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Preventive Medicine Reports

1 **Objective evaluation of the first post-lockdown on physical activity, sedentary behavior**
2 **and food choice in a sample of French young adult students**

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40 **Abstract**

41 From mid-March through early May 2020, France limited outdoor activities to one hour per
42 day because of the Covid-19 epidemic. This inside lockdown could have a lasting impact on
43 post-lockdown sedentary and physical activities and food choice. The aim of this study is to
44 compare behaviors before and after the lockdown in a sample of French young adult
45 students (sex ratio=1:1, 22 ± 3 y old). Over a period of 4 days in both April and after mid-May
46 2020, 50 students used the WellBeNet smartphone application to record accelerometry data
47 to evaluate their sedentary behavior and physical activity, and food consumption. Some
48 behaviors remained stable for both periods: sedentary behavior, light-intensity activity, the
49 number of meals per day, the number of portions of fruits, nuts, dairy products, vegetables,
50 legumes and meat-fish-egg. Moderate-intensity activity duration was higher (+ 1.4%,
51 $p < 0.0001$), whereas the food balance score was lower (-0.3, $p = 0.06$) during the return to
52 free-living conditions. Different food behaviors in male and female students were observed
53 between the two periods. The total daily number of food portions and of whole starchy
54 products post lockdown was lower in female students (-1.07 and -0.47 portion/d, $p = 0.07$ and
55 0.04) but remained stable in male students, post-lockdown. The consumption of snacks was
56 similar in men and women during the lockdown, whereas it was higher in men post-
57 lockdown (+0.8 portion/d, $p = 0.01$). During the COVID-19 lockdown, food consumption
58 choice was better overall and the moderate-intensity physical activity level was lower
59 compared with the free-living subsequent period.

60

61

62

63 **Keywords:** lockdown, sedentary behavior, physical activity, food choice, student, COVID-19

64

65 **Introduction**

66 The coronavirus led to the lockdown of more than half of the world's population (i.e., more
67 than 3.9 billion people were confined in May 2020, Euronews, 2020). In France, the first
68 lockdown took place from March 17 to May 11, 2020 (Decree No. 2020-260, 2020).-Outdoor
69 activity was limited to a maximum of one hour and to within a radius of one kilometer
70 around the home. The lockdown had an impact on people's work, school children's and
71 university students' activities, social relationships, lifestyle habits such as physical activity
72 (PA) level and food behavior.

73 A systematic review was undertaken by Stockwell et al. (2021) to analyze the changes in PA
74 and sedentary behaviors from before to during the COVID-19 pandemic lockdown. This
75 review included 66 articles of which 64 showed behavioral changes measured either by
76 devices (only in four studies out of 66) or by self-report tools (questionnaires) in various
77 populations (Stockwell et al., 2021). In the healthy adult population, 13 out of 18 studies
78 reported longer sedentary behavior during the lockdown. All the studies except one
79 indicated less time spent in PA during lockdown in comparison with the period before
80 COVID-19.

81 A few studies compared young adult students' PA during and after lockdown. A study in
82 Bangladesh found a similar percentage of students having no physical training after than
83 during lockdown (47.5 % vs 43.6%) (Shaun et al., 2021). The percentages of students who
84 practiced PA one to three times within a week, were also similar (37.6% and 36.3%) during
85 both periods (Shaun et al., 2021). McCarthy et al. (2021) showed that young British people
86 were engaged in significant level of PA before lockdown (160 minutes/week), then
87 ~~decreased~~ spent 20 minutes less per week in PA level during lockdown and became even less
88 active post lockdown (no PA).

