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

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This peer-reviewed article has been accepted for publication but not yet copyedited or typeset, and so may be subject to change during the production process. The article is considered published and may be cited using its DOI 10.1017/S0007114521000921. The British Journal of Nutrition is published by Cambridge University Press on behalf of The Nutrition Society.
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Short Title: Pandemic confinement’s effect on body weight

Keywords Quarantine, Lockdown, Body weight, Obesity, Weight determinants, Pandemic
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 gray sources from their inception until July 1st 2020 with an update in PubMed and Scopus on February 1st 2021. In total, 2,361 unique records were retrieved, of which 41 studies were identified eligible: 1 case control study, 14 cohort and 26 cross-sectional studies (469, 362 total participants). The participants ranged in age from 6–86 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 (±1.3) to 3.0 (±2.4) kg, and weight loss ranged from 2.0 (±1.4) to 2.9 (±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 lock down. 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.
Introduction

Devastating physical morbidity and mortality outcomes due to coronavirus disease 2019 (COVID-19) have been mitigated by social distancing and quarantine measures, with significant direct and indirect health implications. Although lockdown has reduced the “R number”, physical wellbeing may have suffered from increased levels of stress, anxiety, and mental health issues. Moderate weight gain in people with a normal body mass index (BMI) has an adverse effect on metabolism, which increases the risk of diabetes, cardiovascular disease, or long-term ill-health. Lockdown may precipitate weight gain similar to that seen during the six-week summer holidays because of increased inactive time spent at home and snacking on energy dense foods. Rundle and colleagues argued that the extent and haste of the restrictions have exaggerated these observations leading to rapid weight gain. This presents particular issues with the gained weight being more difficult to shed. Moreover, physical and social isolation is a recognized risk factor for obesity, with weight due to overconsumption, particularly when large “emergency” food stores are present. Reduced physical activity has further exacerbated the weight gain.

The COVID-19 outbreak adversely affected food supply and demand on a global scale. 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.

Recent research has linked obesity to an increased risk of contracting severe infections of COVID-19, thereby increasing the risk for extended hospitalization and increased mortality. Importantly, therapeutic interventions and prophylactic treatments are more difficult and less effective in this group, 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 (27) and is reported in accordance with the Preferred Reporting Guidelines for Systematic Reviews and Meta-analyses (PRISMA) (28). 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 was retrieved from open-source databases and internet searches.

Search strategy

A medical librarian (LÖ) 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” was systematically developed with the help of PubMed and PubMed’s MeSH and reviewed and discussed with a subject specialist (MK). 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 gray literature and the preprint archive medRxiv were additionally included in the literature search. A search update in PubMed and Scopus was conducted on February 1st, 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 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 July 1st, 2020 and from an update in PubMed and Scopus on February 1st, 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 gray searches (n = 5,070) were uploaded to the systematic review tool Covidence (Veritas Health Innovation, 2020) for automatic
Two reviewers (HM and MK) independently screened the references at both the title/abstract (n= 2,361) and full-text level (n = 78). A third reviewer (PM) resolved any conflicts. The gray references and preprints were screened and deduplicated manually by MK and LÖ. 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) (Figure 1). One study investigating weight gain exclusively in pregnant women was excluded 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 (MK). The other reviewers (PM, RG, and AS) extracted and reviewed the data independently. Determinants that had an impact on body weight were extracted and reviewed (primarily by MK and secondarily by PM, RG, and AS).

Quality assessment (n = 51)

Two reviewers (MK and PM) independently performed a quality assessment of the 51 studies identified as eligible in the screening (Appendix 2). We applied a validated Newcastle–Ottawa Quality Assessment Scale to assess the quality of the studies that were included in the review. 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 MK and PM, 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 (Appendix 2).

Results (n = 41)

Categorization 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 behavior changes during the confinement
d. Behavior changes observed in obese participants
e. Determinants of obesity during pandemic confinements

Our search yielded 5,070 records of which 2,361 unique studies remained after de-duplication. After applying the inclusion and exclusion criteria in the title and abstract screening, 78 articles were eligible for full-text screening (Figure 1). We excluded 10 studies based on a quality assessment of the results, and 27 studies were excluded based on reasons presented in the PRISMA flow diagram (Figure 1). The range of observations covered dietary choices (14,21–26,33–36,36–47), lifestyle changes in children (24,36,48–51), physical activity levels (33–35,37,38,38–41,43,46,47,49,52,53,53–60), psychosocial factors (22,23,26,38,44,45,51,52,55,56,58,61,62), socioeconomic factors (23,37,48,52,54,61) and sleeping patterns (26,46,51,63).

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

Table 2 describes the characteristics of each of the 41 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 (22,52).
The included studies had the following countries of origin: Brazil (59), China (40, 57), Croatia (51, 64), France (47, 52, 56), Jordan (58), India (48, 55), Iraq (61), Italy (21, 23, 24, 35, 36, 45, 45, 53), Korea (50), Lithuania (39), Netherlands (60), Poland (25, 42, 51), Spain (44, 46, 63), Turkey (43, 49, 65, 66), United Arab Emirates (33), United Kingdom (54) and the United States of America (26, 38, 41, 67).

Furthermore, multi-regional studies conducted intercontinentally (22), among eighteen countries in the Middle East and North Africa (MENA) region (34), and Paraguay and Italian based multinational research (62) 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 (37). 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 (21, 23, 25, 26, 33, 35–37, 39–41, 43, 44, 44–49, 49–52, 55, 57, 57–62, 64–68) (Figure 2). The mean weight gain ranged from 0.6 (±1.3) to 3.0 (±2.4) kg.

