



Research article

Weight gain, new-onset overweight or obesity, and their influencing factors during the social distancing era of the COVID-19 pandemic

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ABSTRACT

The prevalence of obesity is gradually increasing in South Korea, and the coronavirus disease 2019 (COVID-19) pandemic has accelerated the weight gain. In response to COVID-19, South Korea implemented targeted distancing measures based on the number of COVID-19 cases, rather than a full lockdown. This study focused on two subgroups that influence the rise in obesity prevalence during the early stages of the COVID-19 pandemic and explored the factors contributing to rapid weight gain in this group during this period. This cross-sectional study involved 3,462 participants recruited through the MicroEmbrain Inc. Online survey panel. Participation emails were sent by the research company to the online survey panel, and individuals who voluntarily agreed to participate responded to the survey. The participants consisted of residents aged 19 and above from Seoul, with sample distribution taking considering sex, age, and region. Height, and weight before and during the COVID-19 pandemic were self-reported. The analysis revealed that compared with that of pre-COVID-19 statistics, 11 % of all participants entered the overweight or obese categories post COVID-19, and among those who were overweight or obese before COVID-19, 42.5 % reported weight gain. Both groups had relatively younger individuals, higher stress levels, spent more time alone, and had increased usage of online platforms including online food purchasing. Post-COVID-19 wt gain among individuals with pre-existing overweight or obesity status was associated with a higher frequency of solitary drinking (odds ratio [OR] = 1.407, 95 % confidence interval [CI] = 1.024–1.932), increased online leisure time (OR = 1.336, 95 % CI = 1.063–1.678), and increased use of meal delivery services (OR = 1.307, 95 % CI = 1.026–1.664). The prevalence of obesity has continued to rise after COVID-19 pandemic, highlighting the need for interventions that mitigate the negative impact of the pandemic on health behavior.

Abbreviations: coronavirus disease 2019, (COVID-19); odds ratio, (OR); confidence interval, (CI); Korea Disease Control and Prevention Agency, (KDCA); World Health Organization, (WHO); Community Health Survey, (CHS); Korea Rural Economic Institute, (KRED); Body mass index, (BMI).

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1. Introduction

The coronavirus disease 2019 (COVID-19) has emerged as a global health crisis, affecting millions of people worldwide. Although respiratory symptoms and disease transmission have received primary attention, growing evidence suggests that COVID-19 is associated with various other health effects, including weight gain. The “Quarantine 15” phenomenon, which refers to the fear of gaining excessive body weight during the pandemic, has gained traction on social media. Several studies have investigated the relationship between the situation during the COVID-19 period in each country and weight gain. In the United States, 42.4 % of adults were obese in 2020, and 22 % of the study participants experienced a weight gain of 5–10 pounds during the pandemic [1]. In Spain, 45 % of participants reported weight gain during the COVID-19 lockdown period [2]. In China, 30.6 % experienced weight gain during the COVID-19 outbreak confinement [3]. In a study targeting Malaysian youth, 48.8 % of the youth experience weight gain during the COVID-19 outbreak confinement, and the prevalence of overweight/obesity increased from 39.8 % before the pandemic to 41.5 % during the pandemic [4].

In the South Korean population, a notable increase in the prevalence of obesity and weight gain has been observed. The prevalence of obesity in South Korea has undergone noteworthy shifts over the past decade. The prevalence was 31.7 % in 2007, and it increased modestly to 33.2 % in 2015. Subsequently, the rates exhibited a somewhat stable pattern, hovering at approximately 35 % in 2020. However, a remarkable transformation occurred in 2020, when the prevalence surged to 38.3 %, indicating a 4.5 % increase [5]. This change suggests that external factors such as societal shifts or health-related events may have influenced the obesity landscape within this timeframe. In 2021, there was a marginal decline in the obesity rate, with the prevalence decreasing to 37.1 % from that in the preceding year. In a broader context, the upward trajectory of obesity rates in South Korea has remained consistent since 1998, the year in which national obesity statistics were first systematically reported; however, it appears to have slowed down after the occurrence of COVID-19 pandemic [6].

In Seoul, the capital city of South Korea, the prevalence of obesity has exhibited a distinct pattern. Despite maintaining a lower obesity rate than the national average, Seoul’s obesity prevalence has been steadily increasing since 2008, when it was 20.7 %. Over the span of a decade, the prevalence surged to 28.6 % by 2018, marking a clear shift in the local obesity landscape. Following the emergence of the COVID-19 pandemic in 2020, Seoul’s obesity rate continued to increase, reaching 28.5 %, 29.2 %, and 30.2 % in 2020, 2021, and 2022, respectively [7].

It is crucial to consider that the impact of the pandemic on weight gain potentially varies with factors such as age, sex, ethnicity, and socioeconomic status despite acknowledging the overall increase in obesity rates during the pandemic [8,9]. Understanding these disparities is essential to develop targeted interventions and public health strategies that address the specific requirements of diverse populations. Based on obesity prevalence statistics from 2019 to 2020, middle-aged adults exhibited a higher obesity rate than other age groups [10,11]. Sex disparities have also emerged in obesity prevalence, with a greater increase observed among South Korean men [6,12], whereas, women in the United States and Spain exhibited a more significant increase in obesity rates during the pandemic [2,13]. Data collected from 26 countries worldwide, including a 64 % representation of Asians, it was revealed that individuals in younger age groups, those with higher levels of education, urban residents, individuals living with family, and full-time workers were more vulnerable to weight gain during the COVID-19 pandemic [14]. The pre-pandemic weight status also played a role. Individuals who reported being overweight before the pandemic were the most likely to gain weight in the United States [15], whereas in China, those with normal weight were more likely to gain weight than those who were overweight or obese [3]. Understanding these disparities is essential to tailoring interventions and public health strategies that address the specific requirements of various population groups.