89 Twenty-three studies pertaining to dietary changes during the lockdown were included in
90 the scoping review of Bennett et al. (2021), and are mostly based on self-reported data
91 among adult Western populations. This review showed favorable and unfavorable changes
92 in dietary habits during the lockdown. Eleven studies reported better dietary habits with a
93 higher consumption of fresh food and home cooking and a lower consumption of alcohol,
94 sweets, processed and fried food, while ten studies reported more snacks consumed by 40%

95 to 50% of the consumers and two other studies showed a higher alcohol consumption. The
96 results of the studies were country-, age- and sex-dependent. The study of Ruiz-Roso et al.
97 (2020) analyzed the food consumption of adolescents during confinement in five countries
98 using a questionnaire comparing consumption before vs. during confinement. This survey
99 showed a significant higher consumption of fruits and vegetables in girls aged 10 to 19 years.
100 43% and 33% of the adolescents consumed vegetables and fruit every day during the
101 confinement. These percentages were higher than those observed before lockdown (33%
102 and 25%, respectively). A cross-sectional study by López-Bueno et al. (2020) of several
103 thousand Spanish participants showed that 55% vs 49% of participants were compliant with
104 the fruit consumption recommended guidelines during and before the lockdown. The results
105 of the survey of Scarmozzino et al. (2020) showed contrasting results: more than half of the
106 participants declared that they had not felt any attraction for fruit and vegetables during the
107 confinement, 21% declared that they had a higher consumption of fruit and vegetables and
108 9% reported that they had a lower consumption, notably for financial reasons. An
109 international study of 1000 people, half of whom were between 18 and 35 years of age, also
110 revealed a degraded evaluation of diet during lockdown, based on subjective scores other
111 than fruit and vegetable consumption (Ammar et al., 2020). The French Nutrinet Santé study
112 also showed contrasting results on eating habits during lockdown. For some people,
113 lockdown produced adverse health changes with an average weight gain of 1.8 kg in two
114 months associated with higher energy intake of 443 kcal/day and snacking on sweets,
115 cookies and cakes, and higher alcohol consumption. Eating more compensated for boredom
116 and reduced stress. Participants who presented this profile were more often young, female,
117 telecommuting during lockdown with high anxiety and depressive symptoms, high education
118 but lower income, with children present at home. For other young, overweight or obese,
119 telecommuting individuals or students with high education and income, the lockdown
120 resulted in a 2-kg weight loss, more time spent cooking, greater consumption of fruits,
121 vegetables, legumes, nuts and fish, and lower consumption of sweets, cookies and cakes and
122 alcohol. The lockdown led to an improvement in eating habits in the latter group
123 (Deschasaux-Tanguy et al., 2020).

124 Before collecting the data, our hypothesis is that the lockdown could have drastically
125 changed life habits, including high level of sedentary behavior and changes in diet. Are these

126 behavioral changes sustainable post-lockdown when free-living conditions are restored? Our
 127 aim is to assess changes in time spent in sedentary behavior and physical activity, and in diet
 128 between sexes in a group of 22 year-old French students. The contribution of the present
 129 study also concerns more accurate, reliable and safe means to measure behavioral changes
 130 during and after an epidemic.

131

132 2. Method

133 2.1 Sample of volunteers

134 This observational study was conducted on a non-probability convenience sample of 50
 135 volunteers. They were 22-years old, students, Caucasian, half of the volunteers male. They
 136 were anonymously recruited through social networks during the lockdown.

137 Only 10% of the volunteers were alone during the lockdown; the others were in a family or
 138 in a couple. Their anthropometric characteristics are shown in Table 1. Their height and
 139 weight are close to the young French adult average. Almost all had a normal body mass
 140 index (BMI) between 18.5 and 24.9 kg/m². Three volunteers were underweight (<18.5 kg.m⁻²)
 141 ²), five were overweight (25<BMI<29.9 kg.m⁻²) and one was obese. This sample is composed
 142 of 12% of overweight subjects as opposed to 17% in the national average. The average waist
 143 circumference is normal and lower than the value for which there is a risk of non-
 144 communicable chronic disease.

145 This observational study was conducted according to the guidelines laid down in the
 146 Declaration of Helsinki. The protocol was approved by the French Committee for the
 147 Protection of Human Subjects (Sud-Est VI). It was registered under the references 2020/CE
 148 06. All participants provided informed consent prior to participating in the study.

