ORIGINAL ARTICLE

Determinants of body weight changes during COVID-19 pandemic in older urban residents

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KEY WORDS

body weight, COVID-19, nonhospitalized, older

EDITORIAL

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ABSTRACT

INTRODUCTION COVID-19 pandemic is associated with unfavorable body weight changes. However, little is known about these changes in older individuals, a particularly vulnerable group with limited representation in both direct and online research.

OBJECTIVES The aims of the study were to assess changes in body weight and determinants of these changes, and to evaluate the prevalence of COVID-19 history and its impact on the changes in body weight in older individuals.

PATIENTS AND METHODS The analysis included 2076 residents of Kraków, aged 60 to 84 years. Data on sociodemographic factors, lifestyle, history of COVID-19, and changes in body weight were collected in 2021 and 2022 by a postal survey. Multinomial logistic regression analysis was used.

RESULTS COVID-19 tests were performed in 29.3% of the participants, with one-third of them being positive. A total of 14.3% of the participants had any history of COVID-19. Almost two-thirds of the study participants declared no change in their body weight during the pandemic, while 26.2% gained weight. The weight gain was associated with unfavorable sociodemographic and lifestyle conditions. Weight loss was reported by 11.3% of the participants, and it was associated with poor perceived health and a history of COVID-19. After adjusting for covariates, the history of COVID-19 was associated with about 4 times higher odds of weight loss in any case (odds ratio [OR], 2.69; 95% CI, 1.59–4.57 for nonhospitalized, and OR, 18.96; 95% CI, 5.64–63.73 for hospitalized individuals).

CONCLUSIONS Most people with a change in their body weight gained weight due to unfavorable lifestyle modifications, but the history of COVID-19, especially hospitalization, was a strong determinant of body weight loss.

INTRODUCTION On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 pandemic.[1] In Poland, the first case of the disease was recorded on March 4, 2020, and on March 20 restrictions on gatherings, traveling, and the obligation to isolate or quarantine were introduced. As a consequence, similarly to the other countries, most people had to significantly change their lifestyle, that is, switch to remote work, abandon regular physical activity (PA), change the place and the way of eating, etc. These changes often had a significant impact on their health. In Poland, a proportion of the adult population not overweight or obese was declining already in the prepandemic period. In the adult population, the prevalence of obesity was about 25%, but in the age group from 65 to 74 years it reached over 30% in men and almost 50% in women.[2,3] Studies evaluating the changes in body weight during the COVID-19 pandemic showed an increase in body weight in the general population,[4-6] which was associated primarily with a decrease in PA, worse eating habits,[4,5,7,8] and increased stress.[7] On the other hand, most of the general population did not change their weight and a loss of body weight was observed in some participants.[1] However, little information is available on the association between the age group and the direction of body weight change. In some studies, the participants aged 65 years or more did not show significant changes in their body mass index (BMI) during the pandemic[9] or the changes were less pronounced than in the younger age groups.[1,5]

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WHAT'S NEW?

There is a common opinion that during the COVID-19 pandemic, social isolation, lack of physical activity, and unfavorable dietary changes increased body weight in the general population. This article provides comprehensive information on the changes in body weight and their determinants during the pandemic in the older inhabitants of Poland. This group was underrepresented in the studies carried out during the pandemic, which mostly used online data collection methods. Our results indicate that only about one-third of the older individuals experienced weight change (26% gain and 11% loss). Weight gain was related to sociodemographic and lifestyle characteristics, while weight loss was related to poor perceived health and a history of COVID-19, particularly with severe course of the disease that required hospitalization but also with milder course treated at home.

Also, many studies in the elderly population have shown no change in the health-related lifestyle characteristics during the pandemic. In a review of 22 studies carried out in people over 50 years of age, 13 reported a decrease in PA, but the other reported no major changes.[10] Similarly, 6 out of 10 studies assessing dietary changes during the lockdown due to COVID-19 showed no significant quantitative or qualitative variations, while in the remaining 4 papers the changes were unfavorable.[10]

A larger proportion of weight loss could be expected in people infected with SARS-CoV-2. COVID-19 patients are prone to weight loss for several reasons. Infection with SARS-CoV-2 causes inflammation of varying severity, which is associated with impaired cellular homeostasis, dysregulation of metabolism, and proteolysis.[11] In addition, the symptoms of COVID-19 infection itself, such as loss of taste and smell causing a loss of appetite and consequently reduced food intake, combined with fever, may be associated with an increase in catabolic processes.[11] Further, longer immobilization of patients could be associated with a decrease in muscle mass. Unintentional weight loss can have delayed adverse consequences that include malnutrition, sarcopenia, limitation of physical functioning, and general worse prognosis after the disease.[12] In the study of older people with COVID-19, functional impairment increased the risk of death after discharge from a hospital.[13]

