



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

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ABSTRACT

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

1. Introduction

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

food behavior.

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

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COVID-19.

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

Twenty-three studies pertaining to dietary changes during the lockdown were included in the scoping review of Bennett et al. (2021), and are mostly based on self-reported data among adult Western populations. This review showed favorable and unfavorable changes in dietary habits during the lockdown. Eleven studies reported better dietary habits with a higher consumption of fresh food and home cooking and a lower consumption of alcohol, sweets, processed and fried food, while ten studies reported more snacks consumed by 40% to 50% of the consumers and two other studies showed a higher alcohol consumption. The results of the studies were country-, age- and sex-dependent. The study of Ruiz-Roso et al. (2020) analyzed the food consumption of adolescents during confinement in five countries using a questionnaire comparing consumption before vs. during confinement. This survey showed a significant higher consumption of fruits and vegetables in girls aged 10 to 19 years. 43% and 33% of the adolescents consumed vegetables and fruit every day during the confinement. These percentages were higher than those observed before lockdown (33% and 25%, respectively). A cross-sectional study by López-Bueno et al. (2020) of several thousand Spanish participants showed that 55% vs 49% of participants were compliant with the fruit consumption recommended guidelines during and before the lockdown. The results of the survey of Scarmozzino and Visioli (2020) showed contrasting results: more than half of the participants declared that they had not felt any attraction for fruit and vegetables during the confinement, 21% declared that they had a higher consumption of fruit and vegetables and 9% reported that they had a lower consumption, notably for financial reasons. An international study of 1000 people, half of whom were between 18 and 35 years of age, also revealed a degraded evaluation of diet during lockdown, based on subjective scores other than fruit and vegetable consumption (Ammar et al., 2020). The French Nutrinet Santé study also showed contrasting results on eating habits during lockdown. For some people, lockdown produced adverse health changes with an average weight gain of 1.8 kg in two months associated with higher energy intake of 443 kcal/day and snacking on sweets, cookies and cakes, and higher alcohol consumption. Eating more compensated for boredom and reduced stress. Participants who presented this profile were more often young, female, telecommuting during lockdown with high anxiety and depressive symptoms, high education but lower income, with children present at home. For other young, overweight or obese, telecommuting individuals or students with high education and income, the lockdown resulted in a 2-kg weight loss, more time spent cooking, greater consumption of fruits, vegetables, legumes, nuts and fish, and lower consumption of sweets, cookies and cakes and alcohol. The lockdown led to an improvement in eating habits in the latter group (Deschasaux-Tanguy et al., 2020).

Before collecting the data, our hypothesis is that the lockdown could have drastically changed life habits, including high level of sedentary behavior and changes in diet. Are these behavioral changes sustainable post-lockdown when free-living conditions are restored? Our aim is to assess changes in time spent in sedentary behavior and physical activity, and in diet between sexes in a group of 22 year-old French students. The contribution of the present study also concerns more accurate, reliable and safe means to measure behavioral changes during and after an epidemic.

2. Method

2.1. Sample of volunteers

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

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

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

2.2. Measures

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

NutriQuantic was used to collect the daily number of meals, and of portions consumed in each of the 12 food groups (fruit, vegetable, legume, nut, refined starchy product, meat-fish-egg, dairy product, fatty-salty-sugary product, snack, alcohol, whole starchy product and hot drink) during the same period. On the basis of these groups, we designed four major categories: plant products, animal products, junk food and starchy products. The plant product category is the sum of the number of portions of fruits, vegetables, nuts and legumes; the animal product category is the sum of the dairy and meat-fish-egg groups; the junk food category is the sum of alcohol, fatty-salty-sugary products and snacks; and the starchy food category is the sum of refined and whole starchy products. A guide for the estimation of a portion was sent to each participant. A food balance score was assigned to each of the 11 food categories based on the number of portions and according to French and international nutritional guidelines. The score in each category varies between 0 (unsatisfactory), 0.5 (intermediate) and 1 (satisfactory). The nutritional balance score of the diet is the result of a confidential calculation over the 11 food groups (Cissoko et al., 2015) and of the French nutritional guidelines (Hercberg et al., 2008).

