Effect of COVID-19 Lockdowns on Physical Activity, Eating Behavior, Body Weight and Psychological Outcomes in a Post-Bariatric Cohort

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Abstract

Purpose: Little is known about the consequences of COVID-19 lockdowns on physical activity (PA), eating behavior and mental health in post-bariatric surgery (BS) patients. We aimed to analyze the relations between changes in PA during COVID-19 lockdowns and changes in body weight and a comprehensive set of lifestyle and psychological outcomes in patients who have undergone BS.

Material and methods: In April-May 2020 (lockdown#1), we performed an online survey in a cohort of 937 adults who underwent BS and were followed-up at our university medical center for at least one year. We assessed changes in PA, eating behavior, body weight, fatigue, and depression (PHQ-9). In November-December 2020 (lockdown#2), we recorded body weight in 280 patients who had reported decreased PA during lockdown #1.

Results: During lockdown #1 (N=420 patients included, 44% response rate), decreased PA was reported by 67% patients. Compared to those who reported increased or unchanged PA, patients with decreased PA were more likely to report a ≥5% weight gain (OR [95%CI]: 3.15 [1.46-7.65], increased fatigue (2.08 [1.36-3.23]), a worsening of eating behavior (2.29 [1.47-3.58]), and moderate-to-severe depressive symptoms (4.74 [2.14-11.76]). During lockdown #2 (N=225 patients, 80% response rate), significant weight gain since before lockdown #1 was reported (+2.8 [95% CI: 1.7-3.8] kg, $p < 0.001$), with 36% patients reporting a ≥5% weight gain.

Conclusions: PA may counteract detrimental effects of COVID-19 lockdown on post-BS weight trajectories and mental health outcomes. Follow-up measures are needed in this setting to assess the long-term impact of lockdown.

Keywords: COVID-19, lockdown, bariatric surgery, physical activity, nutrition

Key points

- 67% of post-bariatric patients reported decreased physical activity during lockdown
- Patients who reported decreased physical activity reported greater weight regain
- They were also more likely to report moderate-to-severe depressive symptoms
- Eating behavior was adversely modified in patients with decreased physical activity

Introduction

In response to the COVID-19 pandemic, numerous countries around the world implemented periods of lockdown during the year 2020 [1]. In France, strict lockdown measures took place between March and May 2020 and between November and December 2020. These measures included the closure of most "non-essential" public places, businesses, and services, the placement on partial/technical unemployment or the adoption of telework by the majority of the working population, and the prohibition of being outdoors except to take care of essential needs [2]. Recreational activity was only allowed for one hour within a one-kilometer radius from one's residential address. As a consequence, a decrease in physical activity (PA) occurred during the COVID-19 lockdown throughout many countries and in different populations [3]. In France, 47% of a representative sample of 2000 adults reported decreased PA during compared to before lockdown [4].

PA is an important component of the management of patients undergoing bariatric surgery (BS), as it is associated with a substantial improvement in physical fitness and a slightly greater weight loss after BS [5]. PA may also prevent weight regain after BS [5]. Two online surveys conducted in the USA reported a decrease in PA during the COVID-19 lockdown in 49% and 55% of patients with a history of BS [6,7]. In addition, two studies conducted in the context of COVID-19 lockdown in the USA and in Italy in 208 and 48 patients after BS, respectively, found that a decrease in PA, or a lower weekly duration of PA, was associated with a greater weight gain, thus suggesting the importance of PA for weight control after BS [6,8].

Dietary habits and mental health have also been negatively impacted by the COVID-19 lockdown in post-BS cohorts, although their relations with PA have not been investigated in

this population [6]. A large proportion of patients with a history of BS reported a decrease in healthy food eating (46%) and an increase in snacking (63%), loss of control when eating (48%) or depressed mood (44%) [6], or anxiety (67%) and depression (83%) [7]. In the general population [9], as well as in patients with obesity [10], PA during lockdown has been associated with a lower prevalence of depressive symptoms and anxiety disorders [9,10]. The associations between the change in PA during the lockdown and mental health outcomes warrant further investigation in patients with a history of BS.

Therefore, the aim of this study was to analyze the relations between changes in PA during COVID-19 lockdown and changes in body weight and a comprehensive set of lifestyle and psychological outcomes in patients with obesity who had undergone BS.

Material and Methods

Study cohort

The study is based on a BS cohort of 937 patients followed-up at a single academic medical center (Nutrition department of Pitié-Salpêtrière university hospital; Paris, France) since 2014. Patients were operated by Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG) or laparoscopic adjustable gastric band (LAGB). However, we excluded LAGB patients due to their small number (N=3) and their worse BS outcomes in general [11]. Furthermore, we excluded patients who had been operated less than one year before the first COVID-19 lockdown, since maximum weight loss usually occurs at approximately one year after BS. Detailed clinical and anthropometric measures were obtained before surgery [12]. Body composition was assessed based on whole-body dual energy X-ray absorptiometry (DXA) scan (Hologic Discovery W, software v12.9; Hologic, Bedford, MA) [13]. Ethical approval was

obtained from the French Research Ethics Committee of CPP Ile de France-1 N°13533 and the "Commission nationale de l'informatique et des libertés" No. 1222666.

Data collection during COVID-19 lockdowns

A first COVID-19 lockdown (lockdown #1) took place in France from March 17th to May 11th 2020. The 937 BS patients followed in the cohort were contacted by phone and 738 patients provided information about their current medical situation (Figure 1) [12]. Of these, 500 patients also contributed to an online survey including a set of standardized questions that has been used in a large cohort study at the national level [14]. Eighty patients were further excluded for the reasons detailed above. Therefore, 420 patients were included in the present analyses.