The evidence on weight loss in COVID-19 patients is not extensive and most studies focused on the patients with a severe course of the disease who required hospitalization. In such patients, unintentional weight loss was found in up to 52%.[11,14] However, the majority of people infected with SARS-CoV-2 did not require hospitalization, and in 4% to 40% of people with the infection confirmed by a test, an asymptomatic course was observed.[15] The problem of weight changes in the patients with asymptomatic or mild course of the disease, who did not require hospitalization, was less often studied and the results are conflicting.[14,16]

Due to the nature of the disease and state of the pandemic, in most of the studies conducted so far, the participants were recruited and contacted online, and the data were collected using online questionnaires. Older people, who use the Internet tools and social media less frequently than younger ones, were often underrepresented in previous studies. As a consequence, in Poland and many other countries, the impact of COVID-19 on the lifestyle and health of the older population remains less known. This study attempts to fill the gap in the COVID-19 research by examining the people who were not sufficiently represented in online surveys due to their age. We focused on the vulnerable group of elderly individuals in whom the fatal outcome of COVID-19 was much more frequent than in the younger groups.

Our study had 2 main goals. The first was to assess the prevalence of weight changes in the older adults during the pandemic and to assess the relationship between the sociodemographic factors and changes in body weight. The second was to examine the prevalence of COVID-19 in the older individuals and to pinpoint the relationship between the disease and the declared changes in body weight.

We hypothesize that most of the population changed their weight during the pandemic as a consequence of lifestyle changes, but that infection with COVID-19, and especially its severe course was associated with weight loss.

PATIENTS AND METHODS

Study organization and eligibility criteria Data collected in the project "Psychosocial determinants of cardiovascular diseases and ageing process. A prospective study of a cohort of men and women aged 60 to 84 years" were used. In 2021–2022, a cross-sectional study was performed in a cohort randomly selected from Kraków residents, who have been observed since 2003–2005. The eligible population included 5858 men and women aged from 60 to 84 years. Postal questionnaires with return envelopes were sent to the study participants between July 2, 2021 and February 28, 2022. The questionnaire was completed by 2076 people, the response rate was 35% (Supplementary material, *Figure S1*). The study was approved by the Bioethical Committee of the Jagiellonian University Medical College (1072.6120.342.2018). All participants gave their written consent.

Study procedures and research tools Data on sociodemographic characteristics, lifestyle, and health status, including a history of COVID-19 were collected using a standard questionnaire. Specific data included age, sex, education (university, secondary, lower than secondary), married or cohabiting (yes or no if single, divorced, widowed), employed (yes, no), current smoker (yes, no). PA was defined as the average number of hours spent on nonoccupational PA in a typical week. Based on the question about the perceived health, the participants were classified into 3 groups of perceived

health status: good, moderate, and bad. The respondents were asked about their actual height and body weight, then their BMI was calculated, and they were divided into 3 groups in accordance with the WHO criteria: normal body mass or underweight (BMI <25 kg/m^2), overweight (BMI ≥25 to <30 kg/m^2), and obesity (BMI ≥30 kg/m^2). According to the declared change in body weight during the pandemic vs before the pandemic (ie, before March 20, 2020), 3 groups of respondents were defined: no change in body weight, gained, and lost body weight. Dietary changes during the pandemic were assessed with the following questions: "How has the COVID-19 pandemic affected your diet? Compared with the time before the beginning of the pandemic (March 2020) do you consume more, less, or the same amount of the following foods: fruit, vegetables, chocolate and sweets, cakes and confectionery, meat and sausages, ready meals from a store, canned food, sweet drinks, alcohol?" For each item, a favorable change (increased intake of fruit and vegetables, and reduced intake of other foods) was scored +1, an unfavorable change (decreased intake of fruit and vegetables, increased intake of other foods) was scored –1, and no change scored 0. The points were then summarized and gave an index ranging from –6 to 9 points. Based on the value of the index the respondents were classified into 3 groups: 1) unchanged diet (index score 0 meaning no changes in the consumption patterns or the number of favorable changes the same as of unfavorable ones), 2) declared dietary improvement (index score from 1 to 9 points, the number of favorable changes greater than that of unfavorable ones), 3) declared dietary worsening (index score between –6 and –1, the number of unfavorable changes greater than that of favorable ones).