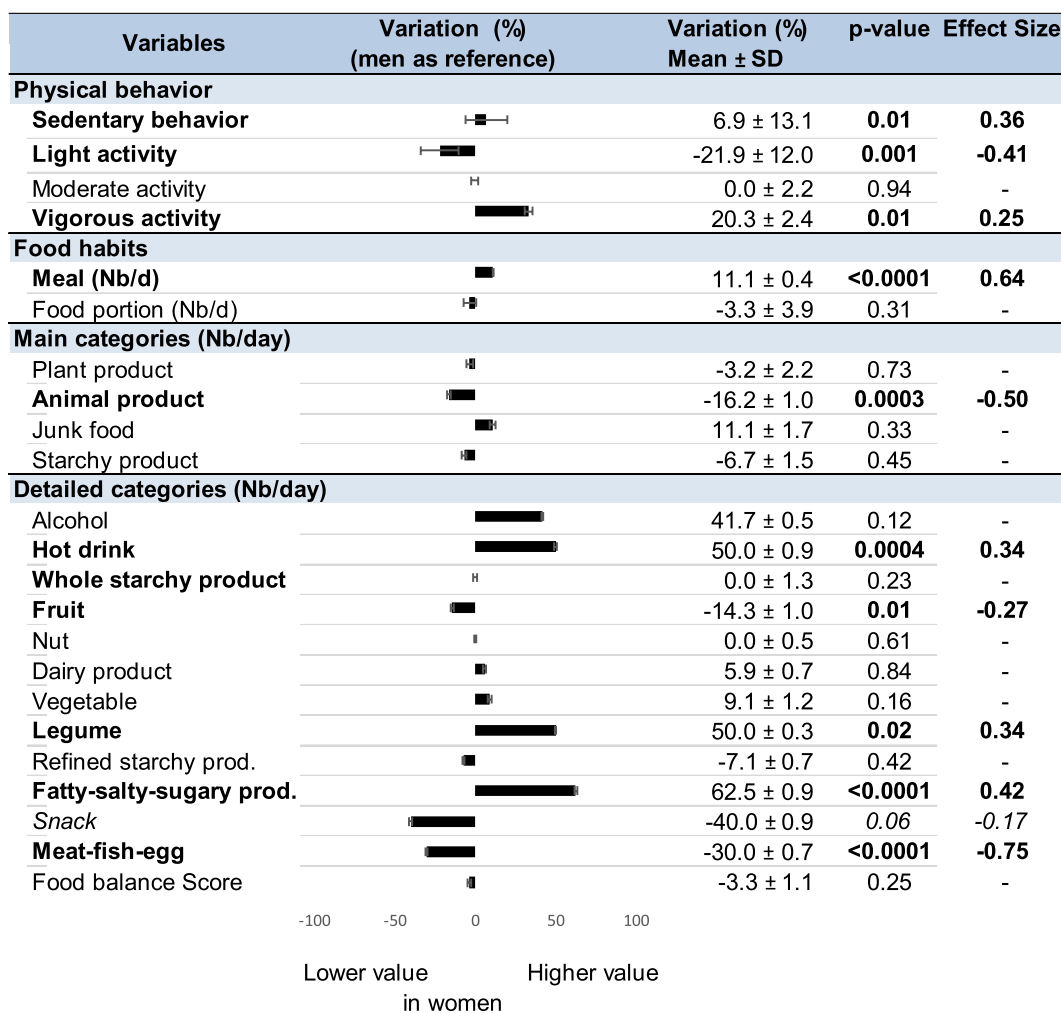


Fig. 2. Differences in behavior between men and women (Mean ± SD) and significance.