The questions pertained to professional occupation and characteristics of lockdown, as well as the perceived changes during lockdown in PA and sedentary behavior, diet quality and eating behavior, alcohol consumption and smoking, sleep duration, and fatigue. Subjects were asked whether they had, in general, increased, decreased or not modified their habitual PA level during lockdown (question formulated as follows: "*Compared to before the lockdown, your physical activity level: increased/ did not change/ decreased/ do not know*). Detailed information was also collected regarding the different types of PA performed over the last seven days, and whether this activity had been started during lockdown. Questions related to eating behavior were formulated as follows: "*Compared to before the lockdown… 1) Your current diet is: better/ neither better nor less good/ less good/ do not know", 2) You snack: more often/ neither less nor more/ less often, 3) You have more/neither more nor less/less cravings for food, 4) You experience more/ neither more nor fewer/ fewer episodes of eating large amounts of food and feeling like you lose control, 5) You experience more/ neither more*

nor less/ less night-time food consumption". Patients were asked to report body weight measured at home before lockdown and at the time of the survey only if specifically measured with a scale. Finally, the presence of depressive symptoms and anxiety were assessed using the Patient Health Questionnaire–9 scale (PHQ-9) [15] and the Generalized Anxiety Disorder–7 scale (GAD-7) [16], respectively.

A second lockdown period (lockdown #2) took place in France seven months later from October 30th to December 15th, 2020. For practical reasons, only patients who had reported a decrease in PA during the first lockdown (N= 280) were contacted by e-mail and by phone before and during lockdown #2 to report their current body weight. A total of 225 patients responded to this survey (i.e., a response rate of 80%).

Statistical analysis

Values are presented as mean (SD) for continuous variables and as absolute values (percentages) for categorical variables. Individual characteristics were compared according to gender using Student's *t*-tests for continuous variables and Pearson's chi-square (χ^2) test or Fisher's exact test for categorical variables. Individual characteristics were also compared according to the change in PA during lockdown #1 (decrease vs. no change or increase in PA) using multivariate logistic regression models including age, gender, type of surgery, and time elapsed since BS as covariates. Linear mixed models adjusted for baseline body weight (before lockdown #1) were used to assess changes in body weight over time. The terms "gender," "time," and "gender × time" were included as fixed effects. All tests were two-sided and a P-value < 0.05 was considered statistically significant. Analyses were conducted using R software version 4.0.3 (http://www.r-project.org).

Results

Individual characteristics of participants

Participants were middle-aged, mostly women (81%), and the most frequent procedure performed was RYGB (56%) (Supplementary Table 1). Patients included in this study did not differ from the non-included patients in terms of gender, preoperative age, BMI or body mass (Supplementary Table 2). However, they were more likely to present a comorbidity such as type 2 diabetes, hypertension or sleep apnea syndrome. The mean (SD) time elapsed between the time of BS and the time of the survey was 4.0 (2.5) y, and the mean percent total weight loss since the surgery was 28.7 (10.0) % (Supplementary Table 3). The mean weight loss at 1-year post-surgery was 29.7 (8.2) %. Since then, 45.0% of the patients experienced additional weight loss (-5.8 (4.8) % of 1-year body weight on average), and 55.0% experienced weight maintenance or weight regain (+7.2 (7.7) % of 1-year body weight on average). The vast majority of participants spent the lockdown #1 period at their usual place of residence, and a minority of participants reported following strict lockdown measures (i.e., no outings during the lockdown period).

Change in PA during lockdown #1

Two thirds of the participants reported a decrease in PA during lockdown #1 whereas one third reported either an increase or no change in PA (Supplementary Table 4). As shown in Table 1, a decrease in PA during lockdown #1 was associated with older age, a shorter time elapsed since BS, lower BMI loss since surgery, working from home, and a higher use of anti-anxiety drugs. The most frequently performed PA during lockdown #1 were house cleaning, walking and gardening, with no significant differences according to the change in PA (Figure 2). Compared to participants who reported a decrease in PA, those reporting an increase or no

change in PA were more likely to have engaged in indoor cycling or resistance training, and more likely to have started these PA during lockdown #1 (all P<0.05).

Changes in body weight, lifestyle and psychological outcomes during lockdown #1, and associations with the change in PA

Body weight increased on average by 1.5 (3.4) % during lockdown #1, and 13% of participants reported a ≥ 5% increase in body weight (Supplementary Table 4). Overall, 65% of participants reported an increase in sitting time, 30% reported a lower diet quality, and 64% reported a worsening in at least one eating behavior. A minority of participants reported an increase in alcohol consumption or smoking (10% and 8%, respectively). Increased fatigue and shorter sleep duration were reported by 45% and 30% of participants, respectively. Finally, 13% of participants reported moderately severe to severe depressive symptoms, and 8% reported severe anxiety. A decrease in PA was associated with a greater weight gain (mean [SD]: 2.1 [3.6] vs. 0.4 [2.6] %, P< 0.001) and longer screen time (Table 2). Participants who reported a decrease in PA were also more likely to report a ≥ 5% weight gain, lower diet quality, an increase in snacking, cravings and night-time eating, a decrease in sleep time, an increase in fatigue, and mild to severe depressive symptoms (all P<0.05).

Changes in body weight between before lockdown #1 to lockdown #2

Since a significant weight gain was observed in patients who had reported decreased PA during lockdown #1, these patients were followed-up 7 months later before and during lockdown #2 to record changes in body weight over this period of time. Of these, 71.6% reported a decrease in PA during lockdown #2. There was a significant weight gain (mean [95% CI]: +2.8 [1.7-3.8] kg, p<0.001 for time effect), which was greater in women (+3.0 [1.8-4.1] kg in women,

+2.5 [0.3-4.7] kg in men, $p<0.05$ for gender x time interaction) (Figure 3). Overall, 77.3% reported weight gain and 36.3% of participants reported a ≥ 5% weight gain.