The COVID-19 pandemic has had a significant impact on the daily lifestyle, leading to weight gain. Restrictions on gatherings and the proximity of sports facilities have resulted in reduced physical activity, while alterations in the food supply chain have changed eating behavior during the COVID-19 pandemic [16]. Moreover, the high levels of stress experienced during the pandemic have been associated with health issues that potentially contribute to weight gain [17,18]. Numerous studies have indicated that weight gain during the pandemic is closely linked to modifications in dietary habits [19–26,27–29]. These include an increase in the consumption of ultra-processed foods, changes in dietary patterns, shifts in food choice motivations, evening snacking, emotional eating, and a sedentary lifestyle owing to prolonged periods spent at home [4,19–21]. Disruptions in food supply chains and increased food prices may affect eating patterns and dietary habits [22]. Consequently, individuals might have resorted to less healthy, cheaper foods or increased their consumption of shelf-stable, high-calorie foods [23–25]. The increase in food deliveries has resulted in increased geographical accessibility to unhealthy, high-calorie foods [26,30]. Research findings indicate that the increased consumption of late-night snacks, overeating, and other negative eating habits following the onset of COVID-19 have contributed to weight gain [18, 27–29]. Additionally, a survey conducted by the Korean Society for the Study of Obesity revealed that individuals reported experiencing weight gain owing to decreased physical activity, irregular eating patterns, and increased stress [31].

The World Health Organization (WHO) recommended physical distancing to prevent the spread of COVID-19 [32]. In response, governments worldwide implemented various measures, including movement restrictions, limitations on large gatherings, promotion of remote work, and closure of schools and public places, to maintain a minimum distance of six feet from others. However, responses to the COVID-19 pandemic have varied across countries and regions, potentially leading to differences in people’s health behaviors and resulting in varying impacts. The severity and drivers of weight gain vary across populations and regions. While previous studies have explored the impact of lockdown on weight gain [2,14,33,34], this study focused on the size and characteristics of the subpopulation that experienced significant weight gain during the initial stages of the COVID-19 pandemic when strict lockdown measures had not been instituted. Specifically, this study focused on the following two groups: (i) individuals who previously had normal weight but became overweight or obese during the pandemic (i.e., those who have recently become targets for new public health weight

management efforts) and (ii) people who were already targets for public health weight management efforts but experienced exacerbated overweight or obesity during the pandemic (i.e., those who were already overweight or obese before the pandemic and gained weight during the pandemic). The South Korean government implemented self-quarantine and social distancing measures during the early stages of the COVID-19 outbreak [35,36]. Social distancing refers to the measures adopted to reduce social interactions among people. This includes staying at home as much as possible, avoiding physical contact with others, and limiting or avoiding direct contact with people outside the household. The measures in South Korea were less severe than those in other countries, allowing for necessary travel, walking, and running.

This study examined the impact of changes in daily life caused by social distancing measures on weight gain in two groups of adults in Seoul, South Korea, approximately 9 months after the COVID-19 outbreak. Unlike cities in other countries, Seoul did not enforce a lockdown during the pandemic, despite being one of the most densely populated cities in South Korea. Seoul's urban characteristics, including its population density, potentially influence people's living environment, habits, and dietary patterns. By targeting Seoul citizens, this study provides valuable insights into the changes in daily life and weight gain in an urban setting.

This study specifically aimed to investigate weight gain resulting from changes in daily life caused by social distancing policies. While previous studies on obesity or weight gain during the COVID-19 pandemic primarily focused on decreased physical activity and unhealthy eating habits during the lockdown period, this study concentrated on the two subgroups that impact the prevalence of obesity. We examined the influence of changes in daily life due to social distancing measures on this particular group. These changes include an increased amount of time spent at home and a reduction in face-to-face interaction, which have been replaced by online leisure activities or solitary drinking. Moreover, a shift towards online food purchases and the more frequent consumption of meals at home has occurred, thus affecting food selection, purchasing, and consumption patterns. According to the "COVID-19 Impact Report" released by Nielsen Media Research Korea in January 2020, the proportion of meal deliveries compared with that in the preceding year increased nearly two-fold from 33 % to 52 % following the onset of the COVID-19 pandemic [37]. Most delivered meals comprised fast food and pizza [38]. Considering these developments, this study aimed to explore the impact of COVID-19-induced alterations in daily life in two groups: (i) those who became overweight or obese during the pandemic and (ii) those who were already overweight or obese but experienced further weight gain. By investigating these groups, this study addresses a gap in the literature by examining the precise effects of social distancing policies on weight gain during the COVID-19 pandemic.

Research Question 1. Which individuals newly entered the overweight and obese categories and became targets for public health weight management efforts after the pandemic?

Research Question 2. Which individuals were already overweight or obese before the pandemic but experienced further weight gain during the pandemic?