The group of people with a history of quarantine included the respondents who answered "yes" to the question "Have you been quarantined?" All respondents were asked if they have been tested for SARS-CoV-2 infection and 2 groups were established (yes, no). The next question was "Have you been ill with COVID-19?" and the disease diagnosis was defined in 3 ways according to the following criteria: 1) a history of COVID-19: yes (if the answer was "Yes, confirmed by a laboratory test" or "Yes, diagnosed by a doctor without performing a test" or a self-declared conviction of the participant "Yes, but the diagnosis was not confirmed by a doctor") or no; 2) a history of COVID-19 confirmed by a doctor or by a test: yes (if the answer was "Yes, confirmed by a laboratory test" or "Yes, diagnosed by a doctor without performing a test") or no (if the answer was "No" or a self-declared conviction "Yes, but the diagnosis was not confirmed by a doctor"); 3) a history of COVID-19 confirmed by a test: yes (if the answer was "Yes, confirmed by a laboratory test) or no (if the answer was "No" or "Yes, diagnosed by a doctor without performing a test" or the diagnosis was self-declared as "Yes, but the diagnosis was not confirmed by a doctor"). Those with COVID-19 were asked about the course of the disease and 2 groups were identified of the individuals hospitalized for COVID-19 and nonhospitalized. All respondents were asked if they were vaccinated against COVID-19, and 2 groups were defined (yes, no). The number of missing data in the answers to particular questions ranged from 1% to 32.4% (Supplementary material, *Table S1*).

Statistical analysis Quantitative data are presented as means with SD or as medians with interquartile ranges (IQRs), as appropriate. The Kolmogorov–Smirnov test was used to test the normal distribution of variables. Categorical variables were reported as numbers and percentages. The relationship between the qualitative variables was assessed with the χ^2 test or the Fisher exact test. Differences in the numerical variables were assessed using the *t* test, the analysis of variance, the Mann–Whitney test, or the Kruskal–Wallis test, as appropriate. The association between the quarantine, history of COVID-19, and declared body weight changes (the reference category was no change in body weight) was examined using a multivariable multinomial logistic regression. Three models were built accounting for the following variables: model 1 (age, sex, BMI), model 2 (model 1 plus perceived health), model 3 (model 2 plus education, marital status, smoking, PA, and dietary changes). The results were presented as odds ratio (OR) with 95% CI.

Two-sided *P* values below 0.05 were considered significant. The analyses were performed using R Core Team software (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS Out of 5858 people eligible for the study to whom the questionnaire was sent, 2076 (1013 men and 1063 women) participated in the study and were included in the analysis. Descriptive statistics for the whole group and according to sex are presented in **TABLE 1**. The men were slightly older than the women (mean [SD] age, 74.1 [6.3] and 73.4 [6.4] years, respectively). In men, the proportion of university education, married or cohabiting, and professional activity (employed) was higher. There was no significant difference in the mean BMI between the men and women. However, in men, the proportion of those with BMI below 25 kg/m^2 was lower than in women, and the proportion of obesity (BMI ≥30 kg/m^2) was higher in women. Only about one-third of the participants declared a change in their body weight, including about 26% of those who gained it and 11% of those who lost weight. Nearly twice more women declared an increase in body weight during the pandemic than men (33.6% and 18.4%, respectively), despite no significant difference in the leisure time PA between the sexes. Nearly 27% of men and 35% of women declared improved quality of their diet, and only about 4% of men and 8% of women declared worsened quality of their diet. There was no

TABLE 1 Descriptive statistics of the study participants

Variable	Total	Men	Women	*P* value
Age, y, mean (SD)	73.7 (6.4)	74.1 (6.3)	73.4 (6.4)	0.02[a]
BMI, kg/m^2, mean (SD)	27.4 (4.6)	27.4 (4.1)	27.4 (5.1)	0.72[a]
Leisure time physical activity, h/w, median (IQR)	13 (6.5–25)	13 (6.5–23.5)	13.8 (7–26.4)	0.28[c]
Education, n (%)				
Lower than secondary	332 (16.7)	194 (19.9)	138 (13.6)	<0.001[b]
Secondary	805 (40.5)	334 (34.2)	471 (46.5)	
University	852 (42.8)	448 (45.9)	404 (39.9)	
Married or cohabiting, n (%)				
Yes	1348 (66.1)	833 (83.6)	515 (49.4)	<0.001[b]
No	691 (33.9)	163 (16.4)	528 (50.6)	
Employed, n (%)				
Yes	427 (21)	237 (23.8)	190 (18.4)	0.003[b]
No	1604 (79)	759 (76.2)	845 (81.6)	
Current smoker, n (%)				
Yes	284 (14)	128 (12.9)	156 (15)	0.17[b]
No	1749 (86)	865 (87.1)	884 (85)	
Perceived health, n (%)				
Good	837 (44)	424 (44.9)	413 (43)	0.63[b]
Moderate	820 (43)	403 (42.7)	417 (43.4)	
Bad	247 (13)	117 (12.4)	130 (13.6)	
BMI groups, n (%)				
<25 kg/m^2	637 (31)	281 (28)	356 (33.9)	<0.001[b]
≥25 to <30 kg/m^2	938 (45.6)	512 (50.9)	426 (40.6)	
≥30 kg/m^2	480 (23.4)	212 (21.1)	268 (25.5)	
Declared change in body weight during the pandemic, n (%)				
Weight gain	530 (26.2)	182 (18.4)	348 (33.6)	<0.001[b]
Weight loss	229 (11.3)	117 (11.8)	112 (10.8)	
No change	1267 (62.5)	690 (69.8)	577 (55.6)	
Declared change of the quality of diet during the pandemic, n (%)				
Improved	492 (30.7)	218 (26.8)	274 (34.7)	<0.001[b]
No change	1011 (63.1)	562 (69.1)	449 (56.8)	
Worsened	100 (6.2)	33 (4.1)	67 (8.5)	

