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Trabajo Original

Otros

Effect of lockdown for COVID-19 on self-reported body weight gain in a sample of obese patients

Efecto del confinamiento por COVID-19 sobre la ganancia de peso corporal autorreportada en una muestra de pacientes obesos

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Abstract

Objective: the COVID-19 pandemic, by restricting population mobility, may exacerbate the risk factors for weight gain associated with physical inactivity and increased consumption of calorie-dense foods. The aim of this cross-sectional study was to evaluate the risk factors related to self-reported body weight gain among obese subjects.

Methods: the study involved a population of 284 adult obese subjects. After a 7-week confinement period starting on March 17, a telephone interview (May 4 through 7) was conducted. In this phone call, self-reported body weight gain and a number of factors were recorded. In order to obtain the baseline data of this population, biochemical and anthropometric parameters were collected from electronic medical records.

Results: mean age was 60.4 ± 10.8 years (range: 23-71) and mean body mass index (BMI) was 35.4 ± 4.7 kg/m2 (range: 30.6-41.2). Gender distribution was 211 females (74.3 %) and 73 males (25.7 %). Self-reported body weight gain was 1.62 ± 0.2 kg. Among patients who reported doing a lot of exercise self-reported body weight gain was lower (1.62 ± 0.2 vs 1.12 ± 0.3 kg; p = 0.02). Regarding eating habits, patients recognized snacking in 17 % of the sample. Patients who reported snacking had higher self-reported body weight gains (2.60 ± 0.36 vs 1.30 ± 0.17 kg; p = 0.001). The remaining variables did not influence self-reported body weight gain. In the multiple regression analysis with self-reported body weight gain as dependent variable, adjusted for age, sex, and physical activity, the snaking habit remained a risk factor: beta = 1.21 (95 % CI: 1.11-2.13; p = 0.01).

Conclusions: the lockdown decreed during SARS-CoV-2 pandemic has produced an increase in self-reported body weight among obese subjects, which was related to the habit of taking snacks.

Keywords:

COVID-19. Lockdown. Obesity. Snacking.

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Ethical approval: all procedures performed involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (HVUVA committee PIP-201766), and with the 1964 Helsinki Declaration and later amendments or comparable ethical standards.

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Resumen

Objetivo: la pandemia de COVID-19, al restringir la movilidad de la población, podría exacerbar los factores de riesgo del aumento de peso asociados a la inactividad física y un mayor consumo de alimentos ricos en calorías. El objetivo de este estudio transversal fue evaluar los factores de riesgo relacionados con el aumento de peso corporal autoinformado entre sujetos obesos.

Métodos: el estudio incluyó una muestra de 284 sujetos obesos adultos. Después de un período de reclusión de 7 semanas a partir del 17 de marzo, se realizó una entrevista telefónica (del 4 al 7 de mayo). En esta llamada telefónica se registraron el aumento de peso corporal autoinformado y diferentes factores asociados. Para obtener los datos basales de esta población, se registraron parámetros bioquímicos y antropométricos a partir de la historia clínica electrónica.

Resultados: la edad media fue de 60,4 ± 10,8 años (rango: 23-71) y el índice de masa corporal (IMC) medio de 35,4 ± 4,7 kg /m2 (rango: 30,6-41,2). La distribución por géneros fue de 211 mujeres (74,3 %) y 73 hombres (25,7 %). El aumento de peso corporal autoinformado fue de 1,62 ± 0,2 kg. Los pacientes que reconocieron que hacían mucho ejercicio informaron de que la ganancia de peso corporal había sido menor (1,62 ± 0,2 vs 1,12 ± 0,3 kg; p = 0,02). En cuanto a los hábitos alimentarios, los pacientes reconocieron practicar el picoteo en el 17 % de la muestra. Los pacientes que reconocieron picar entre horas presentaron una mayor ganancia de peso corporal autoinformada (2,60 ± 0,36 vs 1,30 ± 0,17 kg; p = 0,001). Las demás variables no influyeron en el aumento de peso corporal autoinformado. En el análisis de regresión múltiple, con la ganancia de peso corporal autoinformada como variable dependiente y ajuste de edad, sexo y actividad física, el hábito del picoteo permaneció como factor de riesgo: beta = 1,21 (IC 95 %: 1,11-2,13; p = 0,01).