Research Question 3. What were the effects of changes in daily life due to social distancing measures on individuals who became overweight or obese during the pandemic and those who were already overweight or obese before the pandemic?

2. Materials and methods

2.1. Study design

This study was a cross-sectional, population-based online survey between October 12 and 21, 2020, using a structured questionnaire in Korean language to assess the impact of eating behaviors and weight gain on Seoul residents during the COVID-19 pandemic.

2.2. Data collection

This study utilized the online survey panel platform of MicroEmbrain Inc., which holds a panel of over 1.65 million online survey participants. The survey panel consists of respondents who have expressed willingness to participate in surveys and have provided personal information through agreements with survey companies. The research company distributed survey invitations to potential participants who were informed about the purpose and content of the survey. Eligible participants were required to be residents of Seoul aged ≥ 19 years. Proportionate quota sampling was employed to ensure representation across age and sex, following the population distribution of the 25 districts in Seoul. The survey was anonymous and voluntary, and the participants provided consent by confirming their participation on the first page of the online questionnaire.

Based on a total population of 8,379,486 residents registered in Seoul as of June 2020, with a 99 % confidence level and a margin of error of 2.2 %, the minimum sample size required for this study was estimated to be 3437. After excluding missing data, a total of 3669 questionnaires were collected. Among them, 207 participant who tested positive for COVID-19 or had undergone self-quarantine were excluded from this analysis, resulting in a final sample size of 3462.

This survey was conducted approximately 9 months after the country's first confirmed case of COVID-19, as reported by the Korea Disease Control and Prevention Agency (KDCA). Throughout the survey timeframe, Seoul and its surrounding metropolitan region were subjected to Level 1.5 social distancing protocols, which sanctioned indoor and outdoor gatherings of up to 100 and 150 people, respectively. High-density, high-risk establishments, such as nightclubs and karaoke rooms, were permitted to function under stringent regulatory protocols. Culinary establishments and cafés were granted operational authorization until 10 PM, contingent upon the prerequisite of maintaining a 1-m separation between contiguous tables, individual patron seating per table, and/or the incorporation of partitions between tables. Educational institutions held sessions with certain limitations, while businesses were encouraged to

implement flexible working hours and telecommuting options. Attendance at religious ceremonies or sporting events was limited to ≤30 % of the venue’s capacity.

2.2.1. *Dependent variables*

The participants reported their weight and height values before and during the pandemic, with January 20, 2020, marking the onset of COVID-19 as the reference point. Body mass index (BMI) was calculated as weight in kilograms divided by the square of their height in meters and categorized based on the Asia–Pacific perspective of the WHO (2000) and Korean Society for the Study of Obesity guidelines, as follows: underweight (<18.5 kg/ m²), normal weight (18.5–22.9 kg/ m²), overweight (23–24.9 kg/ m²), and obesity (BMI ≥25 kg/ m²) [39,40].

2.2.2. *Independent variables*

This study collected data on demographic factors, including date of birth, sex (male or female), marital status (married, single, widowed, divorced, or separated), highest level of educational background (“high school and below” or “college and above”),

Table 1
Descriptive statistics for the entire sample and individuals.

Participant characteristics	Full sample (N = 3,462) N (%)
Age groups	
20–29 years	716 (20.7)
30–39 years	738 (21.3)
40–49 years	793 (22.9)
50–59 years	787 (22.7)
60–69 years	428 (12.4)
Sex (F)	1771 (51.2)
Marital status	
Married	1888 (54.5)
Single/Widowed/Divorced/Separated	1574 (45.5)
Educational level	
High school or below	848 (24.5)
College or above	2614 (75.5)
Employment status	
Full-time	2212 (63.9)
Part-time	324 (9.4)
Not employed	926 (26.7)
Household income	
Low	521 (15.0)
Middle-low	553 (16.0)
Middle	746 (21.5)
Middle-high	810 (23.4)
High	832 (24.0)
Income changes during COVID-19	
Upward or no change	2048 (59.2)
Downward change	1497 (40.8)
Pre-pandemic BMI class	
Underweight	212 (6.1)
Normal	1585 (45.8)
Overweight	746 (21.5)
Obesity	919 (26.5)
Post-pandemic BMI class	
Underweight	205 (5.9)
Normal	1483 (42.8)
Overweight	757 (21.9)
Obesity	1016 (29.3)
Behavioral changes compared with pre-COVID-19 era:	
Increased stress ^a	2094 (60.4)
Changes in lifestyle behavior	
Increased solitary drinking	389 (11.2)
Increased high-risk alcohol consumption	747 (21.6)
Increased time spent at home	2459 (71.0)
Increased online time for leisure	2232 (64.5)
Changes in food-purchasing style (agree) ^a	
Hesitation to visit local grocery stores	1790 (51.7)
Increased online grocery shopping	1,993 (57.6)
Increased meal delivery	1952 (56.4)
Increased takeout orders	1835 (53.0)
Increased consumption of ready-to-eat meals	1549 (44.7)

^a Number of participants who scored 4 or 5 on a 5-point Likert scale ranging from 1 to 5.

employment status (full-time, part-time, or not employed), monthly household income, and income changes during COVID-19 pandemic (increased, decreased, or similar to that before the pandemic). To adjust for differences in household size, household income was calculated by dividing the monthly household income by the square root of the number of people in the respective household and was categorized into quintiles. Demographic variables were based on the national statistical survey method of the Community Health Survey (CHS), which is conducted annually by the KDCA (2019) [41].