Statistical significance tested with: **a** *t* test, **b** χ^2 test, **c** Mann–Whitney test

Abbreviations: BMI, body mass index; IQR, interquartile range

significant difference between the sexes in smoking status and in the distribution of perceived health.

The percentages of respondents with a history of quarantine, vaccinated against COVID-19, tested for SARS-CoV-2 infection, and with a history of COVID-19 in the whole sample and according to sex are presented in TABLE 2. About 12% of the participants were quarantined. A test for SARS-CoV-2 was performed in nearly 30% of the respondents and in nearly one-third of them (32%) the result was positive. Over 14% of the participants declared a history of COVID-19, but only in 10% the diagnosis was confirmed by a test or a doctor, and only in 9.5% by a test. Among the participants with a history of COVID-19 confirmed by the test, nearly one-fourth (23.1%) were hospitalized. As many as 92% of the study participants were vaccinated against COVID-19. There were no significant differences in the above characteristics between men and women.

Distribution of sociodemographic and lifestyle characteristics and of perceived health is presented by the category of body weight change in TABLE 3. In the subgroup who gained weight, the percentage of women was the highest, as well as the highest was the mean BMI and the proportion of people with overweight and obesity, and those who reported worsened quality of their diet. In the subgroup who declared a loss of body weight, the highest proportions of participants with bad perceived health and the lowest proportion of current smokers were found. For the entire studied group there were no significant differences between the categories of body weight change and mean age, education level, proportion of married or cohabiting, employment status,

TABLE 2 Frequency of quarantine, testing for SARS-CoV-2 infection, COVID-19 vaccination, and the history of COVID-19

Variable	Total	Men	Women	*P* value
Quarantine				
Yes	246 (12.2)	129 (13)	117 (11.3)	0.24
No	1776 (87.8)	861 (87)	915 (88.7)	
Tested for SARS-CoV-2 infection				
Yes	597 (29.3)	296 (29.7)	301 (29)	0.73
No	1438 (70.7)	701 (70.3)	737 (71)	
Result of the test for SARS-CoV-2 infection among 597 participants in whom the test was performed				
Positive	191 (32)	104 (35.1)	87 (28.9)	0.25
Negative	406 (68)	192 (64.9)	214 (71.1)	
History of COVID-19				
Yes	289 (14.3)	149 (15)	140 (13.6)	0.38
No	1731 (85.7)	844 (85)	887 (86.4)	
History of COVID-19 confirmed by a doctor or by a test				
Yes	217 (10.7)	115 (11.6)	102 (9.9)	0.23
No	1803 (89.3)	878 (88.4)	925 (90.1)	
History of COVID-19 confirmed by a test				
Yes	191 (9.5)	104 (10.5)	87 (8.5)	0.12
No	1829 (90.5)	889 (89.5)	940 (91.5)	
Hospitalization among participants with COVID-19 confirmed by a test				
Yes	43 (23.1)	28 (27.5)	15 (17.9)	0.12
No	143 (76.9)	74 (72.5)	69 (82.1)	
COVID-19 vaccination				
Yes	1862 (92)	920 (92.4)	942 (91.5)	0.49
No	163 (8)	76 (7.6)	87 (8.5)	

Results are presented as numbers and percentages.

Statistical significance was tested by the χ^2 test.

and PA. In the analysis by sex, in the women who gained weight the percentage of those who were married or cohabiting was the highest. The results of other comparisons between the categories of body weight change were similar to those in the entire group described above (Supplementary material, *Table S2*).