Conclusiones: el encierro decretado durante la pandemia por el SARS-CoV-2 ha producido un aumento del peso corporal autoinformado en los sujetos obesos y este se ha relacionado con el hábito de picar entre horas.

Palabras clave:

COVID-19. Confinamiento. Obesidad. Picoteo.

INTRODUCTION

Coronavirus disease-2019 (COVID-19) is the infectious disease caused by the coronavirus SARS-CoV-2. The first case of COVID-19 was reported to the World health Organization (WHO) by Chinese authorities on December 31th, 2019. COVID-19 produces a respiratory infection characterized by mild to severe symptoms. According to the National Center for Immunization and Respiratory Diseases, the high-risk categories for severe illness from COVID-19 include people aged 65 years or older, immunocompromised individuals, and people with chronic diseases such as serious heart conditions, diabetes mellitus, chronic lung diseases, chronic liver or kidney diseases, and obesity (1).

Of this pandemic, one of the multiple implications is the abrupt cessation of outside activities for the population in Spain, who by mandate had to remain in their homes during a "lockdown" aimed at containing and mitigating COVID-19 spread. There are reasons to worry about housebound patients who have obesity: some previous studies have shown that younger people had worse weight control while at home when compared to when allowed their usual activities (3). These observations (1,3) and the well-known relationship between sedentary habits and obesity (4) advance the argument that the COVID-19 pandemic, by restricting population mobility, will exacerbate the risk factors for weight gain associated with physical inactivity. This decrease in activity plus an increased consumption of calorie-dense foods (snacking) and ultra-processed food, a second risk factor strongly supported by observations in real-world settings (5), allow to hypothesize a weight gain during these weeks of confinement that will likely have metabolic repercussions in the near future, and then an increased risk of cardiovascular events.

The aim of this cross-sectional study was to test the hypothesis that risk factors related to body weight gain among obese subjects are exacerbated during a pandemic-associated lockdown, and a significant increase in body weight may be detected.

MATERIALS AND METHODS

SUBJECTS AND CLINICAL INVESTIGATION

The population studied was selected from obese patients seen during the past year in our Department, including those referred by other physicians in our Health Area. Obesity is defined by a body mass index (BMI) ≥ 30 kg/m^2. We retrieved the relevant anthropometric and biochemical information from the electronic medical records during the last visit to our clinic, and a telephone survey was conducted during the week of May 4-8, 2020. A total of 284 obese Caucasian subjects were enrolled using a non-probabilistic, consecutive sampling approach. The obese subjects recruited fulfilled the following inclusion criteria: BMI ≥ 30 kg/m^2; no a history of cardiovascular disease, thyroid disease, renal or hepatic disorders; no history of alcoholism or malignancies. Exclusion criteria included age under 18 years or above 65 years, BMI over 45 kg/m^2; and COVID-19 disease during the study.

The Ethics Committee (HCUVA Committee) approved the study, which was in accordance with the guidelines laid down in the Declaration of Helsinki (PIP-201766). All participants provided a written informed consent. For all subjects, we recovered from the electronic medical records the following data as of the last face-to-face visit: systolic and diastolic blood pressure, and anthropometric parameters (weight, height, body mass index (BMI), and waist circumference). The following biochemical data were recovered from the medical records: glucose, insulin, total cholesterol, LDL-cholesterol, HDL-cholesterol, and triglyceride levels.