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

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

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

4. Discussion

The main results show that moderate-intensity PA was lower during the lockdown than after (-48%) and the light and vigorous intensity activities were similar. Compared to free-living conditions, lockdown was associated with shorter time spent in walking. Eleven minutes less time was devoted to daily PA. Compared to the international PA guidelines (150 min of moderate PA per week, i.e., 21 min/day, World Health Organization, 2010) (PA Guidelines Advisory Committee, 2011), that 10-minute decrease is half of the daily-recommended PA. The effect size of period was medium and can be considered significant according to the duration. Several studies showed less PA during than before lockdown in different population samples and countries (Buoite Stella et al., 2021; Sañudo et al., 2020; López-Bueno et al., 2020). Thus, in a population of more than 1000 adults of various nationalities and all ages, significant less time spent in vigorous-intensity (-33.1%) and moderate-intensity (-24%) activities, walking (-35%), and all physical activities combined (-24%), and longer periods in sitting time of 28.6%, were observed via the PA questionnaire responses (Ammar et al., 2020). Another study showed that the Spanish population performed an average of 45 min less PA per day, and that the proportion of the population meeting the PA recommendations decreased from 60.6% to 48.9% (-11.7%, López-Bueno et al., 2020). Finally, a study targeting the German population also showed that the population globally was less engaged in physical activity, but that this behavior was less pronounced in 14 to 30-year-olds (35% had a lower level during the confinement) compared to people 30–64 and over 65-years old (more than 50% had a

Table 2
Behavioral components in men and women during and after the lockdown (Mean (SD)) and 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
Food portion (Nb/d)	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
Animal product	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

lower level in physical activity). Indeed, the majority of 14–30-year-olds (54.5%) maintained their PA level during confinement and 9.8% even had a higher level (Mutz and Gerke, 2020). Moreover, two studies showed either higher levels or similar PA practice in young people during than after lockdown (McCarthy et al., 2021; Shaun et al., 2021). Our findings had some common points and some differences with the findings shown above. The results of the present study showed a higher level of moderate PA but no difference in sedentary behavior or in light or vigorous intensity activities during free-living conditions (pre or post-lockdown). The tools used to measure PA and the country of origin were different between the studies referred to above and could partially explain the gaps in the results. Ammar et al. (2020), López-Bueno et al. (2020), and Mutz and Gerke (2020) used questionnaires to evaluate time spent in PA. The responses to questionnaires are subjective and less accurate than objective measurements made by accelerometers (Prince et al., 2020). McCarthy et al. (2021) used the BetterPoints smartphone application, which did not capture steps accumulated in the home or workplace. In the present study, accurate times of both outdoor and indoor PA, even for short periods, was measured by eMouve unlike BetterPoints. In Shaun et al. (2021), the proportion of students having no PA or practicing PA one to three times or more was only asked. It was a rough evaluation of the PA level.

The end of lockdown was associated with a higher level of PA in our study. Thus, this two-month lockdown did not lead to a sustainable low level of PA. In one of our previous works published in 2018, we showed that normal-weight adults (mean age 33 ± 9 years) in free-living conditions spent 65.2%, 29.4%, 4.9% and 0.4% in immobility, light-, moderate and vigorous- intensity activities, respectively (Rousset et al., 2018). Compared to this activity split, that of the students post lockdown seems a little different for immobile and light intensity activity. The students in the present work were more sedentary, spent less time in light-intensity activity but similar time in moderate intensity activity. However, since we did not measure the duration of PA before lockdown, we cannot say for sure that post-lockdown PA is similar to that before the lockdown, but only that moderate-intensity activity was higher after than during the lockdown. Furthermore this post-lockdown moderate activity was equivalent to that of another French normal-weight adult

group.

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

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

We observed differences in the number of portions consumed for some food categories between sexes. Men ate more meat-fish-egg products while women ate more fatty-salty-sugary products. Higher

meat consumption by men was well-known (Pfeiler and Egloff, 2018; Aston et al., 2013). Other previous studies also agreed with these findings. With respect to the nutritional guidelines, the male university students showed significantly lower level of compliance for meat products consumption but higher levels of compliance for sweets and lemonade/soft drinks than the female students (Smith and Smith, 1994).

4.1. Limitations

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

4.2. Conclusion

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

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

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

Data availability

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

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