There was a higher weight gain among participants who self-reported stress (26, 45, 55, 56, 58, 61, 62), anxiety and depression (23, 52, 58, 61, 62). Weight loss was observed in 11.1%–32.0% of participants (21, 25, 33, 35, 37, 40, 51, 52, 55, 60, 65, 68). The mean experienced weight loss ranged from 2.0 (±1.4) to 2.9 (±1.5) kg.

**Dietary and other lifestyle behavior changes during confinement**

Table 3 describes dietary and behavioral changes that were caused by pandemic-related confinements. Most studies reported an increase in food intake associated with increased
snacking and all these studies documenting perceived weight gain.

Appetite was modified either negatively or positively and was associated with employment change, suspension or working from home, or due to suspension of school attendance.

The initiating factors were as follows: response to smell and sight of food, boredom, binge eating and food cravings, snacking post dinner and visual stimulation through social media. A significant correlation was observed between snacking, the consumption of high density processed food, and a higher BMI.

Increased energy intake by 10%–49.4% was observed among study participants, particularly those with an increased consumption of high density processed foods, female sex, or with a higher BMI. There was an increase in the number of meals eaten per day and participants ate more than usual. The proportion of respondents engaged in cooking increased from 40% to 62% in our study sample. Likewise, consumption of homemade recipes increased and eating homemade desserts increased compared to pre-lockdown.

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. In contrast, some studies have shown a decrease in unhealthy food consumption.

Where Mediterranean diet was followed, 18- to 30-year-olds were more compliant than other age groups. Inverse associations were found between adherence to Mediterranean diet and BMI. 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 < 0.001). Among app users, mobile behavioral change app interaction was reduced by 9%. Eating in response to stress was associated with weight gain.

There was increased alcohol consumption during the lockdown, while a decrease in alcohol consumption was also noted compared with pre-COVID-19 in another study.
There was an increase in cigarette smoking generally \cite{47,51,56,64} while in contrast, 3.3\% of the smokers surveyed reported reduced smoking during quarantine \cite{20}.

Although, the participants reported spending more time in bed before lockdown \cite{24,26,55,57}, the overall sleep quality was worse \cite{46,55,63}. In contrast, secondary school students felt refreshed on awakening and increased sleeping hours \cite{51}. Weight gain was reported by others to be related to decreased night time sleep and reduced physical activity time \cite{26,41,60}.

Sedentary lifestyle and screen time increased during the lockdown \cite{24,26,38,47,55–57}. 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 \cite{21,21,52,58}.

Physical activity altered by varying amounts, reduced in some studies to between 18\% and 84\% \cite{23,24,34,35,40,47,52,54,55,59}. People who were already overweight or obese engaged in less physical activity and had decreased energy expenditure during lockdown \cite{37,39,44,52–54,56,59}.

Obese children spent less time participating in sports activities \cite{24}.

By contrast, studies reporting an increase in physical activity \cite{21,52} found greater engagement in yoga/pilates, functional training, home training, and treadmill use and overall increased training frequency \cite{21}.

**Behavior 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 \cite{21,23–25,37,39,44,46,49,64}.

Increased snacking and food consumption were observed in participants with a higher BMI \cite{24,25,33,34,68}. Many of the participants agreed that they consumed less fruits and vegetables on a daily basis \cite{22,25,34,52,69,70} but more high energy processed foods \cite{23–25,41,44}.
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This intake was associated with an enhanced appetite and after-dinner hunger \((21,37,39,45)\). Obese children reported an increase in the number of meals eaten along with an increased consumption of sweetened drinks, potato chips, and red meat \((24)\). A decrease in intensive physical activity was associated with obesity \((54)\). An inverse relationship was found between changes occurring in sporting activities and the number of meals consumed per day \((24,41,53,68)\). The participants self-reporting anxiety and depression displayed an estimated weight gain \((23,45,55,56,58,62)\).

**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 this current systematic review. This includes past behaviors, dietary behaviors, physical activity patterns, work environment, psychosocial and socioeconomic factors, and pre-existing comorbidities.

Female sex \((21,35,39,43,52,64)\), age under 25 years and over 45 years \((25,39,52,54)\) are in particular at higher risk of gaining weight. Initial weight status, diet quality and physical exercise pattern before lockdown are important factors \((21,23–25,37,45,49,52,64)\). In Chinese \((40)\) and Korean \((50)\) 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 \((25,37)\).

Poor diet quality before the lockdown was associated with weight gain \((52)\). Decreased consumptions of legumes, fruits, and vegetables \((25,39)\) was related to an increased consumption of sweets \((23–25)\). Moreover, more home cooking with consumption of unhealthy foods are associated with increased weight gain \((20,22,23,34–36,38,40,42,43,48,65)\) as is increased alcohol intake \((35,37,39,47,68)\).

Less intense physical behaviors were noted during lockdown periods compared with behaviors before lockdown causing increased weight gain \((23,24,26,33–35,37–41,43,46,47,49,53,55–60)\).
This was due to the limitations of outdoor activities and in-gym activities\textsuperscript{(21,43,53)}. In addition, there has been more sedentary behavior with increased screen time\textsuperscript{(23,37,38,47)} 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\textsuperscript{(21,52,58)}, having children aged <18 years at home\textsuperscript{(52)}, urban residence and attaining a lower educational level\textsuperscript{(23)} were associated with weight gain.