Discussion

This study aimed to analyze the relations between the self-reported change in PA during the COVID-19 lockdown and a set of lifestyle and psychological outcomes in a cohort of 420 patients with a history of BS. Two thirds of patients reported a decrease in PA, which is in line with previous studies that found decreased PA in 40 to 61% of adults with obesity [10,17] and 49 to 55% of patients who underwent BS [6,7]. Although outdoor PA was restricted to one hour per day in a 1-km radius around home, outdoor walking was the most frequently performed leisure-time PA. Interestingly, patients who were able to maintain or increase PA during the lockdown were more likely to engage in indoor activities such as cycling or resistance training, and to have started these activities during the lockdown. This shift toward indoor activities may have been favored by the communication campaigns that were carried out to promote home-based PA during the lockdown [18–20].

We found a significant association between decreased PA and depressive symptoms, which is in agreement with a recent systematic review concluding that PA was associated with less depression during lockdown in adults [9]. Although observational, our findings and others suggest that promoting PA may be an effective strategy to reduce the negative effects of COVID-19 lockdowns on mental health outcomes. This may be particularly important in the post-BS setting, considering the disconcerting proportion of patients who reported moderately severe to severe depressive symptoms (26% in our cohort). Patients with obesity may be particularly vulnerable to the consequences of lockdown, for several reasons. First, obesity is a risk factor for severe forms of SARS-Cov-2 infection [21] and associated mortality [22], and

the fear of infection is known to be one of the main stressors during quarantine [23]. Second, obesity is associated with a lower socioeconomical level [24], described as a risk factor for mental health deterioration during the COVID-19 lockdown [25,26]. Finally, most healthcare services were reduced or completely cancelled for several months after the outbreak of the pandemic, leaving many patients with obesity with insufficient care or support [27].

During the first period of lockdown that occurred in France between March and May 2020, we observed a mean weight gain of 1.5% of pre-lockdown body weight in our cohort of patients with at least one year of follow-up after BS. This is comparable to the 2 kg average weight gain previously reported in patients who were more than 18 months post-BS [6]. The average weight gain reached a total of 2.8 kg at the second period of lockdown that took place in November and December 2020 among patients who had reported decreased PA during the first lockdown, with 36% of them reporting more than 5% weight gain. These findings show the detrimental effect of COVID-19 lockdown on weight trajectories after BS, with potentially negative consequences such as a relapse in obesity comorbidities and decreased quality of life, both tightly linked to weight regain after BS [28,29].

Importantly, during the first lockdown, the self-reported decrease in PA was associated with a greater weight gain (2.1% vs. 0.4%) and an increased proportion of patients with a $\geq$ 5% weight gain (16% vs. 6%). The decrease in PA was also associated with other behaviors that may have favored weight gain, such as increased screen time and a worsening of diet quality and eating behavior (i.e. snacking, cravings, loss of control episodes and night-time eating). These findings show the importance of providing extra care and support to post-BS patients who experienced important weight gain and a worsening of weight-related behavior or mental health outcomes during lockdown.

Our study presents some limitations. First, it relied on self-reported data, as is most often the case for online surveys. This may be of particular concern regarding the change in body weight reported during the lockdown periods, although evidence suggests that self-reported weight can be considered sufficiently accurate in patients undergoing BS when objective weight measurements are not available [30,31]. Second, most questions focused on the perceived change in health-related behaviors during the lockdown. This was specifically the case for the assessment of PA, where no information was collected regarding PA frequency or duration. Although our data showed a worsening of several outcomes in post-bariatric patients with decreased PA during the COVID-19 lockdown, they do not allow firm conclusions to be drawn on the potential benefits that PA may have in this context. Third, the generalization of our findings may be limited in the sense that most patients followed-up at our medical center live in the same area, and regional disparities were reported during the pandemic [32]. The patients included in this study were also more likely to suffer from a comorbidity before surgery compared to other patients followed up at our center, and they may, therefore, not be representative of the post-bariatric population as a whole. Finally, only selected patients were followed during the second lockdown (i.e.s those with decreased PA during the first lockdown), and we were not able to describe the changes occurring in the remaining patients who had reported no change or an increase in PA during the first lockdown.

In conclusion, French patients with a history of BS who reported decreased PA during the first period of COVID-19 lockdown (April-May 2020) were more likely to report weight gain, a worsening of eating behavior, increased fatigue, and more severe depressive symptoms. During the second period of lockdown (November-December 2020), one third of these same patients reported a ≥5% weight gain, suggesting a detrimental effect of the COVID-19 pandemic on

post-BS weight trajectories. Overall, these results point out the need to strengthen the behavioral management of patients who have undergone BS to counteract the negative impact of the pandemic.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest: The authors (Alice Bellicha, Pierre Bel Lassen, Christine Poitou, Laurent Genser, Florence Marchelli, Judith Aron-Wisnewsky, Cécile Ciangura, Flavien Jacques, Pauline Moreau, NutriOmics investigators, Karine Clément, Jean-Michel Oppert) declare that they have no conflict of interest.

Informed consent

Written informed consent was obtained from all individual participants included in the study.

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410

411 **Figures legends**

412

413 **Figure 1. Flow chart**

414 LAGB, laparoscopic gastric banding; RYGB, Roux-en-Y gastric bypass; SG, sleeve

415 gastrectomy

416

417 **Figure 2. Participation (%) in leisure-time and domestic physical activity during**

418 **lockdown #1 (April-May 2020)**

419 The lines represent the proportion of patients who participated in each type of physical activity

420 during the lockdown period. The symbol (◆) represents the proportion of patients who started

421 this physical activity during the lockdown.

422 * P< 0.05, ** P< 0.01, *** P< 0.001. P-values from χ^2 test or Fisher exact test, representing

423 the difference between patients who experienced a decrease vs. an increase or no change in

424 physical activity during lockdown.