After a 7-week confinement period from March 17, a telephone interview (May 4 to 7) was conducted with the following questions: 1) Have you performed regular physical exercise? (yes/no); 2) How many minutes per week of exercise? (numerical); 3) What is your current weight? (numerical); 4) According to your perception, have you gained weight? (yes/no); 5) If the answer was "yes", how much weight have you gained? (numerical); 6) Did you take snacks between meals during the lockdown? (numerical); 7) How many meals do you eat per day since confinement? (numerical); 8) How many main meals did you eat before confinement? (numerical); 9) What is the surface area (m^2) of your home? (numerical); 10) How many members make up your family? (numerical); 11) Do you have a pet? (yes/no); 12) If you were allowed to go outside with your pet, how many minutes per week? (numerical); 13) How many hours a day did you watch TV before confinement? (numerical); 14) How many hours a day do you watch TV now? (numerical). This telephone interview lasted about 15 minutes.

ANTHROPOMETRIC AND BIOCHEMICAL PARAMETERS FROM ELECTRONIC MEDICAL RECORDS

In order to obtain the baseline data of this population, the following parameters were collected from electronic medical records: body weight was measured using scales (Omrom, LA, CA, USA) and recorded to the nearest 50 g; height was measured with a tape measure (Omrom, LA, CA, USA); body mass index (BMI) was calculated as body weight (in kg) divided by height (in m^2). Waist circumference (WC) was measured at the umbilical level. The following biochemical parameters were obtained from the medical records: serum total cholesterol and triglyceride levels were determined by enzymatic colorimetric assay (Technicon Instruments, Ltd., New York, N.Y., USA), while HDL-cholesterol was measured in the supernatant after precipitation of other lipoproteins by enzymatic methods; LDL-cholesterol was calculated using Friedewald's formula (LDL-cholesterol = total cholesterol - HDL cholesterol – triglycerides / 5) (6); glucose levels were measured by an automated glucose oxidase method (Glucose analyser 2, Beckman Instruments, Fullerton, CA, USA); insulin was determined by radioimmunoassay (RIA) (RIA Diagnostic Corporation, Los Angeles, CA, USA) with a sensitivity of 0.5 mIU/L (normal range, 0.5-30 mIU/L) (7), and the homeostasis model assessment for insulin resistance (HOMA-IR) was calculated using these values (8).

STATISTICAL ANALYSIS

Data were analyzed using the SPSS for Windows, version 19.0, software package (SPSS Inc. Chicago, IL, USA). Sample size was calculated to detect an increase in self-reported body weight gain during confinement of 1.5 kg with 90 % power and 5 % significance. The results were expressed as average ± standard deviation. The Chi-squared test was used for the analysis of categorical parameters. Numerical variables were analyzed with Student's t-test, the ANOVA test, or the Kruskal-Wallis test. Pearson's test and Spearman's test were used to correlate numerical variables. Multiple regression analyses adjusted by age and gender were used to calculated the "beta" and 95 % confidence intervals (CI) to estimate the association of self-reported body weight gain with different variables of the phone questionnaire. A p-value under 0.05 was considered statistically significant.

RESULTS

The sample was comprised of 284 Caucasian obese subjects. Mean age was 60.4 ± 10.8 years (range: 23-71), and mean body mass index (BMI) was 35.4 ± 4.7 kg/m^2 (range: 30.6-41.2). Gender distribution was 211 females (74.3 %) and 73 males (25.7 %).

Table I shows the biochemical and epidemiological data of the study population in the last face-to-face visit at the Hospital. Patients were predominantly female, with a BMI within the grade-II obesity range. The following parameters show statistical differences between genders (male vs female: delta: 13.4 ± 2.1 kg; p = 0.01): height (male vs female: delta: 0.11 ± 0.08 kg; p = 0.01), and HDL-cholesterol levels (male vs female: delta: 5.9 ± 1.1 kg; p = 0.04).