Patients with pre-existing psychiatric comorbidities had weight gain during COVID-19 lockdown\textsuperscript{(35,38,44,45,52,62)}, and stress\textsuperscript{(22,26,45,55,56,58,61,62)}, anxiety and/or depression\textsuperscript{(23,58,61,62)}, eating in response to stress\textsuperscript{(22,26)}, boredom\textsuperscript{(23)}, living alone\textsuperscript{(23)} emotional eating (EE)\textsuperscript{(22,43,45)} or weight or body shape concerns\textsuperscript{(38)} were associated with an increase in body weight during confinement. Decreased sleeping time\textsuperscript{(26)} or poor quality sleep\textsuperscript{(46,51,63)} were further associated with weight gain.

Socioeconomic factors such as urban residence\textsuperscript{(52,61)}, lack of access to garden\textsuperscript{(54)}, lower socioeconomic level\textsuperscript{(48)} or lower education levels\textsuperscript{(23)} and residence in a macroeconomic region\textsuperscript{(37)} were associated with significant gain in the weight.

Patients with chronic illness such as diabetes, hypertension, lung disease, chronic coronary heart disease, 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\textsuperscript{(35,41,45,47,52,54,56,62,65)}.

Those who were previously underweight before the lockdown tended to lose more weight\textsuperscript{(25,25,37)}. Those whose diet included more fruits and vegetables, pulses and drank more water lost weight\textsuperscript{(37)}. 
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\(^{(71)}\). Other influences were inadequate sleep, decreased physical activity, EE in response to stress, lack of control in dietary habits\(^{(21,25,54)}\), and increased alcohol consumption and smoking\(^{(35,37,39,51,56,64,68)}\). The impact of these influences is more significant in the obese population.

Eating habits as well as diet composition are linked to weight gain\(^{(72)}\). Increased snacking after meals, particularly post dinner, was associated with weight gain\(^{(72)}\). Jakubowicz et al. also concluded that increased calories at dinner increased the subjects’ weight\(^{(73)}\). Thus, decreasing food consumption during and post dinner should be recommended.

Social networks, neighborhood social activities, and physical activity can influence an individual’s opportunity to make better choices contributing to protection from obesity\(^{(74)}\). The absence of these influences during extended lockdown periods may facilitates a more obesogenic environment, thus encouraging weight gain\(^{(75)}\).

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 favorable lifestyle choices during the lockdown in April 2020 and providing practical guidelines on healthy behaviors\(^{(76,77)}\).

Pandemic confinements undoubtedly increase stress\(^{(34,34,56,59–61,61)}\). 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 \(^{(23,41,78)}\). Weight loss was reported in three studies by 13% to 19% of participants \(^{(21,25,52)}\). Two studies showed stress related weight among working professionals and university students \(^{(79,80)}\). The mechanism is twofold and results from decreased, unchanged or increased energy intake coupled with adaptive adrenergic stimulated thermogenesis involving brown adipose tissues \(^{(81)}\). The weight loss observed in this systematic review may also be attributed to the negative effect of stress \(^{(21,25,26,52,82)}\).

The link between weight changes and stress has been studied extensively \(^{(83,84)}\). Behavioral and physiological explanations suggest that the sensation of eating is associated with a psychological escape from emotional distress \(^{(85)}\) and that the consumption of high calorie foods alleviates stress \(^{(83)}\). During a pandemic, where cities and even entire nations were locked down, fear and anxiety related to COVID-19 induced an over eating behavior. However, management of this associated condition is difficult \(^{(86)}\). The adverse effects of lockdown on the psychological and social wellbeing of society emphasize 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 behaviors such as increased screen time were noted which are similar to previous studies \(^{(87)}\). Stress may impair efforts to become physically active; conversely, those who already participate may do so to reduce stress \(^{(88)}\), which may explain the variation in physical activity observed. Siegel et al. (2002) describes this as stress-related behavioral activation or inhibition \(^{(89)}\).
Other unhealthy behaviors were noted during the confinement. There was a 14.6% increase in the consumption of alcohol in participants who had issues with alcohol\(^ {25}\). 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 five- to eight-week period\(^ {90}\). 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\(^ {91}\). 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 savory 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\(^ {92}\).

Positive outcomes from confinement have also been reported\(^ {93}\). These behaviors may result from the increased availability of time to cook, health risk perceptions, lack of negative social distractions\(^ {94}\), and socio-cognitive ideation toward a healthier lifestyle\(^ {95}\). Long-term studies are necessary to determine whether these constructive and preventive behaviors 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\(^ {96}\). Global non-pharmaceutical interventions, such as lockdowns and quarantines, implemented to limit the spread of the virus have seriously impacted food security systems\(^ {97}\), with the greatest burden affecting communities in which nutritional health is fragile\(^ {98}\). Communities with precarious budgeting practices were destabilized 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 (18). Prior to 2020, 690 million people were already food-insecure and hungry (99). By the end of 2020, the COVID-19 pandemic had created an additional 270 million food-insecure people (100,101). Unfortunately, vulnerable populations are not restricted to under-resourced countries; developed nations are suffering as well. In the United States 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 (102).

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 (103). The COVID-19 crisis has highlighted food insecurity as a significant factor in nutritional poverty (97). 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 wellbeing. Redefining these dynamics in preparation for future pandemics is imperative to minimize severe impacts to health and resources (104). 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 behavior (105).

Relief efforts by governmental and non-governmental agencies achieved temporary solutions without significant public pressure (106), 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 programs 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 \(^{(107,108)}\). The evidence suggests a linear relationship with obesity increasing the risk of severe disease and death among COVID-19 patients \(^{(109)}\). The co-existence of both pandemics, COVID-19 and obesity, along with the emergence of obesity evolving from lockdown have caused a ‘syndemic’ or a symbiotic pandemic \(^{(110)}\). 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.