This study also assessed stress levels of the participants and the changes in their lifestyle behaviors during the pandemic. Participants reported their perceived changes in stress levels using a 5-point response scale ranging from 1 (increased significantly) to 5 (decreased significantly) compared with the pre-COVID-19 pandemic era. Additionally, the participants were asked about changes in their drinking habits, such as solitary alcohol consumption and changes in the frequency and quantity of alcohol consumed from before the pandemic. High-risk drinking was defined as drinking at least twice a week, with an average of seven or more drinks in men and five or more drinks in women. Items related to stress and drinking habits were developed based on the CHS [41].

The questionnaire also asked the participants regarding their allocation of time at home, engagement in online leisure activities, and shifts in food-purchasing behavior during the pandemic. Participants reported the duration of time they spent at home as well as on online leisure activities (e.g., games, movies, videos, etc.) using a 5-point response scale ranging from 1 (considerably more than before) to 5 (considerably less than before), contextualized with reference to pre-COVID-19 circumstances. Questions regarding time spent at home and on online leisure activities were formulated based on a comprehensive analysis of approximately 14 million online posts related to daily life, sourced from the repository of the South Korea Ministry of Culture, Sports, and Tourism [42]. Participants documented shifts in their food-purchasing patterns, encompassing experiences such as hesitation to visit local grocery stores, amplified reliance on online grocery shopping, escalated usage of delivery services, increased takeout orders, and the heightened consumption of ready-to-eat meals throughout the pandemic. Responses were captured using a 5-point response scale, denoted by values from 1 (considerably more than before) to 5 (considerably less than before), relative to pre-COVID-19 behaviors. The query regarding "hesitation to visit local grocery stores" was adapted from a survey conducted by the Institute on Aging at the University of Florida [43]. The remaining four inquiries addressed shifts in food-procurement behavior augmented by considerations pertinent to the COVID-19 context that prevailed during the survey period. These inquiries were subsequently structured into a cohesive framework and sequenced based on priority, all tailored to facilitate effective data collection, reflecting the responsiveness of our study to the prevailing COVID-19 situation at that time.

2.3. Statistical analysis

Variable normality was evaluated using the Kolmogorov–Smirnov test. Demographic characteristics were subjected to descriptive statistics. The compositions of the subpopulations that became overweight or obese during the pandemic and those that were already overweight or obese but experienced further weight gain were analyzed using the independent *t*-test and Pearson's chi-square test for quantitative and categorical variables, respectively [44]. Multivariate logistic regression models were used to evaluate the effects of independent factors on dependent variables. Using dependent variables coded 0/1 (0 = decreased, 1 = increased), this study estimated binary logistic regression models. Odds ratios (ORs) and 95 % confidence intervals (CIs) are presented. Statistical analyses were performed using the SPSS 26 (IBM SPSS Statistics for Windows, Version 26.0.; IBM Corporation, Armonk, New York, United States). Reporting adhered to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cross-sectional studies.

3. Results

3.1. General characteristics of the samples

The online survey included 3,462 Seoul residents aged ≥ 19 years. The sample characteristics are listed in Table 1. Except for individuals in their 60s, the participants in the entire sample were evenly distributed across age groups, among whom 51.2 % were women, 54.5 % were married, and 75.5 % had a college education. Most participants were employed full-time (63.9 %), and their monthly household income exceeded 4 million won (approximately USD 4150) on average. Income was distributed as follows: high (24 %), middle-high (23.4 %), and middle (21.5 %). Additionally, 40.8 % of the participants reported a reduction in income during the pandemic. A comparison of the BMI categories before and during the COVID-19 pandemic revealed a decrease in the number of participants who were underweight or of normal weight during the pandemic, whereas the number of participants who were overweight or obese before the pandemic increased. The prevalence of being overweight increased from 21.5 % before to 21.9 % during the pandemic, whereas that of obesity increased from 26.5 % before to 29.3 % during the pandemic.

Participants also reported alterations in their daily routines and food-procurement habits compared with their pre-COVID-19 behaviors. Throughout this timeframe, 60.4 % of the participants reported heightened stress levels compared with those experienced before the pandemic. Additionally, 11.2 % of the participants reported an increase in solitary drinking, and 21.6 % acknowledged a rise in high-risk alcohol consumption. Moreover, 71 % of respondents noted a surge in homebound hours, while 64.5 % reported an increased use of online resources for leisure activities. A substantial number of participants expressed hesitation in visiting local grocery stores (51.7 %), with a notable increase in online grocery shopping (57.6 %), meal-delivery service utilization (56.4 %), and takeout orders (53 %) compared with that during the pre-pandemic era. The baseline variables according to BMI categories before and during the COVID-19 pandemic are provided in Tables 1A and 1B of the supplementary section.

