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

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1 **Effect of COVID-19 lockdowns on physical activity, eating behavior, body weight and**
2 **psychological outcomes in a post-bariatric cohort**

3

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39

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42

43 **Abstract**

44

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

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

55 **Results:** During lockdown #1 (N=420 patients included, 44% response rate), decreased PA
56 was reported by 67% patients. Compared to those who reported increased or unchanged PA,
57 patients with decreased PA were more likely to report a $\geq 5\%$ weight gain (OR [95%CI]: 3.15
58 [1.46-7.65], increased fatigue (2.08 [1.36-3.23]), a worsening of eating behavior (2.29 [1.47-
59 3.58]), and moderate-to-severe depressive symptoms (4.74 [2.14-11.76]). During lockdown #2
60 (N=225 patients, 80% response rate), significant weight gain since before lockdown #1 was
61 reported (+2.8 [95% CI: 1.7-3.8] kg, $p < 0.001$), with 36% patients reporting a $\geq 5\%$ weight
62 gain.

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

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

67

68 **Key points**

- 69 • 67% of post-bariatric patients reported decreased physical activity during lockdown
- 70 • Patients who reported decreased physical activity reported greater weight regain
- 71 • They were also more likely to report moderate-to-severe depressive symptoms
- 72 • Eating behavior was adversely modified in patients with decreased physical activity

73 **Introduction**

74

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

86

87 PA is an important component of the management of patients undergoing bariatric surgery
88 (BS), as it is associated with a substantial improvement in physical fitness and a slightly greater
89 weight loss after BS [5]. PA may also prevent weight regain after BS [5]. Two online surveys
90 conducted in the USA reported a decrease in PA during the COVID-19 lockdown in 49% and
91 55% of patients with a history of BS [6,7]. In addition, two studies conducted in the context of
92 COVID-19 lockdown in the USA and in Italy in 208 and 48 patients after BS, respectively,
93 found that a decrease in PA, or a lower weekly duration of PA, was associated with a greater
94 weight gain, thus suggesting the importance of PA for weight control after BS [6,8].

95

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

98 this population [6]. A large proportion of patients with a history of BS reported a decrease in
99 healthy food eating (46%) and an increase in snacking (63%), loss of control when eating
100 (48%) or depressed mood (44%) [6], or anxiety (67%) and depression (83%) [7]. In the general
101 population [9], as well as in patients with obesity [10], PA during lockdown has been associated
102 with a lower prevalence of depressive symptoms and anxiety disorders [9,10]. The associations
103 between the change in PA during the lockdown and mental health outcomes warrant further
104 investigation in patients with a history of BS.

105

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

109

110 **Material and Methods**

111

112 **Study cohort**

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

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

125

126 **Data collection during COVID-19 lockdowns**

127 A first COVID-19 lockdown (lockdown #1) took place in France from March 17th to May 11th
128 2020. The 937 BS patients followed in the cohort were contacted by phone and 738 patients
129 provided information about their current medical situation (Figure 1) [12]. Of these, 500
130 patients also contributed to an online survey including a set of standardized questions that has
131 been used in a large cohort study at the national level [14]. Eighty patients were further
132 excluded for the reasons detailed above. Therefore, 420 patients were included in the present
133 analyses.

134

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

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

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

158

159 **Statistical analysis**

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

171

172 **Results**

173

174 **Individual characteristics of participants**

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

188

189 **Change in PA during lockdown #1**

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

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

199

200 **Changes in body weight, lifestyle and psychological outcomes during lockdown #1, and** 201 **associations with the change in PA**

202 Body weight increased on average by 1.5 (3.4) % during lockdown #1, and 13% of participants
203 reported a $\geq 5\%$ increase in body weight (Supplementary Table 4). Overall, 65% of participants
204 reported an increase in sitting time, 30% reported a lower diet quality, and 64% reported a
205 worsening in at least one eating behavior. A minority of participants reported an increase in
206 alcohol consumption or smoking (10% and 8%, respectively). Increased fatigue and shorter
207 sleep duration were reported by 45% and 30% of participants, respectively. Finally, 13% of
208 participants reported moderately severe to severe depressive symptoms, and 8% reported
209 severe anxiety. A decrease in PA was associated with a greater weight gain (mean [SD]: 2.1
210 [3.6] vs. 0.4 [2.6] %, $P < 0.001$) and longer screen time (Table 2). Participants who reported a
211 decrease in PA were also more likely to report a $\geq 5\%$ weight gain, lower diet quality, an
212 increase in snacking, cravings and night-time eating, a decrease in sleep time, an increase in
213 fatigue, and mild to severe depressive symptoms (all $P < 0.05$).