This 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 \(^{(111)}\). Second, within the common research theme of body weight changes during
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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 \(^{(112)}\). 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 recognized strengths and biases. Although the researchers used this form of data collection to reach a wider population, the likelihood of a bias toward 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 preexisting 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, EE 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 minimized.

Conflict of interest

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

Ethical statement

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

Funding

The authors received no specific funding for this work.

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.

Authorship

MK, PM, RG, LÖ, and HM formulated the research question and designed the study. MK, PM, RG, KA and AS extracted and reviewed the data independently. LÖ and MK performed the literature search. MK, PM, RG, AS, and JN performed the literature review and data analysis. MK, PM, KA, HM, RG, AS, JN, LÖ, JS, EMS and JK contributed to drafting the paper. MK, RG, PM, AS, KA equally contributed to all of the work as co-first authors.
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Figure 1- PRISMA flow chart showing the screening process
### Figure 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
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 obesity or overweight as a risk factor for the pandemic.   |
|                      | Studies showing the impact of quarantine on the overweight/obese population. |                                                                           |
| **Outcome**          | Effect on body weight. Weight change (%), BMI change (kg/m^2).             |                                                                           |
|                      | Demographic, behavioral, social, physical, psychological, lifestyle, and environmental behaviors during confinement that have effect bodyweight. |                                                                           |
|                      | Studies showing measures taken to manage weight changes during confinement. |                                                                           |
| **Study**            | Designs: All study designs. Language: All languages.                       |                                                                           |
|                      | Year: Publication year inception – 1st February 2021.                      |                                                                           |

BMI- Body Mass Index, HIV - Human Immunodeficiency Virus
Table 2  Characteristics of included studies