Distribution of the history of quarantine, history of COVID-19, and hospitalization for COVID-19 by the category of body weight change is presented in **TABLE 4**. In the group of weight loss, the percentages of participants who were quarantined, of people with a history of COVID-19 regardless of the type of the diagnosis confirmation, of those who were hospitalized, and those with a positive test for SARS-CoV-2 infection, were much higher than in the 2 other groups. In the category of weight gain and no change in body weight, the proportions of participants who were quarantined, those with a history of COVID-19, and those with a positive test for SARS-CoV-2 infection were similar. The results were similar in the sex groups and they were confirmed in the univariable regression analysis (Supplementary material, *Tables S3–S5*).

After adjusting for covariates, being in quarantine was associated with about 3.5 times higher odds of weight loss. A history of COVID-19 was related to about 4 times higher odds of weight loss in any case, but the relationship was much stronger in the individuals hospitalized for COVID-19 (about 20 times higher odds of weight loss), as compared with those non-hospitalized (less than 3 times higher odds). There was no significant association between weight gain and being in quarantine or a history of COVID-19. The relationships in women and men were homogeneous and differed only slightly in the effect size (**TABLE 5**; Supplementary material, *Table S6*). The participants with a negative test for COVID-19 and with a diagnosis of COVID-19 confirmed only by a doctor presented similar changes in body weight as the participants with no history of COVID-19 who were not tested (Supplementary material, *Table S7*).

DISCUSSION In our study, in which 14% of participants had a history of COVID-19 (9.5% confirmed by a test), body weight did not change in 62.5%, its increase was observed in 26.2%, and its decrease in 11.3% of the respondents. Weight gain was related more to socioeconomic characteristics, while the history of COVID-19 and perceived bad health were strongly related to weight loss. The weight loss was more strongly related to a history of hospitalization for COVID-19 but

TABLE 3 Distribution of sociodemographic and lifestyle characteristics and perceived health by the category of body weight change during the pandemic

Variable	Declared change of body weight during the pandemic			*P* value
	Weight gain	Weight loss	No change	
Age, y, mean (SD)	73.2 (6.3)	74.1 (6.4)	73.9 (6.4)	0.059[a]
BMI, kg/m^2, mean (SD)	29.2 (4.6)	26.9 (4.5)	26.8 (4.5)	<0.001[a]
Leisure time physical activity, h/w, median (IQR)	17.5 (15.6)	17.1 (14.4)	18.7 (16.9)	0.31[c]
Sex, n (%)				
Men	182 (34.8)	117 (51.1)	690 (45.5)	<0.001[b]
Women	348 (65.2)	112 (48.9)	577 (54.5)	
Education, n (%)				
Lower than secondary	66 (12.8)	39 (17.8)	216 (17.8)	0.14[b]
Secondary	218 (42.4)	85 (38.8)	486 (40.1)	
University	230 (44.8)	95 (43.4)	511 (42.1)	
Married or cohabiting, n (%)				
Yes	332 (63.8)	155 (68.6)	833 (66.6)	0.37[b]
No	188 (36.2)	71 (31.4)	417 (33.4)	
Employed, n (%)				
Yes	107 (20.5)	44 (19.7)	265 (21.3)	0.83[b]
No	415 (79.5)	179 (80.3)	978 (78.7)	
BMI groups, n (%)				
<25 kg/m^2	84 (15.9)	75 (32.9)	462 (36.6)	<0.001[b]
≥25 to <30 kg/m^2	250 (47.5)	107 (46.9)	569 (45.1)	
≥30 kg/m^2	193 (36.6)	46 (20.2)	231 (18.3)	
Current smoker, n (%)				
Yes	64 (12.3)	20 (8.9)	197 (15.7)	0.01[b]
No	457 (87.7)	204 (91.1)	1055 (84.3)	
Perceived health status, n (%)				
Good	211 (43.6)	69 (32.4)	536 (46)	<0.001[b]
Moderate	219 (45.2)	87 (40.8)	504 (43.3)	
Bad	54 (11.2)	57 (26.8)	125 (10.7)	
Declared change in the quality of diet during the pandemic, n (%)				
Improved	154 (36.7)	82 (51.9)	244 (24.5)	<0.001[b]
No change	205 (48.8)	67 (42.4)	725 (72.7)	
Worsened	61 (14.5)	9 (5.7)	29 (2.8)	

Statistical significance tested by: **a** ANOVA; **b** χ^2 test; **c** Kruskal–Wallis test

Abbreviations: see **TABLE 1**

also significantly to a history of nonhospitalized course of the disease.