3.2. The two defined groups: (i) newly developed overweight or obesity status and (ii) exacerbated overweight or obesity status during the pandemic

A significant transition into the overweight or obese categories was noticed among participants who were initially of normal weight before the pandemic. Similarly, participants who were initially overweight before the pandemic transitioned into the obese category during the pandemic. Among the participants with pre-pandemic normal weight, 188 became overweight, and 22 became obese during the pandemic, representing 5.8 % (n = 210) of the entire study population (Fig. 1). Additionally, among the participants who were overweight before the pandemic, 23.2 % (n = 173) shifted to the obese category after the COVID-19 outbreak. Thus, 11.1 % (n = 383) of the entire study population comprised individuals who newly entered the overweight and obese groups.

Notably, during the pandemic, participants who newly entered the overweight and obese groups were relatively younger, with 26.1 % and 24.8 % in their 20s and 30s, respectively, than those in other groups (Table 2). No statistically significant disparities were detected in sex, marital status, educational level, employment status, and household income. However, the reduction in income was more pronounced among participants who were overweight or obese during the COVID-19 pandemic (p < 0.041).

An analysis of participants with newly developed overweight or obesity status during the COVID-19 period revealed significant differences in various health-related lifestyle behaviors, except for the increase in high-risk drinking levels. Most of this group reported heightened stress levels (70.2 %), whereas 16.7 % reported an escalation in solitary drinking. Additionally, a significant proportion spent more time at home (78.3 %) and on online leisure (74.9 %). In terms of food-purchasing behavior, the newly overweight and obese groups exhibited reduced hesitation to visit local grocery stores. However, a greater increase was noted in online grocery shopping (67.1 %), meal delivery (67.6 %), takeout orders (63.2 %), and the consumption of ready-to-eat meals (54 %).

The second group of individuals comprised those who were either overweight or obese before the pandemic and experienced weight gain due to the pandemic. Among the participants who were overweight before the pandemic, 46.2 % (n = 345) gained weight, whereas among those who were obese before the pandemic, 40 % (n = 368) experienced weight gain. Therefore, a total of 713 participants (42.8 % of those who were overweight/obese pre-pandemic) experienced weight gain among those who were overweight or obese before the pandemic (Table 3).

Table 4 presents a comparison of the demographic characteristics of participants who were overweight or obese before the pandemic and experienced weight maintenance or loss with those of participants who experienced weight gain during the pandemic. Among those who were overweight or obese before the pandemic, weight gain tended to occur at a relatively young age, and a significant increase was noted among women. Marital status, educational level, employment status, and income changes due to the pandemic did not differ significantly based on weight change. However, income level was higher among those who experienced weight gain than among those who experienced weight maintenance or loss. Among individuals who were overweight or obese before the pandemic, significant disparities in health-related behavioral shifts stemming from the COVID-19 outbreak were observed between participants who maintained or lost weight and those who gained weight. Participants who experienced weight gain displayed noteworthy differences in heightened stress levels (50.7 % vs. 65.4 %), increased solitary drinking (9.1 % vs. 14.6 %), increased time spent at home (62.8 % vs. 73.9 %), and prolonged online leisure time engagement (54.9 % vs. 69.6 %). Alterations in food-purchasing behaviors were also more prominent in the weight-gain group. Among participants who were overweight or obese before the pandemic, significant increases in online grocery shopping (55.7 % vs. 62 %), meal delivery (47.9 % vs. 63 %), takeout orders (44.7 % vs. 56.1 %), and the consumption of ready-to-eat meals (38.2 % vs. 50.2 %) were noted in the weight-gain group compared with the

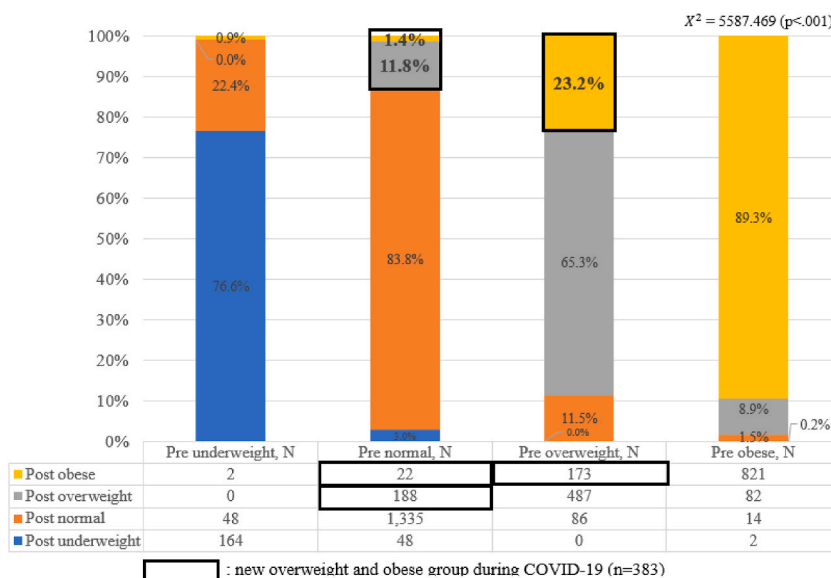


Fig. 1. Chi-square analysis of pre- and post-pandemic BMI categories.

Table 2
 Characteristics of individuals with newly developed overweight or obesity status during the COVID-19 pandemic.