| 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 (yds) | Mean age of participants (SD) | Mean BMI/Centile of participants | Mean weight (kg) of participants |
|------|-----------------------------|------------------------|--------------|-----------------|-------------------------------|----------------------|--------------------------------------|-------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 1    | Adıbelli, et al., 2020, Turkey (1) | 597 | Cross-sectional study | Online Survey | Children aged 7–13 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 (2) | 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 (3) | 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 (4) | 312 | Observationa l retrospective | Self-administered web-based questionnaire | Healthy adults | Validated | 64.1 | NR | 41.12 ± 13.05 | NR | 73.47 ± 16.65 |
| 5    | Chagué et al., 2020, France (5) | 124 | Cross sectional Survey | Phone interviews | Congestive Heart failure patients | New | 39.5 | NR | 71.0 ± 14.0 | NR | 28.2 ± 5.4 |
| 6    | Chopra, et al., 2020, India (6) | 995 | Cross sectional study | Online survey | Adults ≥18 years | Validated | 41.5 | ≤30 >30 | 33.33 ± 14.5 | NR | 24.8 ± 4.7 kg/m2 |
| 7    | Cransac-Miet, et al., 2021, France (7) | 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 (8) | 37,252 | Cross-sectional Survey | Self-administered web-based questionnaire | NutriNet-Santé cohort | Validated | 52.3 | 18-80+ | 52.1 ± 16.6 | NR | NR |
| No. | Authors, Year, Country | Sample Size | Study Design | Data Collection Method | Population | Validated | Minimum | Maximum | Mean ± SD | Age Range | Validated Measure |
|-----|------------------------|-------------|--------------|------------------------|------------|----------|---------|---------|----------|-----------|-------------------|
| 9   | Di Santo et al., 2020, Italy | 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 | 3533       | Cross-sectional survey | Self-administered web-based questionnaire | General public | Validated | 75.1    | 12-86   | ± 13.53   | ± 13.53   | 27.66 ± 4.10       |
| 11  | Đogaš et al., 2021, Croatia | 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 | 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 | 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 | 1769       | Cross-sectional study | Online Survey | Polish women | Validated | 100    | ≥18     | NR       | NR       | NR                |
| 15  | Diogo Gama de Matos et al., 2020, Brazil | 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 | 110       | Observation 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 | 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     |
|   | Study | Sample Size | Study Design | Data Collection | Age | Sex | Anthropometric Parameters |
|---|-------|-------------|--------------|-----------------|-----|-----|--------------------------|
| 18 | He, et al., 2020, China | 339 | Cross-sectional study | Online survey | Adults ≥ 18 years | New | Males: 36.4 (11.9) Females: 37.6 (12.4) NR | Female: 51.1 ± 4.1 Male: 65.6 ± 5.8 |
| 19 | Ismail, et al., 2020, MENA Region | 2970 | Cross-sectional study | Online questionnaire | Adults ≥ 18 years | Validated | 18–55 | NR |
| 20 | Ismail, et al., 2020, UAE | 1012 | Cross-sectional study | Online survey | Adults ≥ 18 years | Validated | 18–55 | NR |
| 21 | Jia, et al., 2020, China | 10,082 | Retrospective study | Online questionnaire | Chinese Youth | Validated | 16-28 | 19.8 ± 2.3 21.8 kg/m² NR |
| 22 | Jimenez, et al., 2021, Spain | 603 | Cross-sectional study | Online survey | Patients attending Obesity clinic | New | 18–55 | 34.2±7.0 NR |
| 23 | Kang, et al., 2021, Korea | 226 | Retrospective cohort study | Retrospective review of medical records | Children followed-up at the Growth Clinic | Not Applicable (Anthropometric and laboratory parameters) | 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 | 140 | Prospective observational case-control study | Physical & biochemical parameters | Known confirmed type 2 diabetes patients matched with healthy patients in outpatient clinic | Non-diabetic: 56.4 Diabetic: 68.2 | Non-diabetic: 52.61 ± 4.88 Diabetic: 54.81 ± 10.53 | Total Mean 31.63 ± 3.57 kg/m² 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 | 90 | Prospective study | Online Surveys | Undergraduate psychology students | Validated | 19.45 (1.26) years | 22.93 63.87 |
|   | Author(s)                          | Year, Country | Sample Size | Study Design | Data Collection Method | Validated | Age Range | Gender | BMI Range          |
|---|-----------------------------------|---------------|-------------|--------------|------------------------|-----------|-----------|---------|---------------------|
| 26 | Kriaucionien e, et al., 2020, Lithuania | 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     | 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  | 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) | No psychiatric illness: 39.88 kg/m² (SD = 6.8, range: 28–55) | NR | NR |
| 29 | Martínez-de-Quel et al., 2021, Spain | 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          | 1,820         | Longitudinal prospective cohort study | Online survey | High schools | Validated | 61 | NR | 19.28 | 70.3 kg |
| 31 | Mitchell et al., 2020, USA        | 3, 81,564     | Observationa l, retrospective, cohort study | Noom app – mobile behavior change weight loss program | App-based food data from a digital behavior change weight loss program | App-based Validated | 83.4 | ≥18 | 47.76 ± 13.59 | NR | 85.57 ± 20.4 |
| 32 | Önmez, et al., 2020, Turkey      | 101           | Retrospective observational study | Questionnaire | Diabetic patients attending | Validated | 53.5 | 18–80 | 55 ± 13 | 30.3 ± 5.5 | 84.7 ± 16.4 kg |
| Study ID | Authors et al., Year, Location | Sample Size | Study Design | Data Collection Method | Target Group | Validated? | Age Range | BMI Range | Notes |
|---------|-------------------------------|-------------|--------------|------------------------|--------------|-----------|-----------|-----------|-------|
| 33      | Özden et al., 2021, Turkey    | 1011        | Cross-Sectional study | Online survey | nursing students | Validated | 50 | NR | 19.97 ± 3.11 years |
| 34      | Pellegrini et al., 2020, Italy | 150         | Observationa l retrospective study | Telephone interviews | Obese patients in weight loss program | Validated | 76.3 | 18–75 | 47.9 ± 16.0 | 36.6 ± 4.5 | 92 ± 17 |
| 35      | Pietrobelli et al., 2020, Italy | 41          | Longitudinal observational study | In-person interview/ telephone interviews | School children | New | 46.35 | 6-18 | 13 ± 3.1 | 30.2 ± 4.1 & BMI % Centile 98.2 ± 1.4 | 77.4 ± 21.9 |
| 36      | Rogers et al., 2020, UK       | 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 | 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 | 435         | Observationa l 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     | 77          | Observationa l 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    | 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     | 173         | Cross-sectional survey | Self-administered web-based | General public | Validated | 55.5 | ≥18 | 28.1 ± 12.5 | 27.0 ± 7.6 | NR |
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Table 3: Behavioral 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 behavior changes identified during the confinement |
|------|-----------------------------|---------------------------------------------------------------|-----------------------|------------------------|----------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------|------------------|---------|--------------------------------------------------------------------------------|
| 1    | Adibelli, et al., 2020, Turkey (1), | 4 weeks | Health related Quality of life | 597 | ↑41.5% | 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 (2), | 1-9 weeks | Body weight | 765 | ↑72.41% | 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 to the period of the outbreak. |
| 3    | Athanasiadis, et al., 2020, USA (3), | 5 | Factors attributed to weight gain | 208 | 2+ 4.2 kgs 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 |
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| Study | Authors | Country | Duration | Study Design | Main Findings |
|-------|---------|---------|----------|--------------|---------------|
| 4 | Błaszczyk-Bebenek, et al., 2020, Poland (4) | | 5-8 weeks | Change in nutrition behaviour during lockdown | Increased weight gain of > 2 kgs in patients >18-month post-bariatric surgery. Increase in consumption of eggs, potatoes, sweets, and canned meat |
| 5 | Chagué et al., 2020, France (5) | | 6-7 weeks | Impact of lockdown on health indicators and behaviors among Congestive heart failure patients | 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 (6) | | 20-22 weeks | Impact of COVID-19 on lifestyle-related behaviours: eating, physical activity and sleep behaviour | In participants <30 years old, increase in healthy food and restriction of unhealthy meals. Increase stress amongst participants (25% vs 38.3%) significantly increased. Increase in daily... |
sleeping hours, screen time, sitting time at work, stress levels. Decreased smoking