Table II shows the results of the answers to the telephone questionnaire. There were no statistically significant differences between the variables analyzed according to the gender of the participants. The sample analyzed showed a low physical activity rate (11.8 %). The patients who reported doing a lot of exercise had an average of physical activity, in minutes, higher than those who reported doing not enough exercise (no regular exercise vs regular exercise: 134.42 ± 22.1 vs 208.63 ± 17.9 min/week; p = 0.01). The increase in self-reported body weight was 1.58 ± 2.7 kg during the 7 weeks of confinement, and self-reported body weight gain was lower among the latter (no regular exercise vs regular exercise: 1.62 ± 0.2 vs 1.12 ± 0.3 kg; p = 0.02).

Regarding eating habits, the patients recognized snacking in 17 % of the sample. Those who reported snacking presented a higher self-reported body weight gain (no snacking vs snacking: 2.60 ± 0.36 vs 1.30 ± 0.17 kg; p = 0.001). The number of meals per day that the subjects took prior to confinement was similar to the number had during confinement. There is no difference between genders.

The correlation analysis between the self-reported gained body weight of the patients and the variables "house area in m^2" (r = 0.12; p = 0.44) and "number of family members at home" (r = 0.19; p = 0.41) was not significant. The presence of pets in the home was not related to self-reported body weight gain (no pet vs pet: 1.62 ± 0.17 vs 1.12 ± 0.31 kg; p = 0.21). The minutes invested in activity outside the home with the pet did not correlate with self-reported body weight gain either (r = 0.10; p = 0.53).

Regarding self-reported TV hours per day, there was a significant increase in hours during confinement (TV hrs before vs TV hrs now: 4.3 ± 1.9 vs 5.4 ± 1.2 hrs; p = 0.01). There was no correlation between number of hours watching TV and self-reported weight gain (r = 0.23; p = 0.22).

In the multiple regression analysis with self-reported body weight gain as dependent variable and adjustment for age, sex, and physical activity, the snacking habit remained a risk factor with a beta coefficient of 1.21 (95 % CI: 1.11-2.13; p = 0.01).

Table I. Epidemiological and biochemical variables

Parameters	Total Group n = 284	Females n = 211	Males n = 73	p-value
Age (years)	60.3 ± 10.8	61.1 ± 10.7	57.9 ± 10.8	p = 0.34
BMI	35.4 ± 4.7	35.6 ± 5.1	35.1 ± 4.9	p = 0.41
Weight (kg)	94.0 ± 1.3	90.9 ± 1.7	104.3 ± 2.1	p = 0.01
Height (m)	94.0 ± 1.3	1.58 ± 0.08	1.69 ± 0.10	p = 0.01
WC (cm)	108.3 ± 8.0	107.1 ± 7.1	112.1 ± 6.2	p = 0.02
SBP (mmHg)	125.1 ± 8.1	124.7 ± 7.0	125.6 ± 6.8	p = 0.45
DBP (mmHg)	81.0 ± 4.8	82.5 ± 3.9	80.6 ± 4.2	p = 0.38
Fasting glucose (mg/dl)	98.4 ± 15.9	96.5 ± 11.1	100.7 ± 7.1	p = 0.18
Total cholesterol (mg/dl)	190.3 ± 26.8	197.6 ± 19.7	171.6 ± 28.6	p = 0.13
LDL-cholesterol (mg/dl)	110.0 ± 17.9	114.1 ± 17.1	103.8 ± 12.3	p = 0.12
HDL-cholesterol (mg/dl)	51.6 ± 13.1	53.9 ± 8.2	47.9 ± 9.4	p = 0.04
Triglycerides (mg/dl)	112.5 ± 44.1	111.6 ± 41.7	114.1 ± 36.1	p = 0.23
Insulin (mIU/l)	13.5 ± 5.0	13.2 ± 6.9	14.3 ± 4.1	p = 0.17
HOMA-IR	3.3 ± 2.5	3.0 ± 1.1*	3.9 ± 1.2	p = 0.16

*BMI: body mass index; DBP: diastolic blood pressure; SBP: systolic blood pressure; WC: waist circumference; LDL-cholesterol: low-density lipoprotein cholesterol; HDL-cholesterol: high-density lipoprotein cholesterol; HOMA-IR: homeostasis model assessment. *p < 0.05, between genders.*