In other countries, the prevalence of weight gain in adults (≥18 years) varied from 23.1% to 40%,[5,7,8,17] but in the subgroup of those over 65 years this percentage was lower (18.4%).[5] In a Polish study of 1097 adults aged 18–71 years, weight gain was found in 29.9%.[6] However, according to the report on the health status of the Polish population issued in 2020,[1] in the people aged 65 years or more, weight gain was slightly less frequent than in our study (18.6% in men and 22.6% in women).

The prevalence of weight loss during the pandemic varied and in the adult population (≥18 years) reached 17.3% in highly developed countries (United States, United Kingdom, Canada, Australia),[8] 23% in France,[17] 18.6% in Poland,[6] and 17% in Saudi Arabia.[5] In the latter study, weight loss was less prevalent in the subgroup aged 65 years or older (11.7%), which is similar to our study. According to the abovementioned report,[1] in the group of people aged 65 or older, the prevalence of weight loss during the pandemic was similar to our study in men (10.2%), but much lower in women (6.6%).

Our findings that women gained weight more frequently than men, that the increase of body weight was more frequent in people with university education, and that weight increase was related to baseline overweight and obesity are consistent with other studies in adults (≥18 years).[1,5,6,8,17,18] The relation between the change in body weight and the quality of diet seems to be more complicated. Although in general weight gain and loss are related to overall

TABLE 4 Distribution of quarantine, history of COVID-19, and hospitalization for COVID-19 by categories of declared change of body weight during the pandemic in the entire study group

Variable	Declared change of body weight during the pandemic			*P* value
	Weight gain	Weight loss	No change	
Quarantine				
Yes	61 (11.7)	51 (22.7)	126 (10.2)	<0.001
No	459 (88.3)	174 (77.3)	1109 (89.8)	
History of COVID-19				
Yes	66 (12.7)	69 (30.9)	145 (11.7)	<0.001
No	454 (87.3)	154 (69.1)	1090 (88.3)	
History of COVID-19 confirmed by a doctor or by a test				
Yes	48 (9.2)	57 (25.6)	104 (8.4)	<0.001
No	472 (90.8)	166 (74.4)	1131 (91.6)	
History of COVID-19 confirmed by a test				
Yes	39 (7.5)	54 (24.2)	91 (7.4)	<0.001
No	481 (92.5)	169 (75.8)	1144 (92.6)	
Hospitalization among participants with COVID-19 confirmed by a test				
Yes	5 (13.5)	22 (41.5)	11 (12.4)	<0.001
No	32 (86.5)	31 (58.5)	78 (87.6)	
Results of the test for SARS-CoV-2 infection				
Positive	39 (27.9)	54 (54.5)	91 (27.2)	<0.001
Negative	101 (72.1)	45 (45.5)	243 (72.8)	

Results are presented as numbers and percentages.

Statistical significance was tested by the χ^2 test.

energy consumed and modified by the composition of food products and nutrients, our results were similar to a Belgian study[18] in which weight gain was associated with both an increase and a decrease in the consumption of unhealthy products, but in a subgroup of older adults (≥55 years) a clear association between worsening eating habits and increased consumption of sweets and salty snacks was visible.

In our study, over 90% of the participants had been vaccinated against COVID-19 before the survey. The vaccination program began in Poland in December 2020, and people aged 60 and over had priority access to the vaccines. According to the European Centre for Disease Prevention and Control data for Poland, 60.5% of the general population have received at least 1 dose of the vaccine, but in the older age groups this percentage is higher. For example, for people over 60 years of age it is 76.2%, and for those aged 70–79 years it is already 82.1%.[19] According to the data of the Municipal Office of the City of Kraków, the percentage of vaccinated residents was 75% in the age group of 60–69 years and 85% in those aged 70 years or more (unpublished data). Nevertheless, the participants of our study have to be considered as having more favorable health behaviors than the general population of Poland.

There is extensive evidence on weight loss in the patients hospitalized for COVID-19.[11,12,14,20,21] However, less is known from the studies published so far about the changes in body weight in people who suffered from COVID-19 but were not hospitalized. We were able to provide comprehensive information on body weight change during the pandemic in people aged from 60 to 84 years, both hospitalized and nonhospitalized for COVID-19, and people who remained free of COVID-19. In the group of COVID-19 patients with a course of the disease that did not require hospitalization, our results were similar to those of nonhospitalized patients in Italy with median age of 51 years (IQR, 40–60 years), in whom 21% lost body weight.[14] However, in a study of 160 nonhospitalized patients of mean age 46 years in Austria, the rate of weight loss was twice as high.[16]