Participant characteristics	Other participants (N = 3,079)	Participants with newly developed overweight or obesity status (N = 383)	P value
	N (%)	N (%)	
Age groups			
20–29 years	616 (20.0)	100 (26.1)	0.001
30–39 years	643 (20.9)	95 (24.8)	
40–49 years	704 (22.9)	89 (23.2)	
50–59 years	721 (23.4)	66 (17.2)	
60–69 years	395 (12.8)	33 (8.6)	
Sex (F)	1564 (50.8)	207 (54.0)	0.230
Marital status			
Married	1688 (54.8)	200 (52.2)	0.335
Single/Widowed/Divorced/Separated	1391 (45.2)	183 (47.8)	
Educational level			
High school or below	747 (24.3)	101 (26.4)	0.365
College or above	2332 (75.7)	282 (73.6)	
Employment status			
Full-time	1972 (64.0)	240 (62.7)	0.848
Part-time	288 (9.4)	36 (9.4)	
Not employed	819 (26.6)	107 (27.9)	
Household income			
Low	417 (15.3)	50 (13.1)	0.090
Middle-low	493 (16.0)	60 (15.7)	
Middle	645 (20.9)	101 (26.4)	
Middle-high	717 (23.3)	93 (24.3)	
High	753 (24.5)	79 (20.6)	
Income changes during COVID-19			
Upward or no change	1840 (59.8)	208 (54.3)	0.041
Downward change	1239 (40.2)	175 (45.7)	
Behavioral changes compared with pre-COVID-19 era:			
Increased stress ^a	1823 (59.2)	269 (70.2)	<0.001
Changes in lifestyle behavior			
Increased solitary drinking	325 (10.6)	64 (16.7)	<0.001
Increased high-risk alcohol consumption	674 (21.9)	73 (19.1)	0.204
Increased time spent at home	2159 (70.1)	300 (78.3)	0.001
Increased online time for leisure	1945 (63.2)	287 (74.9)	<0.001
Changes in food-purchasing style (agree) ^a			
Hesitation to visit local grocery stores	1621(52.6)	169(44.1)	0.002
Increased online grocery shopping	1736(56.4)	257(67.1)	<0.001
Increased meal delivery	1693(55.0)	259(67.6)	<0.001
Increased takeout orders	1593(51.7)	242(63.2)	<0.001
Increased consumption of ready-to-eat meals	1342(43.6)	207(54.0)	<0.001

^a Number of participants who scored 4 or 5 on a 5-point Likert scale ranging from 1 to 5.

Table 3
 Weight-gain values according to pre-pandemic BMI category.

Pre-pandemic BMI categories	Weight changes		Total, N (%)	χ ² (p)
	Weight maintenance or loss, N (%)	Weight gain, N (%)		
Underweight	127 (59.9)	85 (40.1)	212 (100.0)	14.184 (0.003)
Normal weight	839 (52.9)	746 (47.1)	1585 (100.0)	
Overweight	401 (53.8)	345 (46.2)	746 (100.0)	
Obese	551 (60.0)	368 (40.0)	919 (100.0)	
Total	1918 (55.4)	1544 (44.6)	3462 (100.0)	

“weight maintenance or loss” group.

3.3. Factors influencing the two defined groups: (i) newly developed overweight or obesity status and (ii) exacerbated overweight or obesity status during the pandemic

Using the significant variables identified in Table 2, logistic regression analysis was conducted on participants who were newly classified as overweight or obese during the pandemic (Table 5). The results indicated that relatively young participants were more prone to becoming overweight or obese during the COVID-19 pandemic.

Table 4
 Characteristics of weight gain during the COVID-19 pandemic in individuals with pre-pandemic overweight or obesity.

Participant characteristics	Weight maintenance or loss (N = 951)	Weight gain (N = 713)	P value
	N (%)	N (%)	
Age groups			
20–29 years	160 (16.8)	127 (17.8)	0.050
30–39 years	180 (18.9)	158 (22.2)	
40–49 years	215 (22.6)	178 (25.0)	
50–59 years	259 (27.2)	176 (24.7)	
60–69 years	137 (14.4)	74 (10.4)	
Sex (F)	293 (30.8)	264 (37.0)	
Marital status			
Married	536 (56.5)	416 (58.3)	0.418
Single/Widowed/Divorced/Separated	415 (43.6)	297 (41.7)	
Educational level			
High school or below	148 (15.6)	99 (13.9)	0.341
College or above	803 (84.4)	614 (86.1)	
Employment status			
Full-time	657 (69.1)	475 (66.6)	0.105
Part-time	106 (11.1)	68 (9.5)	
Not employed	188 (19.8)	170 (23.8)	
Household income			
Low	146 (15.4)	78 (10.9)	0.039
Middle-low	159 (16.7)	130 (18.2)	
Middle	217 (22.8)	152 (21.3)	
Middle-high	222 (23.3)	167 (23.4)	
High	207 (21.8)	168 (26.1)	
Income changes during COVID-19			
Upward or no change	581 (61.1)	419 (58.8)	0.337
Downward change	370 (38.9)	294 (41.2)	
Behavioral changes compared with pre-COVID-19 era:			
Increased stress ^a	482 (50.7)	466 (65.4)	<0.001
Changes in lifestyle behavior			
Increased solitary drinking	87 (9.1)	104 (14.6)	0.001
Increased high-risk alcohol consumption	199 (20.9)	152 (21.3)	0.846
Increased time spent at home	597 (62.8)	527 (73.9)	<0.001
Increased online time for leisure	522 (54.9)	496 (69.6)	<0.001
Changes in food-purchasing style (agree) ^a			
Hesitation to visit local grocery stores	562 (59.1)	366 (51.3)	0.002
Increased online grocery shopping	482 (50.7)	442 (62.0)	<0.001
Increased meal delivery	456 (47.9)	449 (63.0)	<0.001
Increased takeout orders	425 (44.7)	400 (56.1)	<0.001
Increased consumption of ready-to-eat meals	363 (38.2)	358 (50.2)	<0.001

^a Number of participants who scored 4 or 5 on a 5-point Likert scale ranging from 1 to 5.