Table II. Epidemiological questionnaire

Questions	Total Group n = 284	Females n = 211	Males n = 73	p-value
Have you performed regular physical exercise? (yes/no)	11.4 %/89.6 %	11.3 %/89.7 %	11.4 %/89.6 %	p = 0.34
How many minutes per week of physical exercise? (min)	154.1 ± 16.6	163.9 ± 15.1	131.3 ± 24.8	p = 0.28
What is your current weight? (kg)	95.6 ± 1.7	92.2 ± 1.6	105.9 ± 2.1*	p = 0.01
According to your perception, have you gained weight? (yes/no)	36.3 %/63.7 %	34.6 %/65.4 %	41.1 %/58.9 %	p = 0.21
How much weight have you gained? (kg)	1.58 ± 2.7	1.58 ± 2.9	1.56 ± 2.1	p = 0.34
Did you take snacks between meals during lockdown? (yes/no)	17 %/83 %	18.5 %/81.5 %	24.7 %/75.3 %	p = 0.15
How many meals do you eat per day since confinement?	4.4 ± 0.8	4.3 ± 0.6	4.4 ± 0.5	p = 0.41
How many main meals did you eat before confinement?	4.5 ± 0.9	4.5 ± 0.8	4.6 ± 0.6	p = 0.40
How many m^2 does your home have?	89.6 ± 35.9	86.9 ± 24.1	97.4 ± 30.3	p = 0.33
How many members make up your family?	1.12 ± 0.45	1.11 ± 0.47	1.15 ± 0.43	p = 0.59
Do you have a pet? (yes/no)	10.4 %/89.6 %	10.2 %/89.8 %	11.1 %/88.9 %	p = 0.55
If you have been able to go outside with your pet, how many minutes per week?	222.5 ± 44.1	222.3 ± 39.7	240.1 ± 48.9	p = 0.12
How many hours a day did you watch TV before confinement?	4.3 ± 1.9	4.3 ± 1.8	4.3 ± 1.0	p = 0.61
How many hours a day do you watch TV now?	5.4 ± 2.2	5.3 ± 1.9	5.4 ± 1.3	p = 0.59

DISCUSSION

The main finding of this cross-sectional study was the fact that the lockdown mandated by the Spanish Health Authorities for a period of 7 weeks produced a significant increase in self-reported body weight gain in this sample of obese patients, and that this increase was associated with the snacking habit.

The World Health Organization considers non-communicable diseases, such as obesity, a major risk factor for becoming seriously ill with the novel coronavirus (9). Recently, a study in intensive care units indicates that two thirds of the people who developed serious COVID-19-related complications were obese (10), and his study shows that almost 75 % of those in critical care units are either obese or overweight. Reports from Italy indicate that almost 90 % of deaths occurred in patients with non-communicable diseases such as obesity, diabetes mellitus type 2, hypertension, heart disease, and cancer (11). Lighter et al. (12) have demonstrated that obesity in patients younger than 60 years is a risk factor for COVID-19-related hospital admission. Taking into account everything previously commented, obesity seems to be a risk factor for an adverse outcome of COVID-19, and this propensity of subjects with obesity to develop more complications that are serious could be due to some factors such as delayed, ineffective immune response and chronic inflammatory status. As endocrinologists, we therefore have to be able to identify the risk factors that may increase obesity during the lockdown mandated by health authorities in different countries worldwide. Countries have taken various actions to flatten the curve, and to allow health care systems to cope with their demands, but these actions may produce a deleterious effect on non-communicable diseases such as obesity, which is a risk factor for having a worse course of infection.