The more severe course of COVID-19 was associated with more frequent weight loss, and in our study the percentage of weight loss was similar to that in the Italian study in people of median age 74 years (IQR, 63–84 years) (52% of participants with weight loss).[21] The percent of body loss was smaller (31%) in another Italian study in hospitalized patients of median age 61 years (IQR, 53–69 years).[14] Our results are in line with the observations on muscle loss, weight loss, or sarcopenia in COVID-19 patients. There is evidence that persons with severe COVID-19 require prolonged exercise therapy to prevent or reverse disability.[22]

Study strengths and limitations The analysis was conducted in a large sample of older people. This part of the population was underrepresented in previous studies that used online data collection tools and included mostly young or middle-aged participants.[6-8,16,17] A standard postal questionnaire used in the study allowed for the collection of reliable data among older individuals. Further, the study sample was selected from the general population, which is an advantage over many studies conducted in volunteers who participate in online surveys. On the one hand, we assessed changes in body weight during the COVID-19 pandemic, which may reflect social changes related to the restrictions and lifestyle alterations during the lockdown, but on the other hand, the changes in body weight were assessed in relation to the history of COVID-19. While most previous studies focused on COVID-19 patients requiring hospitalization, we addressed the problem of changes in body weight in participants with a milder course of the disease, which is much more common. Finally, the data we collected on a wide range of covariates allowed for the assessment of the relationship between COVID-19 and the changes in body weight independent of sociodemographic, behavioral, and health characteristics.

The main limitation of the study is its design of a postal cross-sectional survey. All data obtained, including the key variable, that is, the change in body weight and covariate (BMI) were not collected by objective methods. At the time of the study, restrictions on social contacting and safety rules

TABLE 5 Adjusted odds ratio (OR) of body weight change in the participants in quarantine and with a history of COVID-19 (reference: no change of body weight)

Variable	N	Weight gain		Weight loss	
		OR (95% CI)	*P* value	OR (95% CI)	*P* value
Quarantine[a]	1973	1.08 (0.76–1.51)	0.67	2.63 (1.82–3.78)	<0.001
Quarantine[b]	1814	1.04 (0.73–1.49)	0.88	2.67 (1.82–3.92)	<0.001
Quarantine[c]	1150	1.31 (0.82–2.09)	0.25	3.60 (2.15–6.05)	<0.001
History of COVID-19 (reference: not ill)					
Nonhospitalized[a]	1963	0.96 (0.68–1.35)	0.8	2.47 (1.69–3.62)	<0.001
Hospitalized[a]	1963	1.08 (0.37–3.13)	0.89	13.41 (6.49–27.71)	<0.001
Any[a,d]	1971	1 (0.72–1.38)	0.99	3.42 (2.44–4.78)	<0.001
Nonhospitalized[b]	1807	0.87 (0.6–1.25)	0.45	2.51 (1.69–3.72)	<0.001
Hospitalized[b]	1807	1.6 (0.51–5.02)	0.42	17.81 (7.64–41.54)	<0.001
Any[b,d]	1813	0.94 (0.67–1.33)	0.74	3.39 (2.38–4.82)	<0.001
Nonhospitalized[c]	1145	0.93 (0.58–1.47)	0.74	2.69 (1.59–4.57)	<0.001
Hospitalized[c]	1145	1.19 (0.21–6.88)	0.85	18.96 (5.64–63.73)	<0.001
Any[c,d]	1148	1 (0.65–1.56)	0.98	3.64 (2.26–5.86)	<0.001
History of COVID-19 confirmed by a doctor or by a test (reference: not ill or self-declared diagnosis not confirmed by a doctor)					
Nonhospitalized[a]	1965	0.98 (0.65–1.46)	0.91	2.6 (1.69–4)	<0.001
Hospitalized[a]	1965	1.18 (0.40–3.46)	0.77	14.12 (6.7–29.74)	<0.001
Any[a,d]	1971	1.02 (0.70–1.48)	0.91	3.79 (2.63–5.46)	<0.001
Nonhospitalized[b]	1808	0.92 (0.60–1.41)	0.71	2.63 (1.68–4.12)	<0.001
Hospitalized[b]	1808	1.84 (0.57–5.95)	0.31	19.66 (8.11–47.65)	<0.001
Any[b,d]	1813	1.02 (0.69–1.51)	0.93	3.85 (2.62–5.66)	<0.001
Nonhospitalized[c]	1146	0.83 (0.47–1.47)	0.53	2.83 (1.53–5.21)	<0.001
Hospitalized[c]	1146	1.53 (0.24–9.71)	0.65	23.5 (6.15–89.73)	<0.001
Any[c,d]	1148	0.95 (0.56–1.61)	0.85	4.2 (2.47–7.14)	<0.001
History of COVID-19 confirmed by a test (reference: not ill or disease diagnosed by a doctor without performing a test or self-declared diagnosis not confirmed by a doctor)					
Nonhospitalized[a]	1966	0.88 (0.56–1.37)	0.57	2.72 (1.74–4.26)	<0.001
Hospitalized[a]	1966	1.17 (0.4–3.45)	0.78	14.03 (6.66–29.54)	<0.001
Any[a,d]	1971	0.95 (0.63–1.43)	0.81	4.09 (2.81–5.96)	0.001
Nonhospitalized[b]	1809	0.87 (0.55–1.38)	0.55	2.78 (1.74–4.44)	<0.001
Hospitalized[b]	1809	1.84 (0.57–5.95)	0.31	19.56 (8.07–47.4)	<0.001
Any[b,d]	1813	1 (0.65–1.52)	0.98	4.18 (2.81–6.23)	0.001
Nonhospitalized[c]	1146	0.75 (0.41–1.4)	0.37	2.56 (1.34–4.91)	0.005
Hospitalized[c]	1146	1.52 (0.24–9.67)	0.66	22.79 (5.97–86.98)	<0.001
Any[c,d]	1148	0.89 (0.50–1.56)	0.67	4.04 (2.34–6.99)	<0.001