149 **Table 1**

150 **Anthropometric characteristics of the sample (Mean ± SD).**

				Hip circumference (cm)	Waist circumference (cm)	BMI (kg/m ²)
Sex	n	Height (cm)	Weight (kg)			

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Women	25	165.5 ± 6.3	61.1 ± 10.0	96.2 ± 6.5	73.1 ± 8.9	22.3 ± 3.2
Men	25	177.5 ± 8.8	68.5 ± 10.1	88.6 ± 8.9	78.7 ± 9.1	21.7 ± 2.0

151

152 *2.2 Measures*

153 The volunteers downloaded the WellBeNet app at the Play Store and informed the
154 researcher about age and sex. They filled in height and weight in the app. They were then
155 asked to use the eMouve and NutriQuantic parts of the WellBeNet application for three to
156 five consecutive days both from 11 April to 7 May, and after the lockdown from 12 May to
157 24 May). They were told to wear the smartphone in a pant pocket to collect accelerometry
158 data for the waking period (8:00 AM to 10:00 PM) by using eMouve. In previous studies, we
159 developed and published eMouve algorithms to quantify PA and sedentary behaviors. From
160 accelerometry data collected during different types of activity in controlled and free-living
161 conditions, we defined three activity thresholds to discriminate immobility/light intensity
162 activity, light- /moderate- intensity activity, and moderate/vigorous intensity activity in
163 normal weight and overweight subjects (Guidoux et al., 2017; Rousset et al., 2017).
164 Algorithms automatically rank, minute by minute, accelerometry data in each of the four
165 categories according to their intensity and in relation to the threshold values. eMouve
166 provides an accurate estimation of time spent in four activity categories: immobility, light-,
167 moderate- and vigorous-intensity, i.e., approximately 3.25% of mean error in absolute value.
168 .

169 NutriQuantic was used to collect the daily number of meals, and of portions consumed in
170 each of the 12 food groups (fruit, vegetable, legume, nut, refined starchy product, meat-fish-
171 egg, dairy product, fatty-salty-sugary product, snack, alcohol, whole starchy product and hot
172 drink) during the same period. On the basis of these groups, we designed four major
173 categories: plant products, animal products, junk food and starchy products. The plant
174 product category is the sum of the number of portions of fruits, vegetables, nuts and
175 legumes; the animal product category is the sum of the dairy and meat-fish-egg groups; the
176 junk food category is the sum of alcohol, fatty-salty-sugary products and snacks; and the
177 starchy food category is the sum of refined and whole starchy products. A guide for the
178 estimation of a portion was sent to each participant. A food balance score was assigned to

179 each of the 11 food categories based on the number of portions and according to French and
 180 international nutritional guidelines. The score in each category varies between 0
 181 (unsatisfactory), 0.5 (intermediate) and 1 (satisfactory). The nutritional balance score of the
 182 diet is the result of a confidential calculation over the 11 food groups (Cissoko et al., 2015)
 183 and of the French nutritional guidelines (Hercberg et al., 2008).

184 *2.3 Analytical plan and statistical analyses*

185 The analytical plan for data analysis was determined before the data collection. We chose to
 186 compare behavioral components between the two periods (during and post lockdown in
 187 female and male students). Statistical analysis software, SAS version 9.4, was used to test
 188 the normal distribution of the data (Shapiro-Wilks). We used a log transformation when the
 189 variables were not normally distributed. A mixed model approach (MIXED procedure) was
 190 then carried out to assess the effect of sex, subject nested in the sex, period and sex*period
 191 interaction on PA and diet components. Subject was considered as a random factor in this
 192 model. A mean comparison test (LSMeans) was carried out when $p < 0.05$ and the effect size
 193 (ES) was calculated with the Hedges'g equation:

$$194 \quad ES = \frac{\text{mean}(F1) - \text{mean}(F2)}{SD_{pooled}}$$

195 Where F1 and F2 are the two levels of the studied factors (lockdown and post-lockdown for
 196 the period factor, or men and women for the sex factor), SD was the standard deviation.

197 $SD_{pooled} = \sqrt{\frac{SD(F1)^2 + SD(F2)^2}{2}}$. The mean behavioral variations shown in Fig.1 and Fig.2
 198 were calculated as the ratio of the difference between behaviors recorded during the two
 199 periods (or in the two sexes) to the behaviors recorded during lockdown (or in men).

