Selected studies showing percentage of body weight changes. For the full list of weight changes, please refer to Table 3. +, increase in weight; –, decrease in weight.

In contrast, some studies have shown a decrease in unhealthy food consumption[22,33,38,54,67].

Where Mediterranean diet was followed, 18- to 30-year-olds were more compliant than other age groups[20]. Inverse associations were found between adherence to Mediterranean diet and BMI[20,50]. A total of 54 % of respondents used leftovers for at least a third of meals, and those who shopped at farmers' markets or local or organic markets ate up leftovers more (OR = 1·468, $P < 0{\cdot}001$)[20]. Among app users, mobile behavioural change app interaction was reduced by 9 %[21]. Eating in response to stress was associated with weight gain[25,34,58,66]. There was increased alcohol consumption[24,46,55,61,67] during the lockdown, while a decrease in alcohol consumption was also noted compared with pre-COVID-19 in another study[20,46]. There was an increase in cigarette smoking generally[46,50,55,63] while in contrast, 3·3 % of the smokers surveyed reported reduced smoking during quarantine[19].

Although the participants reported spending more time in bed before lockdown[23,25,54,56], the overall sleep quality was worse[45,54,62]. In contrast, secondary school students felt refreshed on awakening and increased sleeping hours[50]. Weight gain was reported by others to be related to decreased night-time sleep and reduced physical activity time[25,40,59]

Sedentary lifestyle and screen time increased during the lockdown[23,25,37,46,54–56]. Those participants who were not currently working or those who started working from home felt that they gained more weight compared with participants who did not have a change in job routine[20,20,51,57].

Physical activity altered by varying amounts, reduced in some studies to between 18 and 84 %[22,23,33,34,39,46,51,53,54,58]. People who were already overweight or obese engaged in less physical activity and had decreased energy expenditure during lockdown[36,38,43,51–53,55,58]. Obese children spent less time participating in sports activities[23].

By contrast, studies reporting an increase in physical activity[20,51] found greater engagement in yoga/pilates, functional training, home training, and treadmill use and overall increased training frequency[20].

Behaviour changes observed in obese participants

Weight gain was more common in those already overweight or obese prior to lockdown and in individuals with pre-existing difficulty in weight management[20,22–24,36,38,43,45,48,63].

Increased snacking and food consumption were observed in participants with a higher BMI[23,24,32,33,67]. Many of the participants agreed that they consumed less fruits and vegetables on a daily basis[21,24,33,38,40,51] but more high energy processed foods[22–24,40,43].

This intake was associated with an enhanced appetite and after-dinner hunger[20,36,38,44]. Obese children reported an increase in the number of meals eaten along with an increased consumption of sweetened drinks, potato chips and red meat[23]. A decrease in intensive physical activity was associated with obesity[53]. An inverse relationship was found between changes occurring in sporting activities and the number of meals consumed per day[23,40,52,67]. The participants self-reporting anxiety and depression displayed an estimated weight gain[22,44,54,55,57,61].

Determinants that can influence body weight during pandemics

Table 4 describes the determinants of body weight changes during the pandemic. Many determinants that can influence increased weight gain during confinement were identified via