|   | Study Reference | Participants | Changes | Impact on Weight | Impact on Alcohol Consumption | Smoking Change |
|---|-----------------|--------------|---------|------------------|-------------------------------|---------------|
| 7 | Cransac-Miet, et al., 2021, France (7) | 4 | Lifestyle changes | 195 | ↑24% | NR | NR | ↓25% | 5% increase in alcohol consumption | Smoking increased by 26% |
| 8 | Deschasaux-Tanguy et al., 2020, France (8) | 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 behavioral trends were observed in those with higher educational attainment with high income but negative trends were reported when income was lower. Positive behavioral trends were observed in the overweight/obese population with higher educational attainment who expressed anxiety: reduced snacking; reduced alcohol consumption; increased more home cooking.
|   | Di Santo, et al., 2020, Italy (9) | 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%) 2 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Di Renzo et al., 2020, Italy (10) | 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/day |
| 11 | Đogaš, et al., 2021, Croatia (11) | 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 genders |
| 12 | Dondi, et al., 2021, Italy (12) | 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 (13) | 3-11 | Lifestyle changes and Psychological state | 531 | ↑19% | ↓32% | No difference in dietary pattern | Increased 20–38% | Increased (65.3% vs. 58.6%) | Unchanged | NR | improved sleep quality 31.5%. Sleep hours increased. Increased intake of legumes (60.6% vs. 53.3%), fish (32.8% vs. 24.4%), and sweets (30.5% vs. 22.4%) Decrease intake of cereals (24.1% vs. 35.6%), nuts (15.1% vs. 18.9%), and dairy products. Increase computer screen time due to
|   | Changes in Body weight due to COVID-19 Lockdown |   |   |   |   |
|---|---|---|---|---|---|
| 14 | Drywie 'n, et al., 2020, Poland | 3-7 | 1769 | ↑34% | ↑65% |
|   |   |   |   | ↓18% | ↓40% |
|   |   |   |   | ↑ in salty snacks (30.4% vs. 11.3%), ↑ in consumption of vegetables (32.3% vs. 16.0%), ↑ in weight gainers (60.7% vs. 31.6%) |   |
|   |   |   |   | ↓ in alcohol who gained weight (25.4% vs. 4.1%) |   |
|   |   |   |   | Unhealthy dietary changes. Increase in screen time in females, those who lost weight ate more fruits, vegetables, 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 (15) | Effects of COVID-19 social distancing on physical activity, stress levels, quality of life | 426 | increased | NR | NR | NR | ↓84% | NR |
| 16 | Gentile, et al.,2020, Vasto-Italy and Paraguay (16) | 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 | ↑2.72% | NR |

The study shows an overall decrease in all sections of quality of life as analyzed 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 genders (P<0.05) although there is no difference of stress levels across children.

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%
| Reference                  | Country/Region        | Page | Table Heading                                                                 | Participants | Physical Activity Change | Nutrition Changes                                                                 |
|---------------------------|-----------------------|------|--------------------------------------------------------------------------------|--------------|--------------------------|--------------------------------------------------------------------------------|
| Giustino et al., 2020, Italy (17) | Italy                  | 1-2  | Changes in physical activity before and during the quarantine among the active Sicilian population. | 802 NR       | ↓ 1168.5 MET-min/week    | Greater impact of decreased physical activity among males and overweight participants. |
| He, et al., 2020, China (18)            | China                  | 4    | Body Weight, Physical Activity, and Lifestyle Changes                            | 339 BMI<24 gained weight females: 2.2 kg males: 1.7 kg | Decreased NR                 | Decreased Weight correlated with the change level of alcohol consumption during the semi-lockdown for COVID-19 (Rs = −0.255; P = 0.002). |
| Ismail, et al., 2020, MENA Region (19) | MENA Region            | 4-6  | Eating behaviors and lifestyle changes during COVID-19 Pandemic in Middle east and North Africa region (MENA) | 2970 ↑30-3 % | Increased 32.9 % had salty snacks | Increased level of inactivity from 34.9 % to 39.1 % |
| 20 | Ismail, et al., 2020, UAE (20) | 1-4 | Effect of quarantine on eating habits, physical activity, stress and sleep behaviors | 1012 | ↑31% | ↑25.71% | 37.1% ate salty snacks | 48.8% consumed fruits daily | ↑14.8 | NR | Increase in home cooked food, decrease in fast food consumption (P<0.0001). Decrease frequency of meal skipping (64.5% to 46.2%). Increase Breakfast intake (66% to 74.2%). Increase water intake (24.1% to 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% to 38.5%). 69.1% and 67.8% of participants relied on social media applications to be updated about nutrition and health news. |

↑ Increase
↓ Decrease
NR Not Reported
| Study | Authors | Country | Sample Size | BMI Changes | Activity Changes | Psychosocial, Lifestyle, and Body Weight Changes |
|-------|---------|---------|-------------|-------------|-----------------|-----------------------------------------------|
| 21    | Jia, et al., 2020, China | 11-14 | 10,082 | BMI increased from 21.8 to 22.1 kg/m² | 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) | 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) |
| 22    | Jimenez, et al., 2021, Spain | 9 | 603 | Increase sedentary lifestyle | 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) | 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) |
| 24 | Kang et al., 2021, Korea |
|---|---|
| Non-diabetic | Non-diabetic |
| BMI score | BMI score |
| 18.9 | 21.8 |
| Increase level of triglyceride (105.8 mg/dL vs. 88.6 mg/dL, P < 0.001). |
| Decrease level of calcidiol level (18.9 mg/dL vs. 23.8 mg/dL, P < 0.001). |

| NR | Increase by (2.9 kg/m²). |
|---|---|
| Decrease due to school closure. |
| NR | Weight gain during epidemic. |

| 23 | Karatas et al., 2020, Istanbul |
|---|---|
| 24 | COVID-19 impact on Childhood obesity and Vitamin D levels |
| 25 | Overweight or Obesity rate increased 7.5% (23.5% to 31.4%) |
| NR | Increase level of low-density lipoprotein-cholesterol (100.2 mg/dL vs. 94.0 mg/dL, P = 0.002). |
| NR | Non-significant change of BMI levels (33.44 ± 6.48 to 33.44 ± 6.48 kg/m²). |
| NR | Increase level of triglyceride (105.8 mg/dL vs. 88.6 mg/dL, P < 0.001). |
| NR | Decrease level of calcidiol level (18.9 mg/dL vs. 23.8 mg/dL, P < 0.001). |

| NR | Normal weight had 9.9 (P < 0.001) times risk of becoming overweight or obesity during epidemic. |