425

426 **Figure 3. Body weight (kg) during lockdown #1 (April-May 2020) and lockdown #2 (Nov-**

427 **Dec 2020) in post-bariatric patients who had reported a decrease in physical activity**

428 **during lockdown #1 (N= 280)**

429 Data are mean (95% CI).

430 P-values for gender, time, and interaction (gender × time) terms in mixed models (adjusted for

431 body weight reported before lockdown #1).

432 [a] Significantly different from body weight reported before lockdown #1. [b] Significantly

433 different from body weight reported during lockdown #1.

434

435 **Table 1. Characteristics of post-bariatric patients according to changes in physical**

436 **activity during COVID-19 lockdown #1 (April-May 2020)**

	Change in physical activity during lockdown			
	Increase/ no change (N = 140)	**Decrease (N= 280)**	**OR [95% CI][a]**	**Adjusted P-value[a]**
Gender, ref: Women	118 (84.3%)	221 (78.9%)	1.00	ref
Men	22 (15.7%)	59 (21.1%)	1.34 [0.78-2.34]	0.29
Age, y	48.1 (13.3)	51.4 (11.2)	1.03 [1.01-1.05]	**0.003**
Type of surgery, ref: RYGB	74 (52.9%)	159 (56.8%)	1.00	ref
Sleeve	66 (47.1%)	121 (43.2%)	0.74 [0.48-1.14]	0.18
BMI at surgery, kg/m^2	46.1 (6.9)	44.2 (6.5)	0.96 [0.93-0.99]	**0.02**
Current BMI, kg/m^2	32.1 (6.5)	32.2 (5.7)	1.00 [0.96-1.04]	0.98
% total weight loss since surgery, %	-30.2 (10.6)	-28.0 (9.6)	1.02 [1.00-1.05]	0.09
Time elapse since surgery, y	4.4 (2.5)	3.9 (2.5)	0.89 [0.81-0.97]	**0.005**
Time elapse since surgery, y, ref: [1-5]	82 (58.6%)	202 (72.1%)	1.00	ref
> 5	58 (41.4%)	78 (27.9%)	0.89 [0.81; 0.97]	**0.005**
Type of lockdown, ref: Partial	118 (84.3%)	232 (83.8%)	1.00	ref
Total	22 (15.7%)	45 (16.2)	1.07 [0.61-1.91]	0.81
Lockdown at usual place, ref: Yes	131 (93.6%)	269 (96.8%)	1.00	ref
No	9 (6.4%)	9 (3.2%)	0.49 [0.18-1.31]	0.15
Professional activity during lockdown, ref: No change	48 (34.3%)	70 (25.1%)	1.00	ref
Work from home	21 (15.0%)	63 (22.6%)	2.08 [1.12-3.98]	**0.02**
No professional activity prior lockdown	28 (20.0%)	52 (18.6%)	1.15 [0.63-2.14]	0.64
Temporary unemployment	17 (12.1%)	22 (7.9%)	1.07 [0.50-2.30]	0.86
Other situation	26 (18.6%)	72 (25.8%)	1.99 [1.11-3.65]	**0.02**
Number of outings per week	3.3 (2.3)	3.0 (2.3)	0.93 [0.84-1.03]	0.15
Duration of outings, min/week	171 (253)	137 (214)	1.00 [0.99-1.00]	0.24
Went out for work, ref: Yes	28 (20.0%)	48 (17.1%)	1.00	ref
No	112 (80.0%)	232 (82.9%)	1.14 [0.66-1.86]	0.64
Went out for food shopping, ref: Yes	91 (65.0%)	202 (72.1%)	1.00	ref
No	49 (35.0%)	78 (27.9%)	0.73 [0.47-1.14]	0.17
Went out for physical activity, ref: Yes	41 (29.3%)	53 (18.9%)	1.00	ref
No	99 (70.7%)	227 (81.1%)	2.02 [1.23-3.31]	**0.006**
Smoking status, ref: Not smoker	120 (87.0%)	242 (87.7%)	1.00	ref
Current smoker	18 (13.0%)	34 (12.3%)	1.07 [0.57-2.04]	0.84
Use of anti-anxiety drugs, ref: No	129 (92.1%)	233 (83.2%)	1.00	Ref
Yes	11 (7.9%)	47 (16.8%)	2.70 [1.37-5.76]	**0.006**
Use of anti-depressant drugs, ref: No	126 (90.0%)	231 (82.8%)	1.00	ref
Yes	14 (10.0%)	48 (17.2%)	1.85 [0.97-3.66]	0.05

437 [a] Logistic regression with age, gender, type of surgery and time since bariatric surgery as covariates.

Table 2. Changes in body weight, health-related behaviors and mental health outcomes in post-bariatric patients according to changes in physical activity during COVID-19 lockdown #1 (April-May 2020)