Table 3. Behavioural and dietary changes related to pandemic confinements

S. no	First author, year, country	Duration of confinement during which study was conducted (weeks)	Outcome area of focus	Number of participants	Weight gain of the participant (%) (weight gain in kg), weight loss of the participant (%) (weight loss in kg)	Energy intake/ food intake	Snacking	Fresh product (fruits and vegetable)	Physical activity	Alcohol	Dietary patterns and other behaviour changes identified during the confinement
1	Adıbelli, *et al.*, 2020, Turkey[48].	4 weeks	Health related quality of life	597	↑41·5 %	NR	NR	NR	NR	NR	Quality of life score mean 73·91 ± 8·44 Increase in sleep time of 34·2 % Increase Internet usage of 69·3 %
2	Ahmed, *et al.*, 2020, Iraq[60].	1–9 weeks	Body weight	765	↑72·41 %	NR	NR	NR	NR	NR	One-third of them became emotionally unstable during the outbreak Even after the isolation process calmed down, the stress was present in more patients compared with the period of the outbreak
3	Athanasiadis, *et al.*, 2020, USA[40].	5	Factors attributed to weight gain	208	2 + 4·2 kg in patients > 18 months post-bariatric surgery	Increased	↑62·6 %	↓45·5 %	↓55·2 %	↑40·1 %	19·5 % reported increase in binge eating 48·2 % reported loss of control when eating Weight gain of > 2 kg in patients > 18-month post-bariatric surgery
4	Błaszczyk-Bebenek, *et al.*, 2020, Poland[41].	5- 8	Nutrition behaviour changes during lock-down	312	↑45·86 % (0·56 ± 2·43 kg) ↓21·72 %	↑11·2 % in number of meals	↑from 72·8 % to 77·9 ($P < 0·0001$)	↑from 63·8 % to 64·7 % ($P = 0·7755$)	NR	Increased	Increase of consumption of eggs, potatoes, sweets and canned meat
5	Chagué *et al.*, 2020, France[46].	6–7	Impact of lockdown on health indicators and behaviours among congestive heart failure patients	124	↑27·4 %	NR	NR	NR	↓41·9 %	↑4 % ↓15 %	Screen time increased by 46 %. Tobacco consumption increased in 44·4 % of current smokers. Adherence to strict salt and fluid restriction decreased by 14·5 %. Increase in heart failure symptoms in 21·8 %
6	Chopra, *et al.*, 2020, India[54].	20–22 weeks	Impact of COVID-19 on lifestyle-related behaviours: eating, physical activity and sleep behaviour	995	↑31·55 % ↓13·87 %	Increased	Increased	↑ 34 *v* 38 %	↓9·5 %	Decreased	In participants < 30 years old, increase in healthy food and restriction of unhealthy meals Increase stress amongst participants (25 % *v* 38·3 %) significantly increased Increase in daily sleeping hours, screen time, sitting time at work, stress levels. Decreased smoking
7	Cransac-Miet, *et al.*,2021, France[55].	4	Lifestyle changes	195	↑24 %	NR	NR	NR	↓ 25 %	5 % increase in alcohol consumption	Smoking increased by 26 % Screen time increased in 65 % of patients
8	Deschasaux-Tanguy *et al.*, 2020, France[51].	2–6	Changes in diet and physical activity during lockdown	37 252	↑ 35 % (1·8 ± 1·3 kg), ↓23 % (2·0 ± 1·4 kg)	↑10 % ↓10 %	↑21·1 %	↓10·1 %	↑52·8 %, ↓ 18 %	↑15 %, ↓ 12 %	Positive behavioural trends were observed in those with higher educational attainment with high income but negative trends were reported when income was lower Positive behavioural trends were observed in the overweight/obese population with higher educational attainment who expressed anxiety: reduced snacking: reduced alcohol consumption: increased more home cooking
9	Di Santo, *et al.*, 2020, Italy[34].	8–10	Lifestyle, mental health Weight change Behavioural changes	126	↑35·7 %, ↓11·1 %	↑19·2 %	NR	NR	1/3 of the subjects decreased their physical activity	Decreased in drinkers 12·4 % Increase in alcoholic drink intake (44·4 %) Two subjects started drinking wine	1/6 of participants decreased mental-stimulating activities 70 % reported an increase in idle time 19·8 % were depressed, 9·5 % anxious and 9·5 % apathetic 31·9 % consumed more sweets 12·8 % ate preserved or frozen foods

Table 3. (*Continued*)

S. no	First author, year, country	Duration of confinement during which study was conducted (weeks)	Outcome area of focus	Number of participants	Weight gain of the participant (%) (weight gain in kg), weight loss of the participant (%) (weight loss in kg)	Energy intake/ food intake	Snacking	Fresh product (fruits and vegetable)	Physical activity	Alcohol	Dietary patterns and other behaviour changes identified during the confinement
10	Di Renzo *et al.*, 2020, Italy[20].	2–4	Lifestyle changes, eating habits, and adherence to the Mediterranean diet during the COVID lockdown	3533	↑ 35 %, ↓ 13·9 %	↑ 34·4 %	↑ 25·6 %	↑ 37·4 %, ↓ 35·8 %	↑38·3 %	NR	Younger participants adhered better to the Mediterranean diet Overweight participants had poor adherence to the Mediterranean diet 9·1 % of participants slept more than 9 h/d
11	Dogaš, *et al.*, 2021, Croatia[63].	2	Lifestyle, mood	3027	↑ 30·7 %	NR	NR	NR	Women decreased their exercise duration and frequency from 57·9 ± 34·5 to 51·1 ± 37·7	Increased	Women smoked more cigarettes ($P < 0·001$) Increased frequency of feeling afraid ($P < 0·001$), discouraged ($P < 0·001$) and feeling sad ($P < 0·001$) in both sexes
12	Dondi, *et al.*, 2021, Italy[35].	24	Perception of food insecurity in children	5811	↑31·8 %	↑27·3 %	↑60·3 %	↑ 14·0 %	NR	NR	27·3 % Children were eating more food there was an increase. 60·3% consumption. 14 % fruit juices 10·4 % soft drinks. 2·5 % reported inadequate food after the pandemic
13	Dragun, *et al.*, 2020, Split, Croatia[50].	3–11	Lifestyle changes and psychological state	531	↑ 19 % ↓ 32 %	No difference in dietary pattern	Increased 20–38 %	Increased (65·3 % *v.* 58·6 %)	Unchanged	NR	Improved sleep quality 31·5 %. Sleep hours increased Increased intake of legumes (60·6 % *v.* 53·3 %), fish (32·8 % *v.* 24·4 %) and sweets (30·5 % *v.* 22·4 %) Decreased intake of cereals (24·1 % *v.* 35·6 %), nuts (15·1 % *v.* 18·9 %), and dairy products Increase computer screen time due to online learning
14	Drywień, *et al.*, 2020, Poland[36].	3–7	Changes in body weight due to COVID-19 lockdown	1769	↑34 % ↓18 %	↑65 % ↓40 %	↑Salty snacks (30·4 % *v.* 11·3 %)	↑Consumption of vegetables (32·3 % *v.* 16·0 %), fruit (23·8 % *v.* 14·3 %) in those with weight loss	↓ In weight gainers (60·7 % *v.* 31·6 %)	↑ In alcohol who gained weight (25·4 % *v.* 4·1 %)	Unhealthy dietary changes. Increase in screen time In females, those who lost weight ate more fruits, vegetable, pulses, seafood, drank > 500 ml water and did not consume alcohol Females who gained weight had increased consumption of sweetened spreads, commercial pastry, confectionery, salty snacks, fast food, sugar-sweetened beverages, processed meat, ice-cream and pudding and alcohol, decreased physical activity
15	Dihogo Gama de Matos, *et al.*, 2020, Brazil[58].	12	Effects of COVID-19 social distancing on physical activity, stress levels, quality of life	426	Increased	NR	NR	NR	↓84 %	NR	The study shows an overall decrease in all sections of quality of life as analysed by the SF-36. The elderly age group showed no significant changes. There has been increase in stress level across adolescents, adults and elderly age groups in both sexes ($P < 0·05$) although there is no difference of stress levels across children