Table 5
 Logistic regression analyses of individuals with newly classified overweight or obesity status.

	OR (95 % CI)	p-value
Age (years)	0.983 (0.974–0.992)	0.000
Reduced income	1.146 (0.921–1.426)	0.222
Stress	1.282 (0.998–1.647)	0.052
Solitary drinking	1.339 (0.991–1.808)	0.057
Time spent at home	1.144 (0.870–1.504)	0.336
Online time for leisure	1.236 (0.947–1.614)	0.119
Hesitation to visit local grocery stores	0.897 (0.706–1.139)	0.372
Online grocery shopping	1.119 (0.856–1.146)	0.409
Meal delivery	1.174 (0.900–1.531)	0.238
Takeout ordering	1.132 (0.876–1.463)	0.343
Consumption of ready-to-eat meals	1.109 (0.861–1.428)	0.423

Values are presented as odds ratios (95 % confidence intervals).

Using the significant variables from Table 4, logistic regression analysis was conducted on the group that was overweight or obese before the pandemic but experienced weight gain during the COVID-19 pandemic (Table 6). The findings revealed that younger age (OR = 0.989, 95 % CI = 0.981–0.998), higher household income (OR = 1.097, 95 % CI = 1.016–1.184), increased stress (OR = 1.133, 95 % CI = 1.133–1.771), more frequent solitary drinking (OR = 1.407, 95 % CI = 1.024–1.932), increased online leisure time (OR = 1.336, 95 % CI = 1.063–1.678), and increased use of meal delivery services (OR = 1.307, 95 % CI = 1.026–1.664) were associated with

Table 6

Logistic regression analyses of the variables associated with further weight gain in individuals with pre-existing overweight or obesity.

	OR (95 % CI)	p-value
Sex	1.235 (0.992–1.536)	0.058
Age (years)	0.989 (0.981–0.998)	0.012
Household income	1.097 (1.016–1.184)	0.018
Stress	1.412 (1.129–1.765)	0.002
Solitary drinking	1.406 (1.024–1.931)	0.035
Time spent at home	1.230 (0.976–1.550)	0.079
Online time for leisure	1.340 (1.066–1.683)	0.012
Hesitation to visit local grocery stores	1.014 (0.810–1.269)	0.906
Online grocery shopping	1.052 (0.823–1.345)	0.686
Meal delivery	1.301 (1.021–1.657)	0.033
Takeout ordering	1.052 (0.832–1.331)	0.671
Consumption of ready-to-eat meals	1.126 (0.885–1.433)	0.335

Values are presented as odds ratios (95 % confidence intervals).

a greater likelihood of weight gain.

4. Discussion

This study focused on individuals who contributed to the increased prevalence of obesity during the COVID-19 pandemic and highlighted the changes influenced by their experiences with COVID-19 social distancing measures. According to our research findings, 11 % of individuals transitioned into the overweight or obese categories owing to their encounter with COVID-19. Among those who were overweight or obese before the pandemic, 42.8 % experienced weight gain, thus contributing to the overall obesity prevalence. This trend was particularly pronounced among the younger participants. This finding is consistent with that of previous studies that demonstrated a decrease in body weight in older populations during the pandemic, while younger populations exhibited weight gain [4,14,20,45]. One possible explanation for the weight gain observed in younger individuals is the adoption of a more sedentary lifestyle such as screen time-based sedentary behavior during the COVID-19 pandemic [46], considering their typically higher levels of physical activity before the outbreak. The rise in TV and smartphone usage has been associated with unhealthy dietary patterns including an increased desire to drink and the consumption of sugary foods [47,48]. This lifestyle shift might have led to a positive energy balance surplus. An investigation of the eating patterns of South Korean university students following the COVID-19 outbreak revealed that they ordered food deliveries more than three times a week [49]. The most frequently ordered items included fried chicken (68.5 %), followed by pizza (38.9 %), fast food (34.8 %), and Chinese food (34.1 %), in descending order [49]. The availability and convenience of online on-demand food delivery services might have contributed to this shift towards more sedentary behaviors. In Seoul, a noteworthy surge in the utilization of delivery mobile applications has become evident, mirroring a trajectory comparable to that of the COVID-19 pandemic. An analysis by the Korea Rural Economic Institute (KREI) Research Service for Food Consumption of the impact of COVID-19 on delivery application usage found a similar trend between the daily number of COVID-19 cases and total delivery app usage time [50]. Furthermore, when comparing the delivery app usage time between 2019 and 2020, there was an increment of approximately 57 %. By October 2021, this trend had intensified, with a substantial 116 % increase in delivery app usage time compared with that in January 2020, underscoring the growing reliance on delivery apps [50]. While not all delivery foods are unhealthy and high in calories, during the COVID-19 period, most delivered food options were unhealthy and calorically dense, and they potentially exerted a negative impact on body weight [22,24,27]. A recently published scoping review on on-demand food and alcohol delivery revealed that on-demand services negatively impact health and potentially exacerbate inequalities [24]. Our findings revealed a significant influence of food delivery on the food-purchasing behavior of participants who were overweight or obese. This serves as a foundation for developing government measures that fortify preventive health management strategies and address post-COVID-19 obesity. Addressing the complex issue of obesity requires a comprehensive approach that not only considers immediate accessibility but also acknowledges the broader food environment, as suggested by previous research [51].