	Change in physical activity during lockdown			
	Increase/ no change (N = 140)	**Decrease (N= 280)**	**OR [95% CI][a]**	**Adjusted P-value[a]**
Body weight				
Change in body weight, %	0.4 (2.6)	2.1 (3.6)	1.20 [1.11-1.30]	< **0.001**
Change in body weight, %, ref: Moderate increase: [0 to 5%[	98 (76.0%)	187 (73.3%)	1.00	ref
Decrease: < 0%	23 (17.8%)	28 (11.0%)	0.70 [0.37-1.31]	0.25
Large increase: ≥ 5%	8 (6.2%)	40 (15.7%)	3.15 [1.46-7.65]	**0.006**
Sitting time				
Change in sitting time, ref: Decrease/no change	75 (54.3%)	69 (25.0%)	1.00	Ref
Increase	63 (45.7%)	207 (75.0%)	3.83 [2.46-6.02]	< **0.001**
Sitting time, h/d	6.8 (3.8)	7.5 (3.6)	1.05 [0.99-1.12]	0.10
Screen time, h/d	5.1 (3.0)	6.4 (3.4)	1.15 [1.07-1.24]	< **0.001**
Diet quality and eating behavior				
Change in diet quality, ref: No change/better	103 (75.7%)	178 (67.2%)	1.00	Ref
Lower quality	33 (24.3%)	87 (32.8%)	1.68 [1.05-2.75]	**0.034**
Unfavorable change in eating behavior*, ref: No	65 (48.5%)	81 (30.3%)	1.00	ref
Yes	69 (51.5%)	186 (69.7%)	2.29 [1.47-3.58]	< **0.001**
Change in snacking, ref: No change/decrease	96 (68.6%)	137 (49.5%)	1.00	Ref
Increase	44 (31.4%)	140 (50.5%)	2.33 [1.51-3.63]	< **0.001**
Change in cravings, ref: No change/decrease	99 (70.7%)	138 (49.8%)	1.00	ref
Increase	41 (29.3%)	139 (50.2%)	2.80 [1.79-4.44]	< **0.001**
Change in loss of control episodes, ref: No change/decrease	101 (74.3%)	184 (66.7%)	1.00	ref
Increase	35 (25.7%)	92 (33.3%)	1.57 [0.99-2.54]	0.06
Change in night-time eating, ref: No change/decrease	111 (82.2%)	200 (73.0%)	1.00	ref
Increase	24 (17.8%)	74 (27.0%)	1.85 [1.10-3.19]	**0.02**
Alcohol and smoking consumption				
Change in alcohol consumption, ref: No change/decrease	127 (92.0%)	247 (88.8%)	1.00	ref
Increase	11 (8.0%)	31 (11.2%)	1.47 [0.72-3.18]	0.29
Change in smoking, ref: No change/decrease	129 (93.5%)	251 (90.6)	1.00	ref
Increase	9 (6.5%)	26 (9.4%)	1.65 [0.76-3.89]	0.21
Sleep and fatigue				
Change in sleep duration, ref: No change/increase	108 (77.1%)	185 (66.8%)	1.00	ref
Decrease	32 (22.9%)	92 (33.2%)	1.82 [1.13-2.98]	**0.01**
Sleep duration, h	6.9 (1.6)	6.8 (1.6)	0.99 [0.87-1.13]	0.88
Change in fatigue, ref: No change/decrease	92 (65.7%)	139 (49.6%)	1.00	ref
Increase	48 (34.3%)	141 (50.4%)	2.08 [1.36-3.23]	**<0.001**
Mental health outcomes				
GAD-7 score, ref: Minimal	81 (61.4%)	135 (51.9%)	1.00	ref
Mild	26 (19.7%)	63 (24.2%)	1.85 [1.06-3.28]	**0.03**
Moderate	17 (12.9%)	39 (15.0%)	1.69 [0.89-3.36]	0.12
Severe	8 (6.1%)	23 (8.8%)	2.42 [1.03-6.18]	0.05
PHQ-9 score, ref: Minimal	76 (58.5%)	109 (42.6%)	1.00	ref
Mild	32 (24.6%)	69 (27.0%)	1.91 [1.12-3.31]	**0.02**
Moderate	14 (10.8%)	37 (14.5%)	2.28 [1.14-4.76]	**0.02**
Moderately severe to severe	8 (6.2%)	41 (16.0%)	4.74 [2.14-11.76]	< **0.001**

[a] Logistic regression with age, gender, type of surgery and time since bariatric surgery as covariates.

* Patients reporting at least one negative change among the following outcomes: snacking, cravings, loss of control episodes, night-time eating.