Table 3. (*Continued*)

S. no	First author, year, country	Duration of confinement during which study was conducted (weeks)	Outcome area of focus	Number of participants	Weight gain of the participant (%) (weight gain in kg), weight loss of the participant (%) (weight loss in kg)	Energy intake/ food intake	Snacking	Fresh product (fruits and vegetable)	Physical activity	Alcohol	Dietary patterns and other behaviour changes identified during the confinement
16	Gentile, *et al.*, 2020, Vasto-Italy and Paraguay[61].	4–6	Provide psychiatric assessments and measure the level of stress related to quarantine in a large sample of psychiatric outpatients	110	↑7·27 %	NR	NR	NR	NR	↑2·72 %	56·3 % self- reported lifestyle changes during the confinement including: 32·7% eating pattern changes, 4·54 % Change in sleeping pattern, increased alcohol in 2·72 % Consumption, more reading and gaming in 16·3 %. Self-reported emotions from the patients ranked: Fear 24·5 % Optimism 20 % Pessimism 14·5 %, Hope 13·6 %, Hopelessness 10·9 %, Serenity, Anger 7·27 %
17	Giustino *et al.*, 2020, Italy[52].	1–2	Changes in physical activity before and during the quarantine among the active Sicilian population	802	NR	↓ 1168·5 MET – min/week	NR	NR	NR	NR	Greater impact of decreased physical activity among males and overweight participants
18	He, *et al.*, 2020, China[39].	4	Body weight, physical activity and lifestyle changes	339	BMI < 24 gained weight Females: 2·2 kg Males: 1·7 kg	Decreased	NR	NR	Decreased	Decreased	Weight correlated with the change level of alcohol consumption during the semi-lockdown for COVID-19 ($Rs = -0·255$; $P = 0·002$)
19	Ismail, *et al.*, 2020, MENA Region[3].	4–6	Eating behaviours and lifestyle changes during COVID – 19 pandemic in Middle east and North Africa region (MENA)	2970	↑30·3 %	Increased	32·9 % had salty snacks	48·8 % of surveyed participants did not consume fruits and 32·5 % did not consume vegetables daily	Increased level of inactivity from 34·9 % to 39·1 %	NR	Skipping meals decreased 74·0 % consumed less than eight cups of water per day. 44·1 % ate sweets or desserts
20	Ismail, *et al.*, 2020, UAE[33].	1–4	Effect of quarantine on eating habits, physical activity, stress and sleep behaviours	1012	↑31 % ↓20·9 %	↑25·71 % ↓12·31 %	37·1 % ate salty snacks	48·8 % consumed fruits daily	↑14·8 ↓41·9	NR	Increase in home cooked food, decrease in fast food consumption ($P < 0·0001$). Decrease frequency of meal skipping (64·5–46·2 %). Increase breakfast intake (66 % to 74·2 %). Increase water intake (24·1–27·8 %.) Main products consumed are sweets and desserts and salty snacks (chips, crackers, and nuts) during COVID-19 pandemic Inactivity levels rise (32·1–38·5%). 69·1 and 67·8 % of participants relied on social media applications to be updated about nutrition and health news
21	Jia, *et al.*, 2020, China[56].	11–14	Activity performance and weight changes	10 082	BMI increased from 21·8 to 22·1 kg/m^2 Overweight subject's percentage increased from 21·4 % to 24·6 % Obesity participants percentage increased from 10·5 % to 12·6 %	NR	NR	NR	Decreased (1·3–0·9 d/week, $P < 0·001$)	NR	Increased sleeping hours (7·4–7·6 h/week, $P < 0·001$) on weekdays and (7·9–8·0 h/week, $P < 0·001$) on weekends Increase sedentary lifestyle (4·2–5·3 h/week, $P < 0·001$) on weekdays and (4·3–5·1 h/week, $P < 0·001$) on weekends Increased screen time (4·9–5·6 h/ week, $P < 0·001$)

Table 3. (*Continued*)