a Adjusted for: age, sex, body mass index (BMI)

b Adjusted for: age, sex, BMI, perceived health status

c Adjusted for: age, sex, BMI, perceived health status, education, marital status, smoking, physical activity, dietary changes

d Hospitalized or nonhospitalized

were in force, and the methods of data collection which did not require a direct contact were broadly accepted.[1,6-8,16,17] In some studies, self-reported height tended to be overestimated and weight underestimated; however, the agreement with the objective anthropometric measurements was rather good and such data are recognized as valid for identification of the relationships in epidemiologic studies, provided they are not key variables.[23,24] Further, the cross-sectional study design does not allow for causal inference. The assessment of COVID-19 prevalence might have been underestimated, as the studied group consisted of people who survived until 2021. As in many other similar studies, the participation rate in our survey was rather low. However, the observations on COVID-19–related morbidity and the percent of vaccinated participants corresponded with the official statistics.[25] Furthermore, the percentage of participants who gained

body weight is similar to the data on urban residents in the national report.[1] This suggests that even though the studied group is not fully representative of the general population from which it was selected, it might still be typical. Given that the healthier part of the population is usually better represented among study participants, our results may underestimate the prevalence of both COVID-19 and increased body weight. However, the impact of low response rate would probably affect less the measures of association (odds ratios) between body weight changes and COVID-19.[26,27]

An important issue of the study was a definition of the history of COVID-19. Even more problematic was a definition of the COVID-19– free status. Adoption of the most objective, restrictive definition (disease confirmed by a test), would result in elimination of all COVID-19 cases for which the test was not done or done out of diagnostic window or produced a false-negative result. On the other hand, adoption of the least restrictive definition (any history of COVID-19 in the interview), might have resulted in a classification of many false-positive cases as an effect of diagnostic shifts between COVID-19 and other viral infections. These problems are reflected in defining COVID-19–free status, which irrespective of the definition includes the most asymptomatic cases. We tried to handle the problem of the definition by analyzing 3 combinations of the definition of the variable "history of COVID-19." Similarity of the results obtained, which indicate a strong relation between COVID-19 and the loss of body weight, may suggest that a problem might be less important than anticipated, but it is possible that the problem of a definition of history of COVID-19 weakened the relation between COVID-19 and body weight change.

Conclusions During the pandemic, most of the older citizens maintained their body weight, but about one-fourth gained weight and about one-tenth experienced weight loss. A history of COVID-19, especially a severe course of the disease that required hospitalization, was a strong determinant of body weight loss, while weight gain was related mostly to sociodemographic and lifestyle characteristics.

Increase in body weight may lead to overweight and obesity and their potential complications. Therefore, it is necessary to take actions to control obesity in seniors after the pandemic. On the other hand, prevention of unintentional body weight loss, including promoting restoration of muscle mass through adequate nutrition, supplementation, and PA may be beneficial for all seniors who experienced SARS-CoV-2 infection, not only for those who were hospitalized. Additionally, proper nutrition is essential to strengthen immunity that declines with age, improve recovery from COVID-19, and reduce the risk of another infection.[28] While unintentional weight loss in the elders who suffered from COVID-19 but were not hospitalized may remain unnoticed at the populational level, our study highlights the need to address this issue. A wide access to education and multidisciplinary rehabilitation for all seniors who recovered from COVID-19 should be considered.

SUPPLEMENTARY MATERIAL

Supplementary material is available at www.mp.pl/paim.

ARTICLE INFORMATION

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