200

201 **3. Results**

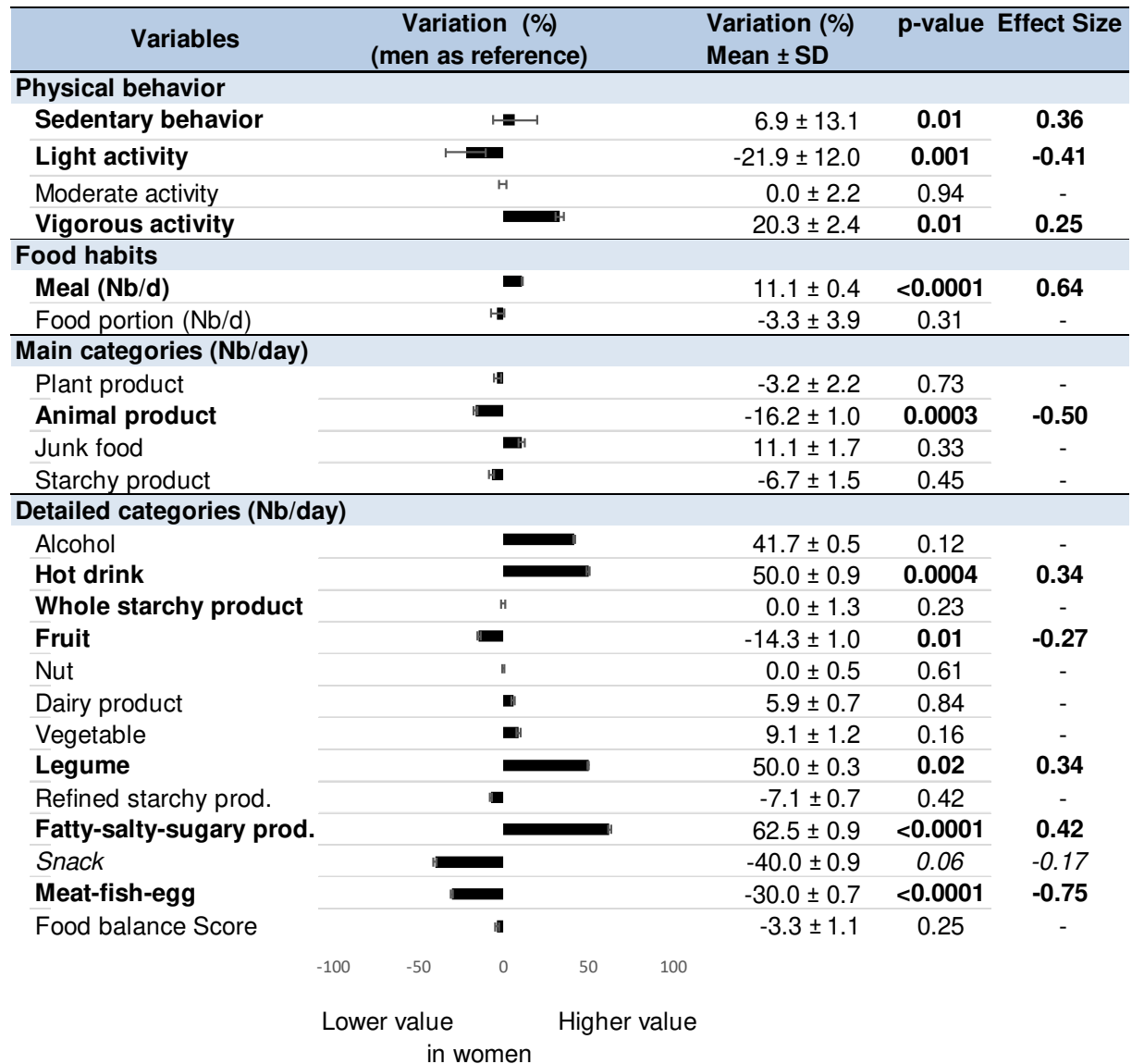
202 *3.1 Effect of post-lockdown on sedentary and physical activity*

203 Fig. 1 shows the changes in percentage of time spent in the four categories of PA post-
 204 lockdown. The moderate-intensity activity significantly was 48.3% higher post-lockdown.
 205 This gap represents about 10 additional minutes of PA per day. The effect size of period for
 206 moderate intensity PA was medium. Sedentary behavior and light-intensity activity remained
 207 stable between the two periods. Volunteers spent about 73% and 21% of their waking time

220

221

222

223 **Fig. 2. Differences in behavior between men and women (Mean \pm SD) and significance.**

224

225 Table 2

226 Behavioral components in men and women during and after the lockdown (Mean (SD)) and
 227 significance of the period*sex interaction.