S. no	First author, year, country	Duration of confinement during which study was conducted (weeks)	Outcome area of focus	Number of participants	Weight gain of the participant (%) (weight gain in kg), weight loss of the participant (%) (weight loss in kg)	Energy intake/ food intake	Snacking	Fresh product (fruits and vegetable)	Physical activity	Alcohol	Dietary patterns and other behaviour changes identified during the confinement
22	Jimenez, *et al.*, 2021, Spain[43].	9	Psychosocial, lifestyle and body weight effect due to COVID-19 lockdown	603	↑52·2	Increased	↑19 %	↑32·5 %	Decreased in > 50 %	Almost unchanged in 81·4 % (1·6 ± 1·2 *v.* 1·3 ± 0·7, $P < 0·01$)	Patients with weight gain rated behavioural changes (4·1 ± 1·5 *v.* 2·5 ± 1·5, $P < 0·01$), physical activity (5·0 ± 1·4 *v.* 4·1 ± 1·6, $P < 0·01$), purchase of unhealthy and comfort foods (3·3 ± 1·6 *v.* 2·0 ± 1·2, $P < 0·01$), increase in consumption of sugary beverages (2·1 ± 1·5 *v.* 1·5 ± 1·0, $P < 0·01$) or alcohol (1·6 ± 1·2 *v.* 1·3 ± 0·7, $P < 0·01$), and snacking (3·6 ± 1·6 *v.* 2·1 ±1·3, $P < 0·01$). Bariatric surgery within 2 years acted as a protective factor against weight gain. Many experiences disordered sleep and mood
23	Kang, *et al.*, 2021, Korea[49].	24	COVID-19 impact on childhood obesity and vitamin D levels	226	Overweight or obesity rate increased 23·9–31·4 % (7·5 % increase)	NR	NR	NR	Decreased due to school closure	NR	BMI *z* scores increased by 0·219 ($P < 0·001$) Increase level of TAG (105·8 mg/dL *v.* 88·6 mg/dl, $P < 0·001$) Increase level of LDL-cholesterol (100·2 mg/dl *v.* 94·0 mg/dl, $P = 0·002$). Decrease level of calcidiol level (18·9 mg/dl *v.* 23·8 mg/dl, $P < 0·001$). Patients who were normal weight had 9·9 ($P < 0·001$) times risk of becoming overweight or obesity during epidemic
24	Karatas, *et al.*, 2020, Istanbul[65].	24	Body weight, metabolic control in type 2 diabetic patient and healthy population	140	Non-diabetic group (86·10 ± 10·48 *v.* 85·56 ± 10·53 kg) ($P < 0·05$) (0·54 ± 0·95) Diabetic group (89·75 ± 18·68 *v.* 87·83 ± 18·27 kg) ($P < 0·05$) 1·91 ± 5·48 kg	NR	NR	NR	NR	NR	Non-significant change of BMI 33·44 ± 6·48 to 31·63 ± 3·57 kg/m^2 HbA1c increased more in diabetic than in non-diabetic groups ($P = 0·002$) Glucose, LDL-cholesterol, and TAG increased in diabetic (39·69 ± 74·69, 7·60 ± 34·33, and 58·21 ± 133·54 mg/dl, $P < 0·05$) Waist circumference increased more in diabetic patients compared with non-diabetics (1·20 ± 2·38 *v.* 0·03 ± 0·46 cm, $P < 0·05$) TAG levels increased more in the diabetic group than in the non-diabetic group ($P = 0·041$)
25	Keel PhD, *et al.*, 2020, USA[37].	6–7	Perceived *v* observed weight changes in undergrad students during COIVD-19 confinements	90	No statistically significant	Increased	NR	NR	Decreased	NR	Increase mean of weight description Increase screen time Increase time spent on TV Increased weight/shape concerns were significantly related to increased eating concerns Women had significantly higher weight/shape concerns than men Women at time 2 spent more time on social media compared with men

Table 3. (*Continued*)

S. no	First author, year, country	Duration of confinement during which study was conducted (weeks)	Outcome area of focus	Number of participants	Weight gain of the participant (%) (weight gain in kg), weight loss of the participant (%) (weight loss in kg)	Energy intake/ food intake	Snacking	Fresh product (fruits and vegetable)	Physical activity	Alcohol	Dietary patterns and other behaviour changes identified during the confinement
26	Kriaucioniene, *et al.*, 2020, Lithuania[38].	4	Effect of COVID-19 on health behaviours and body weight	2447	↑31·5 %	↑49·4	↑45·1 %	↓14·7 fruits ↓15·0 % vegetables	69·9 % remained the same ↑14·2 % ↓15·9 %	↓ 60·6	62·1 % cooked at home more frequently and (37·7 % increased the intake of homemade pastries while 26 % decreased intake of commercial pastries 20·6 % ate more fried food 41·3 % decreased fast food orders 19·4 % decreased carbonated and sugary drink intake Bought less manufactured pastries by 26 %
27	Malkawi, *et al.*, 2020, Jordan[57].	1–6	Mental health and changes in lifestyle practices among Jordanian mothers during COVID-19 quarantine	2103	↑37 %	NR	NR	80·7 % consumed healthy diet	NR	NR	Increased teaching time of children Increased (63 %). Family violence Increased (27 %) hours spent in dedicated family time (+ 5 h). Mild levels of depression (mean = 11·5 ± SD = 9; range 0–42), anxiety (mean = 7·2 ± SD = 4; range 0–42), and stress (mean = 14·7 ± SD = 10; range 0–42).
28	Marchitelli, *et al.*, 2020, Italy[44].	9–11	Weight gain in overweight/obese subjects Effect of psychological and psychosocial variables	110	Weight gain by 31 % of overweight/ obesity Weight gain by 31 % of psychiatric patients	60 % increased night eating	No significant changes	NR	NR	NR	Binge eating was significant factor for weight gain in psychiatric patients Increased night eating episodes in response to stress
29	Martínez-de-Quel *et al.*, 2021, Spain[45].	6–7	Changes in physical activity, dietary habits and sleep quality pre- and post-lockdown	161	Pre 67·3 kg ± 14·8 *v* Post 67·7 kg ± 15·1	NR	NR	NR	↓8515·7 ± 10260·0 Met/ week *v* Post 5053·5 ± 5502·0 Met/ week p = <0·001	NR	Significant differences were found pre- and post-lockdown with physical activity sleep and perceived well-being, More people living together had higher weight gain
30	Mason, *et al.*, 2021, USA[66].	10–18	Body weight change during lockdown and factors determining it	1820	Mean weight change 3·47 lbs (SD 14·57); mean % Weight change ↑ 2·5 % (8·6 %)	↑31 %	NR	NR	NR	NR	35 % consumed unhealthy food to cope with the pandemic Overeating as a mechanism of coping with pandemic was related to increase in weight and BMI on overweight
31	Mitchell *et al.*, 2020, USA[21].	1	Alterations in food choices related to lockdown in users enrolled in a digital behavioural change weight loss programme	381 564	NR	NR	NR	↓ 4·2 %	NR	↓ 4·5 %	Use of the mobile app (Noom) decreased by 9 %
32	Önmez, *et al.*, 2020, Turkey[64].	15–24	Glycaemic control in type 2 diabetes patients	101	↑39·6 % ↓38·6 %,	NR	NR	NR	Low: physical functioning on short form 36 – item survey (59·5 ± 26·9)	NR	HbA1c increased from 7·67 ± 1·76 to 8·11 ± 2·48 compared with pre- and post-lockdown. The numbers of patients who exercised regularly and dieted were low. Mean pre-lockdown waist circumference was 105 ± 23 cm, compared with 107 ± 32 cm post-lockdown