214

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

216 Since a significant weight gain was observed in patients who had reported decreased PA during
217 lockdown #1, these patients were followed-up 7 months later before and during lockdown #2
218 to record changes in body weight over this period of time. Of these, 71.6% reported a decrease
219 in PA during lockdown #2. There was a significant weight gain (mean [95% CI]: +2.8 [1.7-
220 3.8] kg, $p < 0.001$ for time effect), which was greater in women (+3.0 [1.8-4.1] kg in women,

221 +2.5 [0.3-4.7] kg in men, $p < 0.05$ for gender x time interaction) (Figure 3). Overall, 77.3%
222 reported weight gain and 36.3% of participants reported a $\geq 5\%$ weight gain.

223

224 **Discussion**

225 This study aimed to analyze the relations between the self-reported change in PA during the
226 COVID-19 lockdown and a set of lifestyle and psychological outcomes in a cohort of 420
227 patients with a history of BS. Two thirds of patients reported a decrease in PA, which is in line
228 with previous studies that found decreased PA in 40 to 61% of adults with obesity [10,17] and
229 49 to 55% of patients who underwent BS [6,7]. Although outdoor PA was restricted to one
230 hour per day in a 1-km radius around home, outdoor walking was the most frequently
231 performed leisure-time PA. Interestingly, patients who were able to maintain or increase PA
232 during the lockdown were more likely to engage in indoor activities such as cycling or
233 resistance training, and to have started these activities during the lockdown. This shift toward
234 indoor activities may have been favored by the communication campaigns that were carried
235 out to promote home-based PA during the lockdown [18–20].

236

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

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

251

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

262

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

271

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

290

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

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

299

300 **Ethical Approval**

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

304

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

309

310 **Informed consent**

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

312

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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 \times 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.

438 **Table 2. Changes in body weight, health-related behaviors and mental health outcomes**
439 **in post-bariatric patients according to changes in physical activity during COVID-19**
440 **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

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

442 * Patients reporting at least one negative change among the following outcomes: snacking, cravings, loss of control episodes,

443 night-time eating.