Period*sex	Lockdown_Men	Lockdown_Women	Post_Men	Post_Women	p-value
Variables	Mean (SD)				

Physical behavior (%)					
Sedentary behavior	70.1 (11.8)	77.1 (14.2)	71.8 (11.0)	74.4 (14.3)	0.19
Light activity	25.3 (10.8)	18.9 (13.4)	23.2 (9.6)	19.6 (12.9)	0.23
Moderate activity	2.9 (1.8)	2.9 (1.9)	4.3 (2.5)	4.4 (2.7)	0.79
Vigorous activity	1.7 (3.4)	1.8 (1.8)	0.6 (1.5)	1.6 (1.3)	0.65
Food habits					
Meal (Nb/d)	2.7 (0.5)	3 (0.4)	2.7 (0.5)	3 (0.5)	0.90
<i>Food portion (Nb/d)</i>	11.9 (3.6)	12.2 (4.4)	12.3 (3.3)	11.2 (4.0)	0.08
Main categories (Nb/d)					
Plant product	3.3 (2.2)	3.1 (2.5)	2.9 (1.0)	3.0 (2.5)	0.48
<i>Animal product</i>	3.6 (0.9)	3.3 (1.1)	3.9 (1.2)	3.0 (1.0)	0.07
Junk food	1.5 (1.4)	2.0 (1.1)	2.5 (2.6)	2.0 (1.3)	0.19
Starchy product	3.0 (1.5)	3.1 (2.0)	3.0 (1.2)	2.4 (1.0)	0.17
Detailed category (Nb/d)					
Alcohol	0.09 (0.2)	0.17 (0.3)	0.16 (0.9)	0.16 (0.3)	0.14
Hot drink	0.7 (0.8)	1.2 (1.1)	0.8 (1.0)	1.0 (1.0)	0.22
Whole starchy product	1.6 (1.2)	1.9 (1.9)	1.5 (0.9)	1.0 (0.7)	0.02
Fruit	1.6 (1.2)	1.3 (1.0)	1.1 (0.8)	1.0 (1.0)	0.62
Nut	0.2 (0.4)	0.2 (0.6)	0.2 (0.4)	0.2 (0.5)	0.88
Dairy product	1.7 (0.6)	1.8 (0.9)	1.7 (0.7)	1.7 (0.8)	0.77
Vegetable	1.2 (1.5)	1.2 (1.2)	1.1 (0.9)	1.2 (1.2)	0.77
Legume	0.2 (0.2)	0.3 (0.4)	0.1 (0.2)	0.3 (0.4)	0.74
Refined starchy product	1.4 (0.8)	1.2 (0.5)	1.4 (0.8)	1.4 (0.6)	0.42
Fatty-salty-sugary product	0.8 (0.8)	1.2 (0.8)	0.9 (1.0)	1.4 (1.1)	0.82
Snack	0.4 (1.0)	0.4 (0.8)	0.6 (1.2)	0.2 (0.6)	0.05
Meat-fish-egg	1.8 (0.6)	1.5 (0.5)	2.2 (1.0)	1.4 (0.7)	0.43
Food balance score	6.2 (1.1)	5.8 (1.2)	5.7 (1.0)	5.7 (1.3)	0.13

228

229

230 3.2 Effect of post-lockdown on food habits and the number of portions

231 Fig. 1 shows that the number of daily meals did not change on average between the two
232 periods. The mean daily number of portions changed differently according to sex: women
233 took one less portion per day ($p = 0.07$, Table 2), while men did not change their food intake
234 ($p = 0.55$). Other changes in food behavior can be observed between the two periods. A
235 lower starchy food consumption was observed, whereas that of junk food was slightly higher
236 post-lockdown (Fig. 1). The food balance score was slightly better during the lockdown for
237 the whole participant sample. A small effect size of period was observed. There were some
238 consumption differences according to sex between the two periods. Women consumed less
239 food portions and less whole starchy foods post-lockdown, while men maintained the same
240 number of portions. Snack consumption was similar during lockdown in men and women,
241 whereas it became higher in men than in women post-lockdown (Table 2).