Table 3. (*Continued*)

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33	Özden, *et al.*, 2021, Turkey[42].	8–10	Nutrition exercise behaviours during lockdown	1011	↑46·9 %	Increased	Increased	NR	↓35·4	NR	26·8 % were bored. Psychological/addictive eating behaviour subscale scores were piled up between 20 and 40, and their unhealthy nutrition-exercise behaviour subscale mean scores were piled up between 30 and 50 (Fig. 1)
34	Pellegrini *et al.*, 2020, Italy[22].	4	Weight and dietary changes before and during the COVID-19 lockdown in obese adults	150	↑1·51 kg	↑40 %	↑33 %	↓18 %	↓ 60 %	NR	Increased weight gain with lower educational attainment and unhealthy food choices. Anxiety and depression increased weight gain by an average of 2·69 kg (95 % CI 1·66, 3·71; $P < 0·001$)
35	Pietrobelli *et al.*, 2020, Italy[23].	3	Impact of COVID-19 lockdown on lifestyle factors in obese children	41	NR	↑1·15 ± 1·56 meals per day	NR	NR	↓2·30 ± 4·60 h/ week	NR	Unhealthy food intake increased with significantly increased potato chips, red meat and sugary drink intakes during the lockdown (0·005 to < 0·001) Screen time increased by 4·85 ± 2·40 h/d Sleep time increased by 0·65 ± 1·29 h/d
36	Rogers *et al.*, 2020, UK[53].	2–4	Altered physical activity among adults with serious health issues during COVID-19 lockdown	5820	NR	NR	NR	NR	↑11·7 %, ↓ 25·4 %	NR	Being a female, living alone or not having access to a garden were also associated with less intensive physical activity
37	Romero-Blanco *et al.*, 2020, Spain[62].	4	Sleep quality before and during the COVID-19 lockdown period in nursing students	207	NR	NR	NR	NR	NR	NR	Pittsburgh sleep quality index (PSQI) scored 0·91 points worse during the lockdown. Poor sleep incidence increased from 60·4 % to 67·1 % during the lockdown. Students with anxiety and depression had reduced sleep quality by 1·74 (0·85–2·63) points
38	Ruissen, *et al.*, 2021, Netherlands[59].	8–11	Lockdown impact on people with type 1 and type 2	435	↑40·9 % ↓12 %	NR	NR	NR	↓45·7 %	NR	Increase in levels of stress 34·1 % Increase in levels of anxiety 27·3 % of all participants Stress correlated with poor glycaemic control ($P < 0·0001$)
39	Shah, *et al.*, 2020, India[47].	12–15 weeks	Glycaemic control, weight and BMI	77	Weight gain *z* score –0·4 ± 0·8 *v.* Post-lockdown weight *z* score –0·2 ± 0·8, $P < 0·05$) No significant increase in BMI	↓ in low socio-economic state	Decreased	NR	NR	NR	Improved glycaemic control via HbA1C 79·4 ± 19·2 *v.* Post-lockdown Hba1C 74·5 ± 16·9 mmol/mol Improved glycaemic control in lower socio-economic state
40	Sidor *et al.*, 2020, Poland[24].	6	Sleep quality before and during the COVID-19 lockdown period in nursing students	1097	↑29·9 % (3·0 ± 1·6 kg), ↓18·6 % (2·9 ± 1·5 kg)	↑43·5 %	↑51·8 %	NR	NR	↑14·6 %	Increased food consumption (55·3 %) and snacking (61·7 %) was reported by individuals with a higher BMI
41	Zachary *et al.*, 2020, USA[25].	4	Diet choices and habits during COVID-19 lockdown	173	↑22 %	↑19 %	↑63 %	NR	NR	NR	73 % ate in response to boredom and 65 % in response to sight/smell of food Participants slept an average of 7·6 ± 1·3 h per night with less sleep related to weight gain

↑, increased; ↓, decreased; NR, not reported; MET–minute/week, metabolic equivalent of task minute/week; IQR, interquartile range; lbs, pound.