Studies investigating factors associated with weight gain during the COVID-19 pandemic have identified reduced physical activity as a contributing factor [22,52]. Although this study did not directly measure alterations in physical activity, it focused on the reduction in physical activity resulting from social distancing measures during daily routines. Compared with that in the pre-COVID-19 era, an increase in homebound hours; greater reliance on online resources for leisure activities; and a rise in sedentary behaviors, such as online grocery shopping, convenience-food purchases, and food delivery, were observed during the pandemic. These changes are probable responses to restricted mobility and the need to identify alternative sources of entertainment and engagement.

The COVID-19 pandemic led to a significant surge in daily online activity, offering convenience and comfort for maintaining a stable lifestyle during this unprecedented period. However, our research findings highlight a concerning trend among individuals with overweight or obesity status who gained weight during the pandemic: leisure activities were replaced by online activities, and the increased use of food-related online platforms potentially led to weight gain. Previous studies indicate that most individuals had significantly reduced physical activity and a notable increase in screen time throughout the COVID-19 period [53,54]. Although home-based exercise has increased, weight management remains a challenge for a considerable number of individuals [28]. Furthermore, a survey indicated that as the COVID-19 pandemic transitions to endemic status, and expectations for normalcy increase,

online lifestyle patterns, including over-the-top video services and Internet usage, are likely to exhibit limited changes [55]. These findings provide valuable insights into the impact of the pandemic on individuals at risk of obesity and potentially inform interventions aimed at addressing the negative effects of the pandemic on health behaviors. In the post-COVID-19 era, concentrating on the environmental changes prompted by the pandemic and exploring how these alterations might have contributed to obesity and may evolve in the future are crucial.

These findings highlight the significant impact of COVID-19 social distancing policies on lifestyle changes, including increased time spent at home, increased engagement in online leisure activities, and the adoption of online grocery ordering and food delivery services, all of which contributed to a notable increase in body weight. However, acknowledging the limitations of this study is important. This study relied on self-reported pre- and post-pandemic weight data, which may not be as accurate as directly measured data. Nevertheless, self-reported weight-change data collection via electronic questionnaires can be used as a secondary measure [56] and is a viable method for collecting data during the COVID-19 period of social distancing. This study was conducted online, limiting the participation of the elderly population. While this study indirectly used variables representing decreased daily activity due to COVID-19 restrictions by substituting previously operational daily activities with online alternatives, it did not directly measure alterations in physical activity. Notably, although certain studies suggest that COVID-19 may have a differential impact on weight gain between men and women, further research is required to fully elucidate the influence of the pandemic on weight gain and potential sex differences. Additional studies are also needed to examine how the lifestyle changes induced by COVID-19 among young individuals have evolved now that COVID-19 has been mitigated. Despite these limitations, this study is significant in that it identified the factors contributing to obesity among those who experienced weight gain during the pandemic, with a particular focus on potential high-risk groups.

5. Conclusions

This study focused on two distinct groups that played a pivotal role in the escalating rates of obesity-related conditions during the persistent COVID-19 era: (i) individuals newly classified as overweight or obese owing to the pandemic's influence and (ii) those with pre-existing overweight or obesity status who experienced further weight gain, thus intensifying the burden of obesity-related diseases. Notably, both groups were comparatively younger and exhibited a demographic characteristic that was particularly susceptible to the transformative impacts of the COVID-19 landscape. The behaviors reported by these groups included heightened stress levels, solitary alcohol consumption, extended periods spent at home, and increased engagement in online leisure pursuits. These altered behaviors diverged from those that did not fall within the aforementioned categories. Importantly, these groups displayed a stronger inclination toward purchasing groceries online than at local stores, and they also reported an increase in the consumption of delivered food, packaged meals, and convenience foods. Specifically, individuals in the overweight and obese categories who experienced weight gain exhibited a significant increase in both the time spent on online leisure activities and the use of food delivery services. These insights underscore a scenario wherein health-related behaviors have undergone noticeable changes in response to the persistent influence of the COVID-19 pandemic. Consequently, our findings highlight the urgency of developing obesity prevention and intervention strategies within the domain of public health that should be carefully calibrated to address these evolving trends. As this investigation delves into the complexities of the groups contributing to rising obesity rates during the prolonged COVID-19 pandemic, it emphasizes the necessity for further research that uses contemporary data to effectively inform nuanced policy formulations and regulatory guidelines.

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Ethics statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee at the Seoul National University (2009/002-015, 2020-09-11).

Data availability statement

Data will be made available on request.

CRedit authorship contribution statement

Jihyun Lee: Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization.
Sunghyun Yoo: Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e34733>.

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