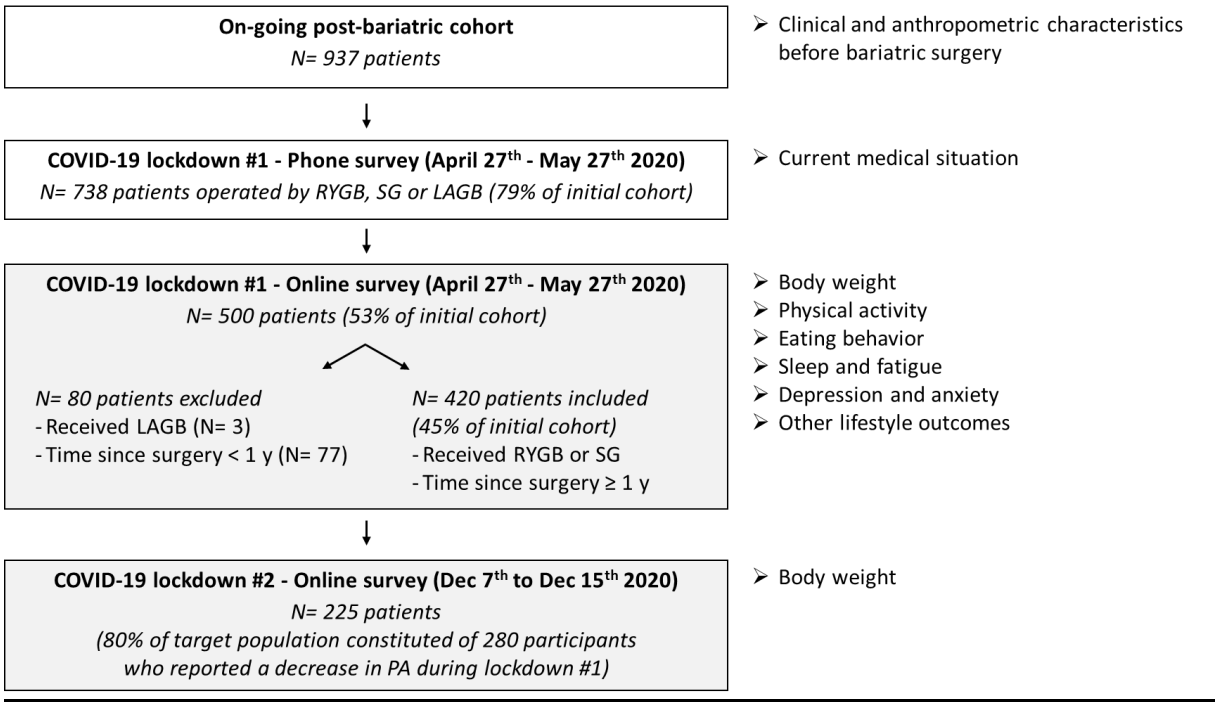

On-going post-bariatric cohort
N= 937 patients
Clinical and anthropometric characteristics before bariatric surgery
COVID-19 lockdown #1 - Phone survey (April 27th - May 27th 2020)
N= 738 patients operated by RYGB, SG or LAGB (79% of initial cohort)
Current medical situation
COVID-19 lockdown #1 - Online survey (April 27th - May 27th 2020)
N= 500 patients (53% of initial cohort)
N= 80 patients excluded
- Received LAGB (N= 3)
- Time since surgery < 1 y (N= 77)
N= 420 patients included
(45% of initial cohort)
- Received RYGB or SG
- Time since surgery ≥ 1 y
Body weight
Physical activity
Eating behavior
Sleep and fatigue
Depression and anxiety
Other lifestyle outcomes
COVID-19 lockdown #2 - Online survey (Dec 7th to Dec 15th 2020)
N= 225 patients
(80% of target population constituted of 280 participants who reported a decrease in PA during lockdown #1)
Body weight

Figure 1

	Patients reporting an increase or no change in physical activity during lockdown (N= 140)		Patients reporting a decrease in physical activity during lockdown (N= 280)	
	Participated during lockdown (%)	Started during lockdown (%)	Participated during lockdown (%)	Started during lockdown (%)
Leisure-time physical activity				
Walking	40.7	9.3	39.3	8.9
Indoor cycling	26.4	10.7	11.8***	3.2**
Resistance training	25.0	4.3	8.2***	0**
Indoor aerobic exercises	16.4	6.4	7.9*	3.9
Outdoor cycling	5.7	2.9	3.2	0.4*
Treadmill (walking, running)	5.0	2.1	1.8	1.1
Stretching	3.6	0.7	2.5	0
Yoga	3.6	0.7	2.5	0.4
Outdoor running	4.3	2.1	1.8	1.1
Dance	3.6	NA	1.1	NA
Indoor rowing	1.4	0.7	0.4	0
Domestic physical activity				
Cleaning	54.3	4.3	59.6	3.6
Gardening	22.9	4.3	20.0	4.6
Walking an animal	15.7	5.7	14.6	3.6
Housework	18.6	3.6	13.2	3.9
Playing with children	5.0	0.7	4.3	0

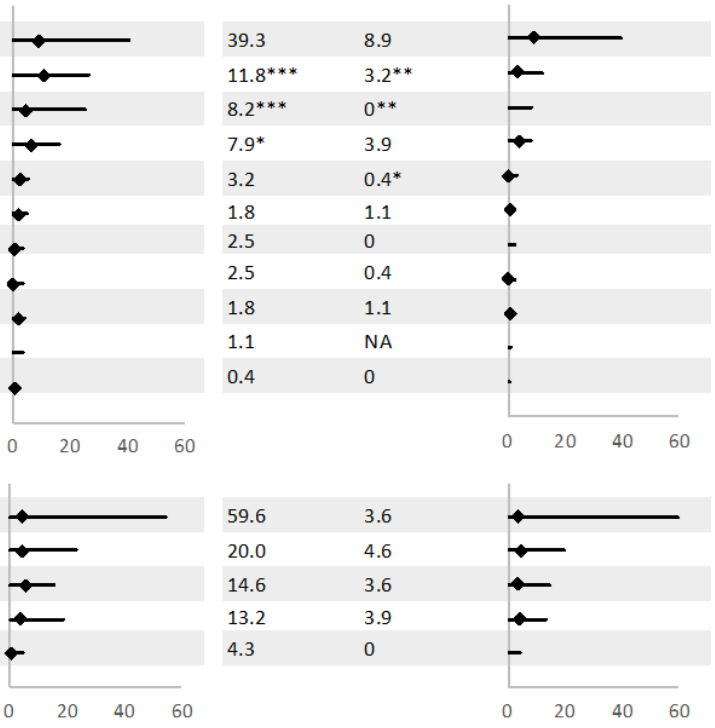
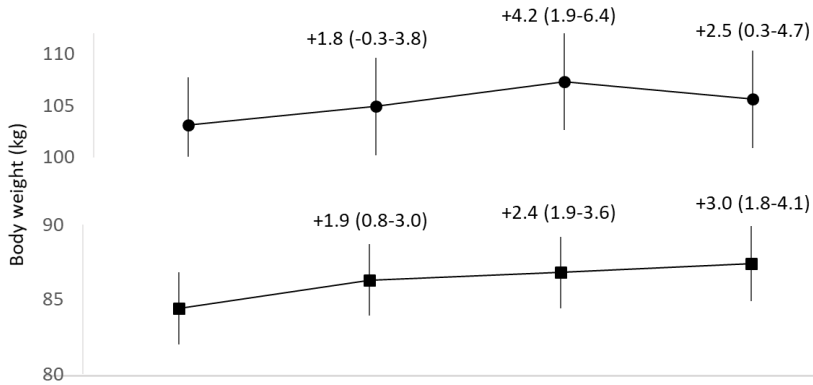