Table 4. Determinants of body weight during pandemic confinements

Determinants that can influence weight gain
Demographics
Female[21,34,39,43,52,64]
Baseline obese and overweight[21,23,24,25,37,38,42,44,49,64,67]
BMI < 24[36,49]
Age group > 45 years[24,38,53]
Age group < 25 years[24,40]
Having children under the age of 18 at home[51]
Changed work environment to working from home[20,40,57]
Work environment
Loss of job[20]
Interruption of work routine[20]
Changed work habits: furloughed or working from home[20]
Suspension of schools[48]
Dietary behaviours
Increased food consumption[23,33,34,37,38,39,44,67]
Decreased consumption of fresh food products (particularly fruits, vegetables and fish)[20,21,36,38,39]
Increased consumption of homemade recipes, sweets and pizza[22,23]
Increased home cooking[38]
Increased cereal consumption[20,22]
Consumption of unhealthy foods[21,23,24,34,37,39,41,43,44,51]
Poor attention to diet balance[22]
Snacking after dinner[20,25]
Binge eating[40,44]
Loss of control to eating[40]
Eating in response to stress as a coping mechanism[21,25]
Eating secondary to appearance and smell of food[25]
Emotional eating[21,42,44]
Increase in alcohol intake[34,36,38]
Psychological factors
Decreased sleep time[25,43]
Lower sleep quality[45,62]
Stress[22,26,44,55,56,58,59,61]
Boredom[22]
Living alone[22,34]
Anxiety/depression[23,58,41,61,64]
Depressive symptoms[34,40,44]
Mood disturbances[43]
Weight/shape concerns[37]
Socio-economic factors
Lack of garden[53]
Urban residence[51,60]
Lower education level[22,57]
Residence in a macroeconomic region > 50 % of EU-28 GDP[36]
Lower socio-economic level[47,57]
Physical inactivity
Physical activity before lockdown[52]
Decreased physical activity[23,24,26,33,34,37–41,44,43,46,47,49,53,55,56–60]
Limitations of outdoor and in-gym activities[20,22,34,42]
Increased screen/TV time[23,37,38,47,55–57]
Co-morbidities
Associated chronic illness[47,52,56,65,66]
Determinants that can be associated with weight loss
Underweight before confinement[24,36]
Younger age[36]
Remote work[36]
Urban residence[51,60]
Ate less[36]
Ate more fruits/vegetable[36]
Drank more water[36]
Ate more pulses/seafood/fish[36]
Did not consume alcohol[36]
Regular exercise before lockdown[63]

this current systematic review. This includes past behaviours, dietary behaviours, physical activity patterns, work environment, psychosocial and socio-economic factors, and pre-existing co-morbidities.

Female sex[20,34,38,42,51,63], age under 25 years and over 45 years[24,38,51,53] are in particular at higher risk of gaining weight. Initial weight status, diet quality and physical exercise pattern before lockdown are important factors[20,22–24,36,44,48,51,63]. In Chinese[39] and Korean[49] populations, BMI < 24 kg/m^2 was associated with weight gain. However, some observed that those who were underweight before confinement lost more weight during confinement[24,36].

Poor diet quality before the lockdown was associated with weight gain[51]. Decreased consumptions of legumes, fruits and vegetables[24,38] were related to an increased consumption of sweets[22–24]. Moreover, more home cooking with consumption of unhealthy foods is associated with increased weight gain[19,21,22,33–35,37,39,41,42,47,64] as is increased alcohol intake[34,36,38,46,67].

Less intense physical behaviours were noted during lockdown periods compared with behaviours before lockdown causing increased weight gain[22,23,25,32–34,36–40,42,45,46,48,52,54–59]. This was due to the limitations of outdoor activities and in-gym activities[20,42,52]. In addition, there has been more sedentary behaviour with increased screen time[22,36,37,46] which has been associated with weight gain.

Changed working habits, whether furloughed or working from home during the lockdown or those who had their job suspended[20,51,57], having children aged < 18 years at home[51], urban residence and attaining a lower educational level[22] were associated with weight gain.

Patients with pre-existing psychiatric co-morbidities had weight gain during COVID-19 lockdown[34,37,43,44,51,61], and stress[21,25,44,54,55,55,57,60,61], anxiety and/or depression[22,57,60,61], eating in response to stress[21,25], boredom[22], living alone[22], emotional eating[21,42,44] or weight or body shape concerns[37] were associated with an increase in body weight during confinement. Decreased sleeping time[25] or poor quality sleep[45,50,62] was further associated with weight gain.

Socio-economic factors such as urban residence[51,60], lack of access to garden[53], lower socio-economic level[47] or lower education levels[22] and residence in a macroeconomic region[36] were associated with significant gain in the weight.

Patients with chronic illness such as diabetes, hypertension, lung disease, chronic CHD, congestive heart failure, depression or disability affecting one or more activities of daily living or lower levels of physically activity had an increase in weight[34,40,44,46,51,53,55,61,64].