| NR | Increase level of triglyceride (105.8 mg/dL vs. 88.6 mg/dL, P < 0.001). |
| NR | Decrease level of calcidiol level (18.9 mg/dL vs. 23.8 mg/dL, P < 0.001). |

| NR | Increase by (2.9 kg/m²). |
| NR | Weight gain during epidemic. |
| NR | Increase level of low-density lipoprotein-cholesterol (100.2 mg/dL vs. 94.0 mg/dL, P = 0.002). |
| NR | Non-significant change of BMI levels (33.44 ± 6.48 to 33.44 ± 6.48 kg/m²). |
| NR | Increase level of triglyceride (105.8 mg/dL vs. 88.6 mg/dL, P < 0.001). |
| NR | Decrease level of calcidiol level (18.9 mg/dL vs. 23.8 mg/dL, P < 0.001). |

| NR | Normal weight had 9.9 (P < 0.001) times risk of becoming overweight or obesity during epidemic. |
| diabetic patient and healthy population | < 0.05) (0.54 ± 0.95) | 31.63 ± 3.57 kg/m² |
|----------------------------------------|-----------------------|-------------------|
| Diabetic group                         | (89.75 ± 18.68 vs. 87.83 ± 18.27 kg) (p < 0.05) | HbA1c increased more in diabetic than in non-diabetic groups (p = 0.002) |
|                                        | 1.91 ± 5.48 kg        | Glucose, LDL-C, and TG increased in diabetic (39.69 ± 74.69, 7.60 ± 34.33, and 58.21 ± 133.54 mg/dl, p < 0.05) |

Triglyceride levels increased more in the diabetic group than in the non-diabetic group (p = 0.041).
| 25 | Keel PhD, et al., 2020, USA (25) | 6-7 | Perceived versus observed weight changes in undergrad students during COIVD-19 confinements | 90 | No statistically significant | increased | NR | NR | Decreased | NR |
|----|---------------------------------|-----|-------------------------------------------------|----|-----------------------------|----------|-----|-----|-----------|-----|
| 26 | Kriaucioniene, et al., 2020, Lithuania (26) | 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 |

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 to men.
|   | Author(s)                          | Year | Country | Study Details                                                                 | Sample Size | Interventions/Outcomes                                                                 |
|---|-----------------------------------|------|---------|--------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------------|
| 27 | Malkawi, et al., 2020, Jordan      | 1-6  |         | Mental health & changes in lifestyle practices among Jordanian mothers during COVID-19 quarantine. | 2103        | ↑37% Increased teaching time of children increased (63%). Family violence increased (27%) hours spent in dedicated family time (+5h). 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   | 9-11 |         | Weight gain in overweight/obese subjects Effect of psychological and psychosocial variables | 110         | Weight gain by 31% of overweight/obese patients 60% increased night eating No significant changes No significant changes Binge eating was significant factor for weight gain in psychiatric patients Increased night eating episodes in response to stress |
| Study | Authors | Age Group | Description | Participants | Pre | Post | % Change | p Value | Conclusion |
|-------|---------|-----------|-------------|--------------|-----|------|----------|---------|------------|
| 29    | Martínez-de-Quel et al., 2021, Spain | 6-7 | Changes in physical activity, dietary habits, and sleep quality pre and post lockdown | 161 | Pre 67.3 kg ± 14.8 vs Post 67.7 kg ± 15.1 | NR | NR | NR | ↓8515.7 ± 10260.0 Met/week vs Post 5053.5 ± 5502.0 Met/week p < 0.001 | Significant differences were found pre and post lockdown with physical activity, sleep and perceived wellbeing. More people living together had higher weight gain. |
| 30    | Mason, et al., 2021, USA | 10-18 | Body weight change during lockdown and factors determining it | 1,820 | Mean weight change 3.47 lbs (SD14.57); Mean % Weight change ↑ 2.5% (8.6%). | ↑31% | NR | NR | NR | NR | NR | 35% consumed unhealthy food to cope with the pandemic. Overeating as a mechanism of coping with the pandemic was related to increase in weight and BMI on overweight. |
| 31    | Mitchell et al., 2020, USA | 1 | Alterations in food choices related to lockdown in users enrolled in a digital behavioural change weight loss program | 381,564 | NR | NR | NR | ↓4.2% | NR | ↓4.5% | Use of the mobile app (Noom) decreased by 9%. |
| Study (Ref) | Country | Sample Size | Description | Pre vs Post | Low Physical Functioning | HbA1c Change |
|------------|----------|-------------|-------------|-------------|--------------------------|--------------|
| Önmez et al., 2020, Turkey [32] | 32 | 15-24 | Glycaemic control in Type 2 Diabetes patients | ↑39.6% ↓38.6% | NR | Low: Physical functioning on Short form 36 – item survey (59.5 ± 26.9) | NR |
| Özden et al., 2021, Turkey [33] | 33 | 8-10 | Nutrition exercise behaviors during lockdown | ↑46.9% | Increased | Increased | ↓35.4 | NR |

Nutritional exercise behaviors during lockdown. The numbers of patients who exercised regularly and dieted were low. Mean pre-lockdown waist circumference was 105 ± 23 cm, compared to 107 ± 32 cm post-lockdown.

HbA1c increased from 7.67 ± 1.76 to 8.11 ± 2.48 compared to 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 to 107 ± 32 cm post-lockdown.