Figure 2



		Mean body weight (95% CI)				P-value		
		Before lockdown #1	During lockdown #1	Before lockdown #2	During lockdown #2	Gender	Time	Gender x Time
All	N	262	260	203	225	0.67	**< 0.001**	**0.047**
	kg	87.7 (87.1-88.4)	89.5 (88.8-90.1)[a]	91.0 (90.3-91.7)[a,b]	90.5 (89.8-91.2)[a]			
Men (●)	N	58	55	45	46	--	--	--
	kg	103.1 (98.5-107.8)	104.9 (100.2-109.6)	107.3 (102.6-112.0)[a,b]	105.6 (100.9-110.3)[a]			
Women (■)	N	204	205	158	179	--	--	--
	kg	84.4 (82.0-86.9)	86.3 (83.9-88.7)[a]	86.8 (84.4-89.3)[a]	87.4 (84.9-89.8)[a]			

Figure 3

SUPPLEMENTARY MATERIAL

Supplementary Table 1. Characteristics of subjects from the cohort before bariatric surgery

	N	All (N= 420)	Women (N= 339)	Men (N= 81)	P-value
Age at surgery, y	420	46.3 (12.0)	45.8 (11.8)	48.5 (12.5)	0.08
Type of surgery	420				1
RYGB, n (%)		233 (55.5%)	188 (55.5%)	45 (55.6%)	
SG, n (%)		187 (44.5%)	151 (44.5%)	36 (44.4%)	
Body weight, kg	402	123.8 (21.8)	119.5 (18.4)	142.5 (25.3)	**<0.001**
BMI, kg/m^2	402	44.8 (6.7)	44.6 (6.3)	45.7 (7.8)	0.23
Body fat, %	365	48.4 (4.9)	49.7 (3.7)	42.0 (4.9)	**<0.001**
Comorbidities, n (%)					
Type 2 diabetes	398	161 (40.5%)	121 (37.4%)	40 (54.1%)	**0.01**
Hypertension	395	188 (47.6%)	140 (43.8%)	48 (64.0%)	**0.002**
Sleep apnea	398	277 (69.6%)	206 (64.0%)	71 (93.4%)	**<0.001**

Data are mean (SD) or n (%).
P-value from Student's *t*-test for continuous data and from χ^2 test for categorical data.
RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy

Supplementary Table 2. Characteristics of patients from the post-bariatric cohort included (N= 420) and not included (N= 517) in the present study

	N	Included (N= 420)	Not included (N= 517)	P-value
Women	937	321 (76.4%)	405 (78.3%)	0.54
Age at surgery, y	937	46.3 (12.0)	45.6 (12.3)	0.37
Type of surgery	931			0.06
RYGB, n (%)		233 (55.5%)	293 (57.1%)	
SG, n (%)		187 (44.5%)	214 (41.7%)	
GB, n (%)		0 (0%)	6 (1.2%)	
Body weight, kg	896	123.8 (21.8)	124.6 (21.8)	0.58
BMI, kg/m^2	896	44.8 (6.7)	45. (6.8)	0.57
Body fat, %	807	48.4 (4.9)	47.8 (5.3)	0.09
Comorbidities, n (%)				
Type 2 diabetes	886	161 (40.5%)	238 (48.8%)	**0.02**
Hypertension	883	188 (47.6%)	286 (58.6%)	**0.001**
Sleep apnea	885	277 (69.6%)	369 (75.8%)	**0.048**

Data are mean (SD) or n (%).
P-value from Student's *t*-test for continuous data and from χ^2 test for categorical data.
GV, gastric banding; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy

Supplementary Table 3. Characteristics of the cohort during lockdown #1 (April-May 2020) according to gender

	N	All (N= 420)	Women (N= 339)	Men (N= 81)	P
Characteristics at the time of the survey					
Age, y	420	50.3 (12.0)	49.8 (11.9)	52.3 (12.4)	0.10
Time since surgery, y	420	4.0 (2.5)	4.1 (2.6)	3.9 (2.1)	0.66
Time since surgery, n (%)	420				0.55
1-5 y		284 (67.6%)	232 (68.4%)	52 (64.2%)	
> 5 y		136 (32.4%)	107 (31.6%)	29 (35.8%)	
% total weight loss since surgery, %	376	-28.7 (10.0)	-29.1 (9.7)	-27.0 (11.0)	0.13
Current body weight, kg	389	89.1 (18.8)	85.5 (16.4)	103.4 (21.0)	**<0.001**
Current BMI, kg/m^2	371	32.1 (6.0)	31.9 (5.8)	33.2 (6.7)	0.14
Current smoker, n (%)	414	52 (12.6%)	42 (12.5%)	10 (12.7%)	1
Takes anti-anxiety drugs, n (%)	420	58 (13.8%)	49 (14.5%)	9 (11.1%)	0.54
Takes anti-depressant drugs, n (%)	419	62 (14.8%)	52 (15.4%)	10 (12.3%)	0.60
Lockdown at usual place, n (%)	418	400 (95.7%)	324 (96.1%)	76 (93.8%)	0.54
Partial lockdown, n (%)	417	350 (83.9%)	281 (83.6%)	69 (85.2%)	0.86
Professional activity during lockdown, n (%)	419				0.33
No change		118 (28.2%)	95 (28.1%)	23 (28.4%)	
Work from home		84 (20.0%)	71 (21.0%)	13 (16.0%)	
Did not work before		80 (19.1%)	59 (17.5%)	21 (25.9%)	
Temporary unemployment		39 (9.3%)	30 (8.9%)	9 (11.1%)	
Other situation		98 (23.4%)	83 (24.6%)	15 (18.5%)	
Number of outings per week	344	3.1 (2.3)	3.0 (2.3)	3.2 (2.2)	0.46
Duration of outings, min/week	325	149 (228)	143 (203)	172 (312)	0.49
Went out for food shopping, n (%)	420	293 (69.8%)	234 (69.0%)	59 (72.8%)	0.59
Went out for physical activity, n (%)	420	94 (22.4%)	77 (22.7%)	17 (21.0%)	0.85
Went out for work, n (%)	420	76 (18.1%)	63 (18.6%)	13 (16.0%)	0.71

Data are mean (SD) or n (%). P-value from Student's *t*-test for continuous data and from χ^2 test for categorical data.