Those who were previously underweight before the lockdown tended to lose more weight[24,24,36]. Those whose diet included more fruits and vegetables, pulses and drank more water lost weight[36].

Discussion

This systematic review highlights contrasting effects of pandemic confinements on body weight, and we identified specific factors associated with change in body weight during the lockdown periods.

A BMI of > 25 kg/m^2 was identified as an independent risk factor for increased food intake during lockdown[68]. Other influences were inadequate sleep, decreased physical activity,

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emotional eating in response to stress, lack of control in dietary habits[20,24,53] and increased alcohol consumption and smoking[34,36,38,50,55,63,67]. The impact of these influences is more significant in the obese population.

Eating habits as well as diet composition are linked to weight gain[69]. Increased snacking after meals, particularly post dinner, was associated with weight gain[69]. Jakubowicz *et al.* also concluded that increased energy content at dinner increased the subjects' weight[70]. Thus, decreasing food consumption during and post dinner should be recommended.

Social networks, neighbourhood social activities and physical activity can influence an individual's opportunity to make better choices contributing to protection from obesity[71]. The absence of these influences during extended lockdown periods may facilitate a more obesogenic environment, thus encouraging weight gain[72].

By contrast, not all effects of pandemic confinement resulted in weight gain. In an Italian study, 38 % of participants adhered to a Mediterranean diet. This may have been assisted by the Italian Ministry of Health publishing online materials regarding favourable lifestyle choices during the lockdown in April 2020 and providing practical guidelines on healthy behaviours[73,74].

Pandemic confinements undoubtedly increase stress[33,55,58–60], 73 and 83 % of respondents experienced an increase in anxiety and depression, respectively, with 70 % reporting weight management issues, stock-piling food and stress eating[22,40,75]. Weight loss was reported in three studies by 13–19 % of participants[20,24,51]. Two studies showed stress-related weight among working professionals and university students[76,77]. The mechanism is twofold and results from decreased, unchanged or increased energy intake coupled with adaptive adrenergic stimulated thermogenesis involving brown adipose tissues[78]. The weight loss observed in this systematic review may also be attributed to the negative effect of stress[20,24,25,51,79].

The link between weight changes and stress has been studied extensively[80,81]. Behavioural and physiological explanations suggest that the sensation of eating is associated with a psychological escape from emotional distress[82] and that the consumption of high energy foods alleviates stress[80]. During a pandemic, where cities and even entire nations were locked down, fear and anxiety related to COVID-19 induced an over eating behaviour. However, management of this associated condition is difficult[83]. The adverse effects of lockdown on the psychological and social well-being of society emphasise the need for strong public health interventions to support particularly at-risk people.

The associations between health outcomes, exercise and physical activity are well-established. The results from studies that we included in this review were mixed; some participants engaged in increased physical activity, while others had lower levels of physical activity. Confinement did not induce many sedentary participants to increase their physical activity. Other unhealthy behaviours such as increased screen time were noted which are similar to previous studies[84]. Stress may impair efforts to become physically active; conversely, those who already participate may do so to reduce stress[85], which may explain the variation in physical activity observed. Seigel *et al.* describe this as stress-related behavioural activation or inhibition[86].

Other unhealthy behaviours were noted during the confinement. There was a 14·6 % increase in the consumption of alcohol in participants who had issues with alcohol[24]. In the acute post-disaster period of the September 11 attacks in Manhattan, New York City, the prevalence of alcohol consumption and marijuana use among New York City residents increased over a 5–8-week period[87]. These results mirror our findings, suggesting shared responses to intense community stresses. Although these activities may not directly affect weight, alcohol consumption and obesity are common risk factors for chronic illnesses leading to increased morbidity and mortality[88]. Furthermore, in a study conducted in the Netherlands, it was reported that overweight and obese individuals found it more difficult to make healthy food choices. More savoury snacks and non-alcoholic beverages were purchased and consumed at home (35·6 %) because of more leisure time (31·5 %) and boredom (21·9 %) during the lockdown[89].

Positive outcomes from confinement have also been reported[90]. These behaviours may result from the increased availability of time to cook, health risk perceptions, lack of negative social distractions[91] and socio-cognitive ideation towards a healthier lifestyle[92]. Long-term studies are necessary to determine whether these constructive and preventive behaviours can be sustained after confinement is over.

Food security, which involves food availability, accessibility and affordability, is another important factor in the relationship between pandemic confinement and body weight changes[93]. Global non-pharmaceutical interventions, such as lockdowns and quarantines, implemented to limit the spread of the virus have seriously impacted food security systems[94], with the greatest burden affecting communities in which nutritional health is fragile[95]. Communities with precarious budgeting practices were destabilised by food price inflation and product shortages. Additional influences on food security included movement restrictions of workers, changes in consumer demand, closure of food production facilities, restricted food trade policies and financial pressures in the food supply chain. As dependence on food banks grew with an exponential increase in demand, basic survival needs presided over healthy dietary choices[17]. Prior to 2020, 690 million people were already food insecure and hungry[96]. By the end of 2020, the COVID-19 pandemic had created an additional 270 million food-insecure people[97,98]. Unfortunately, vulnerable populations are not restricted to under-resourced countries; developed nations are suffering as well. In the USA alone, food insecurity more than doubled as a result of the economic crisis brought on by the outbreak, impacting as many as 23 % of households[99].