242 Sex significantly influenced food behavior. The number of meals per day was higher in
243 women (Fig. 2). The effect size of sex for this variable was medium. The hot drink, legume
244 and fatty-salty-sugary product categories were more frequently consumed by women, while
245 the fruit, animal product, meat-fish-egg and snack categories were more frequently
246 consumed by men (Fig. 2). The effect sizes of sex for the consumption of different food
247 categories were generally small except for the one for meat-fish-egg products, which was
248 large.

249

250 **4. Discussion**

251 The main results show that moderate-intensity PA was lower during the lockdown than after
252 (-48%) and the light and vigorous intensity activities were similar. Compared to free-living
253 conditions, lockdown was associated with shorter time spent in walking. Eleven minutes less
254 time was devoted to daily PA. Compared to the international PA guidelines (150 minutes of
255 moderate PA per week, i.e., 21 minutes/day, WHO, 2010) (PA Guidelines Advisory
256 Committee, 2011), that 10-minute decrease is half of the daily-recommended PA. The effect
257 size of period was medium and can be considered significant according to the duration.
258 Several studies showed less PA during than before lockdown in different population samples
259 and countries (Buoite Stella et al., 2020; Sanudo et al., 2020; López-Bueno et al., 2020). Thus,
260 in a population of more than 1000 adults of various nationalities and all ages, significant less

261 time spent in vigorous-intensity (-33.1%) and moderate-intensity (-24%) activities, walking (-
262 35%), and all physical activities combined (-24%), and longer periods in sitting time of 28.6%,
263 were observed via the PA questionnaire responses (Ammar et al., 2020). Another study
264 showed that the Spanish population performed an average of 45 minutes less PA per day,
265 and that the proportion of the population meeting the PA recommendations decreased from
266 60.6% to 48.9% (-11.7%, López-Bueno et al., 2020). Finally, a study targeting the German
267 population also showed that the population globally was less engaged in physical activity,
268 but that this behavior was less pronounced in 14 to 30-year-olds (35% had a lower level
269 during the confinement) compared to people 30-64 and over 65-years old (more than 50%
270 had a lower level in physical activity). Indeed, the majority of 14-30-year-olds (54.5%)
271 maintained their PA level during confinement and 9.8% even had a higher level (Mutz and
272 Gerke, 2020). Moreover, two studies showed either higher levels or similar PA practice in
273 young people during than after lockdown (McCarthy et al., 2021; Shaun et al., 2021). Our
274 findings had some common points and some differences with the findings shown above. The
275 results of the present study showed a higher level of moderate PA but no difference in
276 sedentary behavior or in light or vigorous intensity activities during free-living conditions
277 (pre or post-lockdown). The tools used to measure PA and the country of origin were
278 different between the studies referred to above and could partially explain the gaps in the
279 results. Ammar et al. (2020), López-Bueno et al. (2020), and Mutz and Gerke (2020) used
280 questionnaires to evaluate time spent in PA. The responses to questionnaires are subjective
281 and less accurate than objective measurements made by accelerometers (Prince et al.,
282 2020). McCarthy et al. (2021) used the BetterPoints smartphone application, which did not
283 capture steps accumulated in the home or workplace. In the present study, accurate times of
284 both outdoor and indoor PA, even for short periods, was measured by eMouve unlike
285 BetterPoints. In Shaun et al. (2021), the proportion of students having no PA or practicing PA
286 one to three times or more was only asked. It was a rough evaluation of the PA level.