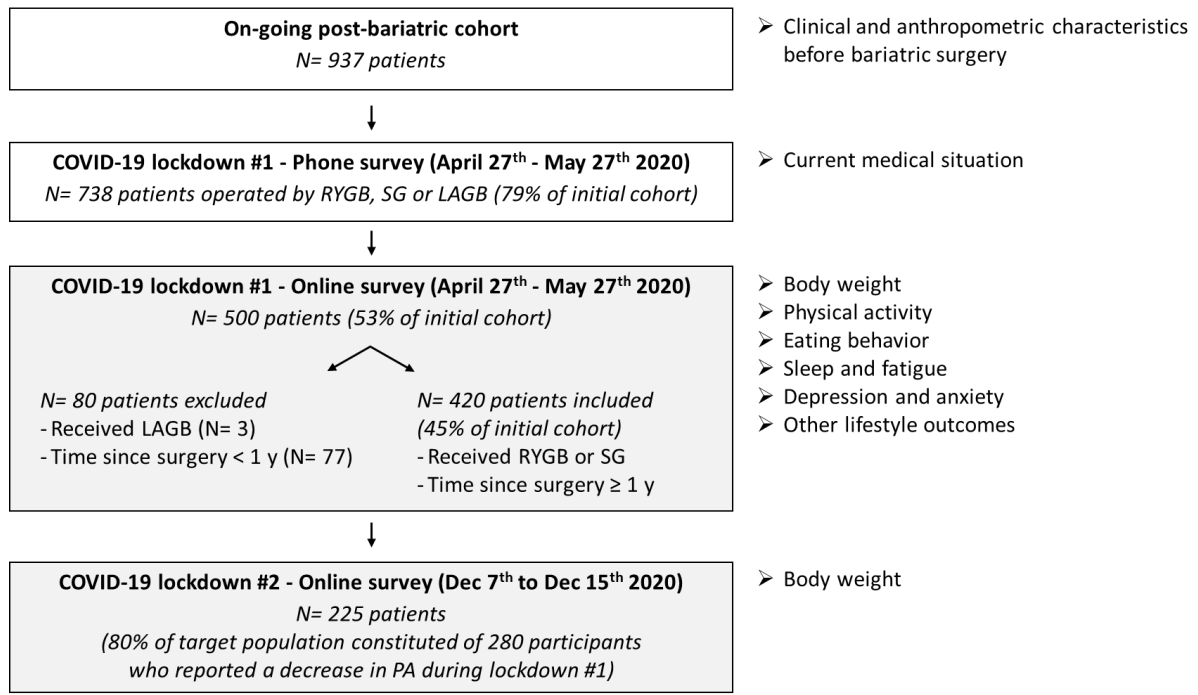


Figure 1

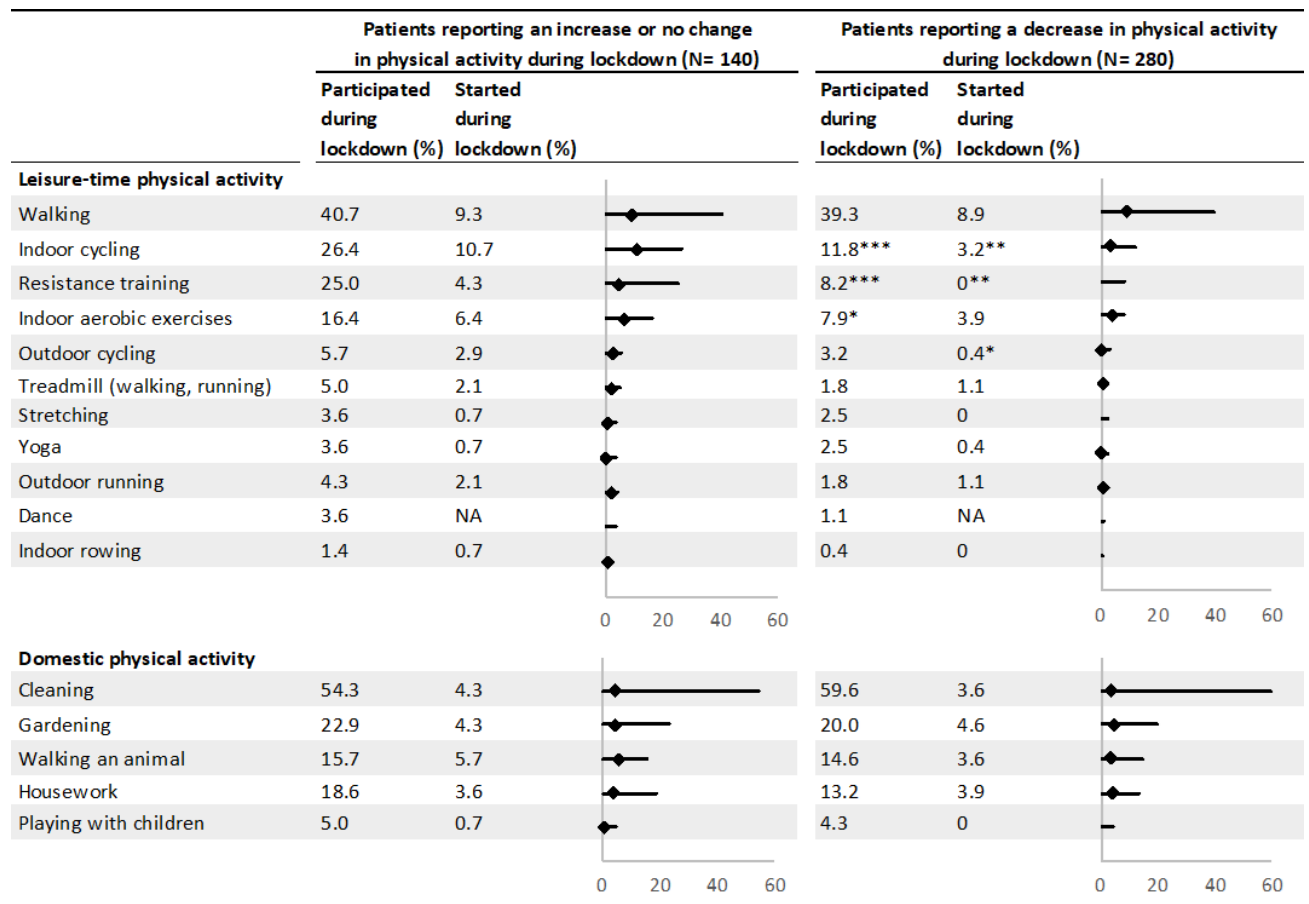
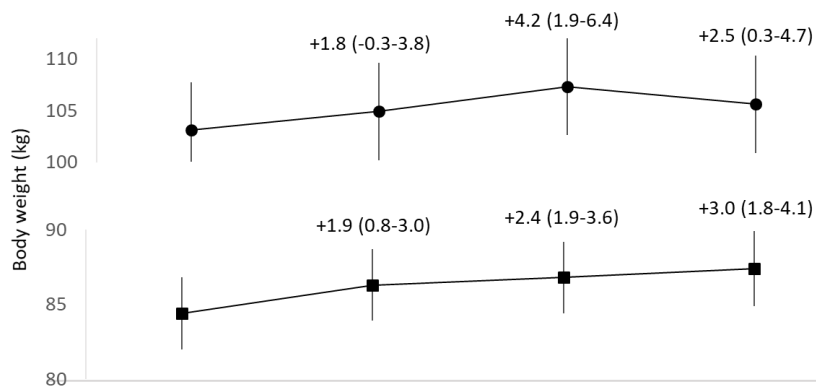


Figure 2



		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 ($\geq 5\%$)		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