In our study, the self-reported body weight gain has been related to variables such as minutes of exercise and snacking. Moreover, only snacking remained in the multivariate model as an independent factor. The effect of lockdown for COVID-19 on lifestyle among obese children has been demonstrated in some studies (13). In this small study of 41 Italian children with obesity (13), an increase in sleep time, a decrease in sports activities, and an increase in eating food such as fried potatoes, sugary drinks, and red meat were reported. However, the effect of lockdown and these changes in lifestyle habits on weight was not evaluated in this work. This study is interesting because it showed that lifestyle habits changed in an unfavorable direction only after 3 weeks into confinement during the Italian lockdown. Our work was carried out after 7 weeks of confinement and with a greater number of patients, in this case obese adults. The self-reported weight gain was significant, and was independently related to the snacking habit. Snacking is defined in the literature as consuming food between regular meals. And there is consensus that nutrient-poor and energy-dense snacks should be regarded as unhealthful (14), linked to increased risk of cardiovascular disease and obesity (15,16). In our study we see how snacking increases the risk of self-reported body weight gain. In the literature, many factors that influence this habit have been described, such as personal factors, both psychological (e.g., self-efficacy, emotions, knowledge) and biological (e.g., sex, age, genes). Perhaps during lockdown, psychological factors have been very important, as it has been demonstrated that individuals under psychological stress consume higher amounts of energy and dense snacks, particularly fatty and sweet snacks (17). Furthermore, the interviewed subjects reported increased TV hours during confinement, although it was not directly related to the self-reported weight gain reported in our study. Perhaps the high number of hours watching TV that subjects already reported before confinement have not allowed us to detect this influence. Moreover, in the literature, it has been demonstrated that, when distracted (e.g., by watching movies or TV), individuals often overconsume and are not necessarily cognizant of the dietary quality of the snacks eaten (18). Nowadays, COVID-19 has spread to several countries around the world and is presently a major global concern. On the other hand, the confinement of the population as a prevention measure for the spread of infection means that the mobility of obese patients is limited, and that they have a greater number of hours a day with access to snacks in their homes. We can hypothesize that, if the mobility limitation is prolonged as a preventive measure, body weight will continue to increase, as well as the alterations secondary to cardiovascular risk factors.

As regards the limitations of our study, firstly it was a cross-sectional study, so we cannot draw any causal conclusions. Secondly, the body weight of patients was self-reported, with under-estimation biases. However, there is generally a strong agreement between self-reported body weight and clinical weight (19). Thirdly, we cannot evaluate the effect on metabolic variables as we cannot perform a second blood extraction due to confinement. Fourthly, exercise, snacking, and TV hours were also self-reported, with their corresponding biases. Finally, we only evaluated Caucasian subjects, and ethnicity, differences in genetic background, and living environment would play a crucial role in our results. All of these limitations are understandable given the exigencies operating during this pandemic. In addition, the strength of this work is that, in an era of uncertainty such as the one we are living in, having data on a large sample of obese patients may allow us to design prevention strategies. Our study offers a local perspective, and is therefore helpful, although it has limitations. It is important to compare data in different healthcare systems, and to focus attention on this risk factor during all the phases of this pandemic. Lack of information regarding the increased risk of illness subjects with morbid obesity (BMI > 40 kg/m^2) have might increase anxiety, given that these subjects have now been categorized as vulnerable to severe illness if they contact COVID-19, and might also give a false feeling of safety to obese people under this BMI cutoff (20).

In conclusion, the confinement decreed during the pandemic by SARS-CoV-2 has produced an increase in self-reported body weight in obese subjects, an increase that is related to the habit of taking snacks. These observations point to an important need for implementing preventive tools during periods of lockdown, particularly when their duration is uncertain. Such measures could be telemedicine lifestyle programs, and endocrinologists may offer online guidance encouraging healthy family habits as well as recommending healthy foods and exercise programs (21).