Supplementary Table 4. Changes in body weight, health-related behaviors and mental health outcomes according to gender during lockdown #1 (April-May 2020)

	N	All (N= 420)	Women (N= 339)	Men (N= 81)	P
Body weight					
Change in body weight, kg	384	1.3 (2.9)	1.4 (3.0)	1.0 (2.5)	0.25
Change in body weight, %	384	1.5 (3.4)	1.7 (3.6)	0.9 (2.6)	**0.03**
Change in body weight, n (%)	384				**0.02**
Large increase (≥ 5%)		48 (12.5%)	45 (14.7%)	3 (3.9%)	
Moderate increase (0 to 4.9%)		285 (74.2%)	225 (73.3%)	60 (77.9%)	
Decrease (<0%)		51 (13.3%)	37 (12.1%)	14 (18.2%)	
Physical activity and sitting time					
Change in physical activity, n (%)	420				0.42
Increase		58 (13.8%)	49 (14.5%)	9 (11.1%)	
Decrease		280 (66.7%)	221 (65.2%)	59 (72.8%)	
No change		82 (19.5%)	69 (20.4%)	13 (16.0%)	
Change in sitting time, n (%)	414				0.84
Increase		270 (65.2%)	220 (65.9%)	50 (62.5%)	
Decrease		21 (5.1%)	17 (5.1%)	4 (5.0%)	
No change		123 (29.7%)	97 (29.0%)	26 (32.5%)	
Sitting time, h/d	383	7.3 (3.6)	7.3 (3.5)	7.3 (4.0)	0.87
Screen time, h/d	394	6.0 (3.3)	6.0 (3.2)	6.0 (3.7)	0.95
Diet quality and eating behavior					
Change in diet quality, n (%)	401				0.90
Better quality		55 (13.7%)	46 (14.1%)	9 (12.2%)	
Lower quality		120 (29.9%)	98 (30.0%)	22 (29.7 %)	
No change		226 (56.4%)	183 (56.0%)	43 (58.1%)	
Change in snacking, n (%)	417				0.99
Increase		184 (44.1%)	148 (44.0%)	36 (44.4%)	
Decrease		30 (7.2%)	24 (7.1%)	6 (7.4%)	
No change		203 (48.7%)	164 (48.8%)	39 (48.1%)	
Change in cravings, n (%)	417				**0.02**
Increase		180 (43.2%)	157 (46.7%)	23 (28.4%)	
Decrease		31 (7.4%)	24 (7.1%)	7 (8.6%)	
No change		206 (49.4%)	155 (46.1%)	51 (63.0%)	
Change in loss of control episodes, n (%)	412				0.54
Increase		127 (30.8%)	105 (31.5%)	22 (27.8%)	
Decrease		35 (8.5%)	26 (7.8%)	9 (11.4%)	
No change		250 (60.7%)	202 (60.7%)	48 (61.8%)	
Change in night-time feeding, n (%)	409				0.28
Increase		98 (24.0%)	84 (25.6%)	14 (17.3%)	
Decrease		33 (8.1%)	25 (7.6%)	8 (9.9%)	
No change		278 (68.0%)	219 (66.8%)	59 (72.8%)	
Unfavorable change in eating behavior*, n (%)	401				0.85
Yes		255 (63.6%)	206 (64.0%)	49 (62.0%)	
No		146 (36.4%)	116 (36.0%)	30 (38.0%)	
Alcohol and smoking consumption					
Increased alcohol consumption, n (%)	416	42 (10.1%)	35 (10.4%)	7 (8.6%)	0.78
Increased smoking, n (%)	420	35 (8.3%)	29 (8.7%)	6 (7.4%)	0.88
Mental health indicators					
Change in sleep duration, n (%)	417				0.06
Increase		86 (20.6%)	77 (22.9%)	9 (11.1%)	
Decrease		124 (29.7%)	98 (29.2%)	26 (32.1%)	
No change		207 (49.6%)	161 (47.9%)	46 (56.8%)	
Sleep duration, h/d	389	6.8 (1.6)	6.9 (1.6)	6.7 (1.8)	0.37
Change in fatigue, n (%)	420				0.85
Increase		189 (45.0%)	153 (45.1%)	36 (44.4%)	
Decrease		48 (11.4%)	40 (11.8%)	8 (9.9%)	
No change		183 (43.6%)	146 (43.1%)	37 (45.7%)	

GAD-7 score, n (%)	392				0.07
Minimal		216 (55.1%)	168 (52.7%)	48 (65.8%)	
Mild		89 (22.7%)	80 (25.1%)	9 (12.3%)	
Moderate		56 (14.3%)	44 (13.8%)	12 (16.4%)	
Severe		31 (7.9%)	27 (8.5%)	4 (5.5%)	
PHQ-9 score, n (%)	386				0.20
Minimal		185 (47.9%)	141 (45.3%)	44 (58.7%)	
Mild		101 (26.2%)	87 (28.0%)	14 (18.7%)	
Moderate		51 (13.2%)	42 (13.5%)	9 (12.0%)	
Moderately severe to severe		49 (12.7%)	41 (13.2%)	8 (10.7%)	

P-value from Student's *t*-test for continuous data and from χ^2 test for or Fisher exact test for categorical data.
P-value from t-test. P-value from χ^2 test. P-value from.
* Patients reporting at least one negative change among the following outcomes: snacking, cravings, loss of control episodes, night-time eating