287 The end of lockdown was associated with a higher level of PA in our study. Thus, this two-
288 month lockdown did not lead to a sustainable low level of PA. In one of our previous works
289 published in 2018, we showed that normal-weight adults (mean age 33 ± 9 years) in free-
290 living conditions spent 65.2%, 29.4%, 4.9% and 0.4% in immobility, light-, moderate and
291 vigorous- intensity activities, respectively (Rousset et al., 2018). Compared to this activity

292 split, that of the students post lockdown seems a little different for immobile and light
293 intensity activity. The students in the present work were more sedentary, spent less time in
294 light-intensity activity but similar time in moderate intensity activity. However, since we did
295 not measure the duration of PA before lockdown, we cannot say for sure that post-lockdown
296 PA is similar to that before the lockdown, but only that moderate-intensity activity was
297 higher after than during the lockdown. Furthermore this post-lockdown moderate activity
298 was equivalent to that of another French normal-weight adult group.

299 There were differences in PA between sexes: the female volunteers spent more time in
300 sedentary behavior and less in light-intensity activity but more vigorous activities than men.
301 Some studies found that young women spent more time in sedentary behavior than young
302 men (Martin et al., 2014), and men more time in vigorous PA than young women (Wickel
303 and Eisenman, 2006) whereas Nelson et al. (2019) found no difference between female and
304 male students aged 18-25 years for objectively measured sedentary, light-, moderate- and
305 vigorous- intensity activities. The differences between these studies and the current findings
306 may be due in part to the different methods of PA measurement (Actigraph, activity diary
307 and eMouve) and to the study period (many years before, during and after lockdown).

308 In our study, the frequency of meals remained unchanged but the food balance score was
309 slightly higher during lockdown because of a lower consumption of junk foods and a higher
310 consumption of starchy foods. The effect sizes of period were generally small. That finding
311 showed that food habits remained stable overall because food supply remained intact. The
312 review of Neira et al. (2021) shows mixed results according to different factors (country, BMI
313 and age). Thus, Ammar et al. (2020) observed that food intake was higher, especially snacks
314 and unhealthy food, during lockdown in participants from Europe, North Africa, West Asia
315 and America, while adherence to the Mediterranean diet improved during the same period
316 in Spain (Rodriguez-Perez et al., 2020). An Italian study showed that most of the participants
317 had no change in the number of their daily meals (Di Renzo et al., 2020). This study also
318 showed that the group aged 18-30 years with low BMI adhered to the Mediterranean diet to
319 a greater degree than the younger, obese and elderly populations during lockdown. This 18-
320 30-year group was more inclined to cook and eat fresh food during this period. In the current
321 volunteer sample, all were young and very few were overweight or alone during this period.

322 Most of the volunteers chose to remain with their families. All these factors seem favorable
323 to making better food choices or maintain the dietary balance.

324 We observed differences in the number of portions consumed for some food categories
325 between sexes. Men ate more meat-fish-egg products while women ate more fatty-salty-
326 sugary products. Higher meat consumption by men was well-known (Pfeiler et al., 2018 ;
327 Aston et al., 2013). Other previous studies also agreed with these findings. With respect to
328 the nutritional guidelines, the male university students showed significantly lower level of
329 compliance for meat products consumption but higher levels of compliance for sweets and
330 lemonade/soft drinks than the female students (Smith and Smith, 1994).

331 *4.1 Limitations*

332 There were some limitations to the present research. The size of our participant sample is
333 small and not fully representative of the young French population because most of the
334 volunteers were students. The great fear induced by the lockdown is social isolation. The
335 consequences of this condition could not be studied in the present work because most of
336 the participants did not live alone during this period. We compared the during- and post-
337 lockdown periods, but we could not make any deductions about the return to normal life
338 because of the lack of data collected before the lockdown.

339 *4.2 Conclusion*

340 The effect of the lockdown in a sample of young French people was deleterious on time
341 spent in moderate-intensity activity. However, that lower level of PA was not dramatic
342 because the participants meet the PA guidelines in spite of the constraints imposed by the
343 lockdown. The lockdown itself compared to the post-lockdown period had a favorable effect
344 on diet with a higher food balance score in this French student sample. The consequences of
345 the lockdown were mixed and participant group-dependent.

346

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353 **Author contributions**

354 The authors contributed equally to the design, data analysis and writing of the manuscript.

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356 **Declaration of competing interest**

357 No conflicts are noted by the authors.

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359 **Data availability**

360 The data collected during the study may be sent on request to the corresponding author.

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