REFERENCES

1. Muscogiuri G, Pugliese G, Barrea L. Obesity: the "Achilles heel" for COVID-19? Metabolism 2020;108:154251. DOI: 10.1016/j.metabol.2020.154251
2. BOE. [Accessed 5 may 2020]. Available at: https://www.boe.es/buscar/doc.php?id=BOE-A-2020-4208
3. Ryan PM, Caplice NM. Is Adipose Tissue a Reservoir for Viral Spread, Immune Activation and Cytokine Amplification in COVID-19. Obesity (Silver Spring) 2020;28(7):1191-4. DOI: 10.1002/oby.22843
4. Zouhal H, Ben Abderrahman A, Khodamoradi A, Saeidi A, Jayavel A, Hackney AC, et al. Effects of physical training on anthropometrics, physical and physiological capacities in individuals with obesity: A systematic review. Obes Rev 2020;21(9):e13039. DOI: 10.1111/obr.13039
5. Vieira Potter VJ. Inflammation and macrophage modulation in adipose tissues. Cell Microbiol 2014;16:1484-92.
6. Friedewald WT, Levy RJ, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge. Clin Chem 1972;18:499-502.
7. Duart MJ, Arroyo CO, Moreno JL. Validation of an insulin model for the reactions in RIA. Clin Chem Lab Med 2002;40:1161-7.
8. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 1985;28:412-4.
9. Ryan DH, Ravussin E, Heymsfield S. COVID 19 and the Patient with Obesity - The Editors Speak Out. Obesity (Silver Spring) 2020;28(5):847. DOI: 10.1002/oby.2280
10. Report on 196 patients critically ill with COVID-19. ICNARC 2020; [Accessed 5 may 2020]. Available at: https://www.icnarc.org/About/Latest-News/2020/03/22/Report-On-196-Patients-Critically-Ill-With-Covid-19
11. Malavazos AE, Corsi Romanelli MM, Bandera F, Iacobellis G. Targeting the Adipose Tissue in COVID-19. Obesity (Silver Spring) 2020;28(7):1178-9. DOI: 10.1002/oby.22844
12. Lighter J, Phillips M, Hochman S, Sterling S, Johnson D, Francois F, et al. Obesity in patients younger than 60 years is a risk factor for Covid-19 hospital admission Clin Infect Dis 2020;71(15):896-7. DOI: 10.1093/cid/ciaa415
13. Pietrobelli A, Pecoraro L, Ferruzzi A, Heo M, Faith M, Zoller T. Effects of COVID-19 Lockdown on Lifestyle Behaviors in Children with obesity living in Verona, Italy: A longitudinal Study. Obesity 2020;28(8):1382-5. DOI: 10.1002/oby.22861
14. Njike VY, Smith TM, Shuval O, Edshteyn I , Kalantari V, Yaroch AL . Snack Food, Satiety, and Weight. Adv Nutr 2016;7:866-78.
15. Larson N, Story M. A review of snacking patterns among children and adolescents: what are the implications of snacking for weight status? Child Obes 2013;9:104-15.
16. Field AE, Austin SB, Gillman MW, Rosner B, Rockett HR, Colditz GA. Snack food intake does not predict weight change among children and adolescents. Int J Obes Relat Metab Disord 2004;28:1210-6.
17. Camilleri GM, Caroline M, Kesse-guyot E, Andreeva VA, Bellisle F, Hercberg S, et al. The associations between emotional eating and consumption of energy-dense snack foods are modified by sex and depressive symptomology. J Nutr 2014;144:1264-73.
18. Wansink B, Kim J. Bad popcorn in big buckets: portion size can influence intake as much as taste. J Nutr Educ Behav 2005;37:242-5.
19. Alberga AS, Edache Y, Forhan M Russell S. Weight biass and health care utilization: a scoping review. Prim Health Care Res Dev 2019;20:e116.
20. Flint SW, Tahrani AA. COVID-19 and obesity—lack of clarity, guidance, and implications for care. Lancet Diabetes Endocrinol 2020;8(6):474-5. DOI: 10.1016/S2213-8587(20)30156-X
21. Jennifer A, Woo Baidal, Jane Chang, Emma Hulse, Robyn Turetsky, Kristina Parkinson. Zooming towards a telehealth Solution for vulnerable children with obesity during COVID-19. Obesity 2020;28(7):1184-6. DOI: 10.1002/oby.22860