Psychological/addictive eating behavior subscale scores were piled up between 20 and 40, and their unhealthy nutrition-exercise behavior subscale mean scores were piled up between 30 and 50 (Figures 1).
|   | Study Reference |   | Study Title | Study Country, Year (ID) |   | Study Details | Study Design | Study Findings |   |
|---|-----------------|---|-------------|---------------------------|---|----------------|-------------|----------------|---|
| 34 | Pellegrini et al., 2020, Italy (34) | 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 (35) | 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 hours/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 hours/day. Sleep time increased by 0.65 ± 1.29 hours/day. |
| 36 | Rogers et al., 2020, UK (36) | 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 |
### Sleep quality before and during the COVID-19 lockdown period in nursing students

| Study | Country | Time | Effect | Sleep Quality Impact | NR | NR | NR | NR | NR | NR |
|-------|---------|------|--------|----------------------|-----|-----|-----|-----|-----|-----|
| Romero-Blanco et al., 2020, Spain (37) | Spain | 4 years | Sleep quality before and during the COVID-19 lockdown period in nursing students | 207 | NR | NR | NR | NR | NR | NR |
| Ruissen, et al., 2021, Netherlands (38) | Netherlands | 8-11 months | Lockdown impact on people with type 1 and type 2 | 435 | ↑40.9% | NR | NR | NR | ↓45.7% | NR |
| Shah, et al., 2020, India (39) | India | 12-15 weeks | Glycemic control, weight and body mass index | 77 | Weight gain z-score −0.4±0.8 vs. post lockdown weight z-score −0.2±0.8, p<0.05 | NR | Decreased | 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.

- Increase in levels of stress 34.1%.
- Increase in levels of anxiety 27.3% of all participants.
- Stress correlated with poor glycemic control (p<0.0001).

- Improved glycemic control via HbA1C 79.4±19.2 vs. post lockdown Hba1C 74.5±16.9 mmol/mol
- Improved glycemic control in lower socioeconomic state
|   | Sidor et al., 2020, Poland<sup>40</sup> | 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<sup>41</sup> | 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 |

↑ Increased. ↓ Decreased. % - Percentage; NR – Not reported; BMI – Body Mass Index; SD – Standard Deviation; MET–minute/week – metabolic equivalent of task minute/week. IQR (interquartile range) - Interquartile Range; lbs- Pound

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Table 4: Determinants of body weight during pandemic confinements

| Determinants that can influence weight gain |
|--------------------------------------------|
| **Demographics**                           |
| Female \(^{(1-6)}\)                         |
| Baseline obese and overweight \(^{(2,3,6-15)}\) |
| BMI < 24 \(^{(16,17)}\)                    |
| Age group > 45 years \(^{(3,9,18)}\)       |
| Age group < 25 years \(^{(1,9)}\)          |
| Having children under the age of 18 at home \(^{(1)}\) |
| Changed work environment to working from home \(^{(1,2,19)}\) |
| **Work Environment**                       |
| Loss of job \(^{(24)}\)                    |
| Interruption of work routine \(^{(2)}\)     |
| Changed work habits: Furloughed or working from home \(^{(22)}\) |
| Suspension of schools \(^{(17)}\)          |
| **Dietary Behaviors**                      |
| Increased food consumption \(^{(1,3,7,12,14,20-22)}\) |
| Decreased consumption of fresh food products (particularly fruits, vegetables, and fish) \(^{(2,3,12,16,23)}\) |
| Increased consumption of homemade recipes, sweets, and pizza \(^{(7,8)}\) |
| Increased home cooking \(^{(3)}\)          |
| Increased cereal consumption \(^{(2,7)}\)  |
| Consumption of unhealthy foods \(^{(2-5,7,8,10,12,24,25)}\) |
| Poor attention to diet balance \(^{(1)}\)  |
| Snacking after dinner \(^{(2,26)}\)        |
| Binge eating \(^{(24,27)}\)                |
| Loss of control to eating \(^{(24)}\)      |
| Eating in response to stress as a coping mechanism \(^{(23,26)}\) |
| Eating secondary to appearance and smell of food \(^{(20)}\) |
| Emotional eating \(^{(5,11,23)}\)          |
| Increase in alcohol intake \(^{(3,4,12)}\) |
| **Psychological factors**                  |
| Decreased sleep time \(^{(22,26)}\)       |
| Lower sleep quality \(^{(28,29)}\)         |
| Stress | (11,19,22,26,30–33) |
|--------|------------------|
| Boredom | (7) |
| Living alone | (4,7) |
| Anxiety/Depression | (6,7,19,24,32) |
| Depressive symptoms | (1,4,11,24) |
| Mood disturbances | (10) |
| Weight/shape concerns | (21) |

**Socioeconomic factors**

| Lack of garden | (18) |
| Urban residence | (1,32) |
| Lower education level | (7,19) |
| Residence in a macroeconomic region >50% of EU-28 GDP | (12) |
| Lower socioeconomic level | (19,34) |

**Physical inactivity**

| Physical activity before lockdown | (35) |
| Decreased physical activity | (3–5,7,8,12,15,16,19–22,24,26,29–31,33,35–39) |
| Limitations of outdoor and in-gym activities | (2,4,5,7) |
| Increased screen/tv time | (1,12,24,31,33,36–39) |

**Comorbidities**

| Associated chronic illness | (1,33,39–41) |

**Determinants that can be associated with weight loss**

| Underweight before confinement | (9,12) |
| Younger age | (12) |
| Remote work | (12) |
| Urban residence | (12,33) |
| Ate less | (12) |
| Ate more fruits/vegetable | (12) |
| Drank more water | (12) |
| Ate more pulses/seafood/fish | (12) |
| Did not consume alcohol | (12) |
| Regular exercise before lockdown | (6) |
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