Serious ethical and health-related issues hinder healthcare providers working with vulnerable populations. In general, differences in weight status and dietary intake reveal that a trend in obesity increases as the degree of food insecurity increases[100]. The COVID-19 crisis has highlighted food insecurity as a significant factor in nutritional poverty[94]. This awareness of food insecurity may provide nations with the impetus to robustly tackle food-related epidemics, such as obesity and diabetes.

COVID-19 has challenged us to consider the role and balance of healthcare, personal health and holistic well-being.

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Redefining these dynamics in preparation for future pandemics is imperative to minimise severe impacts to health and resources[101]. It was previously observed that consumerism is affected by internal factors, such as personal character, and external factors, such as economic crises. The pandemic served as an external factor that altered consumer behaviour[102].

Relief efforts by governmental and non-governmental agencies achieved temporary solutions without significant public pressure[103], but the demand for aid from all sectors of society is mounting. National governments should take the lead in providing strategic directions that will ensure the continuity of food accessibility to all, particularly the most vulnerable. Focus must be on coordinated and integrated public health programmes through legislative action to end sub-standard dietary conditions endured by those most in need. By collaborating with key stakeholders, health professionals must provide aggressive nutritional counseling to improve dietary habits, and concerted efforts across the board are paramount.

Recent research has shown obesity to be an independent risk factor for severe complications and increased mortality from COVID-19[104,105]. The evidence suggests a linear relationship with obesity increasing the risk of severe disease and death among COVID-19 patients[106]. The co-existence of both pandemics, COVID-19 and obesity, along with the emergence of obesity evolving from lockdown has caused a 'syndemic' or a symbiotic pandemic[107]. Researchers must address the significant knowledge gaps that have become apparent during this pandemic regarding preparedness and response to such a crisis. Moreover, COVID-19 has disproportionately affected certain populations, and future research should focus on such vulnerable populations to ensure better outcomes.

Strengths and limitations

To our knowledge, this is the first systematic review evaluating the effects of pandemic confinement on body weight. Our study highlights major determinants that can have an impact on body weight during confinement and those that can be targeted in future pandemics to effectively manage body weight during pandemics via public health initiatives. Moreover, confinements are not solely related to pandemics and can also occur during natural disasters or calamities and in prisons. Determinants identified could be modified via appropriate public health measures to reduce negative impacts.

The present study has limitations. First, there was limited evidence from past pandemics related to obesity and morbidity or mortality. This may reflect the recent evolution of worldwide obesity[108]. Second, within the common research theme of body weight changes during pandemic confinements, our systematic review found marked heterogeneity in the determinants and measured outcomes. This variation could be explained by differences in the study population and types of outcome measurements[109]. Nevertheless, in our systematic review, we followed a rigorous protocol with clear objectives and inclusion and exclusion criteria. This allowed for the identification and pooling of the determinants of body weight changes during pandemic confinements (Table 4). A thorough and complete identification of the different determinants related to pandemic confinements could guide decision makers. Furthermore, our study calls for further research into the level of impact of each determinant. Third, given the contemporary nature of the pandemic, the literature was primarily related to countries where COVID-19 had an early 'first wave' impact. Findings from other continents, particularly from Africa and South America, are yet to emerge. Fourth, online surveys using social media platforms were the predominant data collection method, which has recognised strengths and biases. Although the researchers used this form of data collection to reach a wider population, the likelihood of a bias towards a younger population should be noted. Fifth, although this analysis provides evidence for the effects of confinement on body weight, we are unable to comment on the potential for interventions such as lifestyle changes to attenuate the phenomenon. Sixth, because of the limited number of studies included, we were unable to correct for influences, such as pre-existing diets, and could not quantify the impact of possible factors in isolation. Although we know that weight gain is likely during confinement, further research using more sophisticated data collection techniques is necessary to determine the holistic impact of confinement to provide evidence-based practical solutions for future eventualities.

Conclusion

This systematic review highlights the significant effects that pandemic confinements can have in the short term on body mass. Poor sleep, snacking post dinner, lack of dietary restraint, pre-existing overweight status, emotional eating due to stress and decreased physical activity are risk factors for weight gain.

Preparing for the next 'wave' is challenging given the multitude of factors that must be tailored to the local situations and available resources. Planning for future episodes requires a strong, evidence-based national policy in conjunction with clear guidelines to ensure that the negative sequelae of lockdowns are minimised.

Acknowledgements

We thank Gamila Hassan at the National Medical Library at UAEU for her strategic support in locating and uploading full-text articles to Covidence.

The authors received no specific funding for this work.

M. A. B. K., P. M., R. G., L. Ö. and H. M. formulated the research question and designed the study. M. A. B. K., P. M., R. G., K. K. A. and A. M. B. A. S. extracted and reviewed the data independently. L. Ö. and M. A. B. K. performed the literature search. M. A. B. K., P. M., R. G., A. M. B. A. S. and J. N. performed the literature review and data analysis. M. A. B. K., P. M., K. K. A., H. M., R. G, A. M. B. A. S., J. N., L. Ö., J. E. M. S. and J. K. contributed to drafting the paper. M. A. B. K., R. G., P. M., A. M. B. A. S. and K. K. A. equally contributed to all of the work as co-first authors.

We declare that there are no conflicts of financial and commercial interest that could be perceived as prejudicing the impartiality of the present study.

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This article was not plagiarised and had not previously been published in other journals.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114521000921

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